## 3.2 Collection, Hauling and Street Sweeping System

At present the waste collection system of Alexandria makes no clear distinction between collection of household and commercial waste and the street sweeping. Household waste is discharged directly on the streets, because of non-periodical collection service and lack of citizen cooperation. This is the main reason of the increase of street sweeping burden, and it is indispensable to establish a reliable collection system in order to decrease the burden. On the other hand, it is desirable to establish an independent system of the street sweeping itself.

### 3.2.1 Study of the collection and hauling system

1) Study area

The study area is defined inside the Green Belt proposed on Plan 2005, excluding Lake Maryut, factory areas, and green and agricultural areas as shown in Fig. 3-2-1. The land use in the study area is shown in Tab. 3-2-1.

The urban area (mainly residential and center area) currently being collected and the future urban areas to be collected are shown in Fig. 3-2-1. The estimated present and future waste generation amounts in each zone are shown in Fig. 3-2-2 and Fig. 3-2-3. The waste generation density in each sub-district is shown in Fig. 3-2-4.

At present, the density of household waste at discharge stage is 0.26 ton/$m^3$ and it is presumed that this value will not be so much influenced by future changes in the waste composition as discussed in Chapter 2. Therefore, the study is carried out on the assumption of 0.25 ton/$m^3$.

Tab. 3-2-1 LAND USE

(Km²)

| | MONTAZAH IN* | MONTAZAH OUT** | EAST IN | EAST OUT | MIDDLE IN | MIDDLE OUT | GOMROK IN | GOMROK OUT | WEST IN | WEST OUT | AMERIYAH IN | AMERIYAH OUT | TOTAL IN | TOTAL OUT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Administrative and commercial center | -- | -- | -- | -- | 2.4 | -- | 2.7 | Harbor | | -- | 2.9 | | 8.0 | |
| Housing | 32.3 (12.0) | -- | 12.0 (12.0) | -- | 5.3 (5.3) | -- | -- | | 4.8 (4.3) | -- | 172.4 (14.2) | | 226.8 (47.8) | |
| Factory | 2.3 | 6.7 | 7.7 | -- | 3.3 | -- | 0.8 | (0.8) | 11.6 | -- | 32.4 | 80.0 | 58.1 | 86.7 (0.8) |
| Green | 4.1 | 46.4 | 1.7 | -- | 0.9 | 2.2 | 0.7 | | 0.4 | 3.9 | 20.5 | 80.2 | 28.3 | 132.7 |
| Agriculture | -- | 29.7 | 3.8 | -- | | -- | -- | | -- | -- | | 63.7 | 3.8 | 93.4 |
| Military, etc. | 1.9 | 0.7 | -- | 3.0 | | 1.2 | 0.3 | (0.3) | -- | -- | 10.4 | | 12.6 | 4.9 (0.3) |
| Lake | -- | | -- | -- | | 0.6 | -- | | -- | 15.0 | | 53.5 | | 69.1 |
| Sub-total | 40.6 | 83.5 | 25.2 | 3.0 | 11.9 | 4.0 | 4.5 | (1.1) | 16.8 | 18.9 | 238.6 | 277.4 | 337.6 (47.8) | 386.8 (1.1) |
| TOTAL | 124.1 | | 28.2 | | 15.9 | | 4.5 | | 35.7 | | 516.7 | | 724.4 (48.9) | |

Note:

1. *In: Study area.
   **Out: Non-study area.
2. Measured from the land use map of the Plan 2005.
3. Excluding areas outside the green belt.
4. ( ): Present status

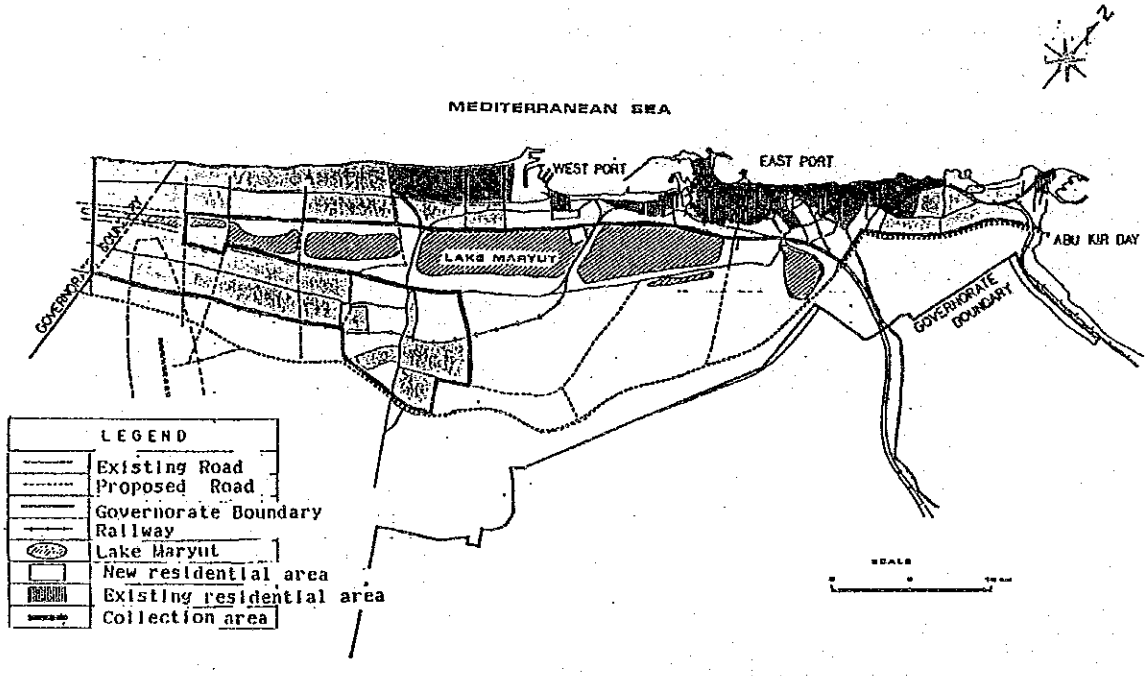



Fig. 3-2-1 PRESENT AND FURURE SOLID WASTE COLLECTION AREA

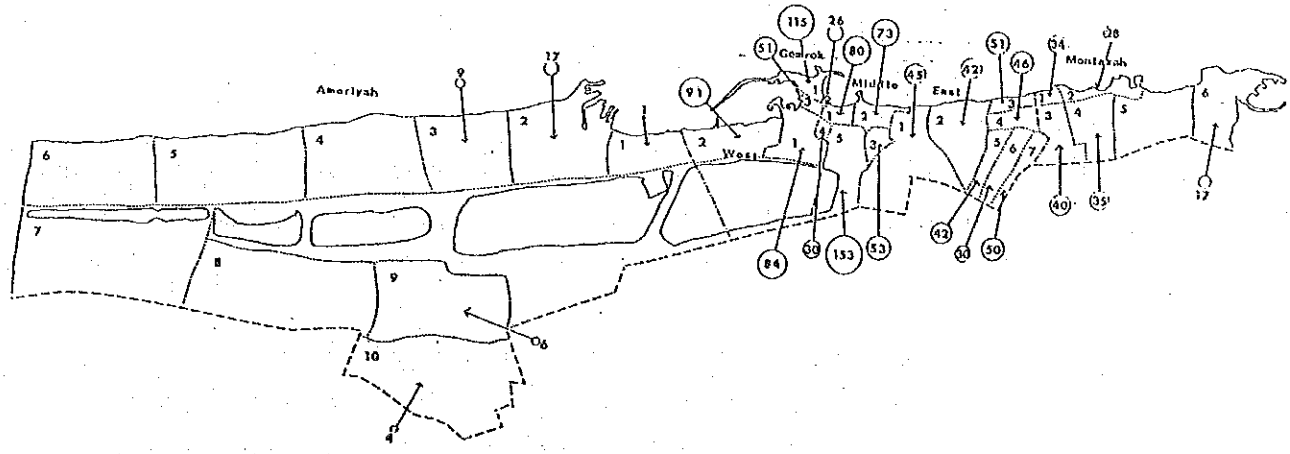



Fig. 3-2-2 ESTIMATED SOLID WASTE GENERATION AMOUNT IN 1984 (T/D)

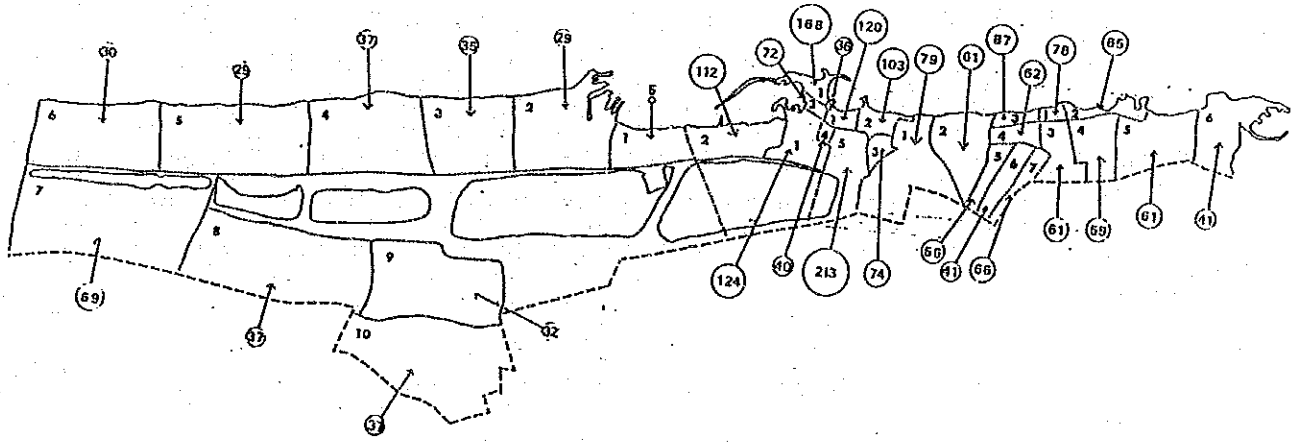


Fig. 3-2-3 ESTIMATED SOLID WASTE GENERATION AMOUNT IN 2000 (T/D)

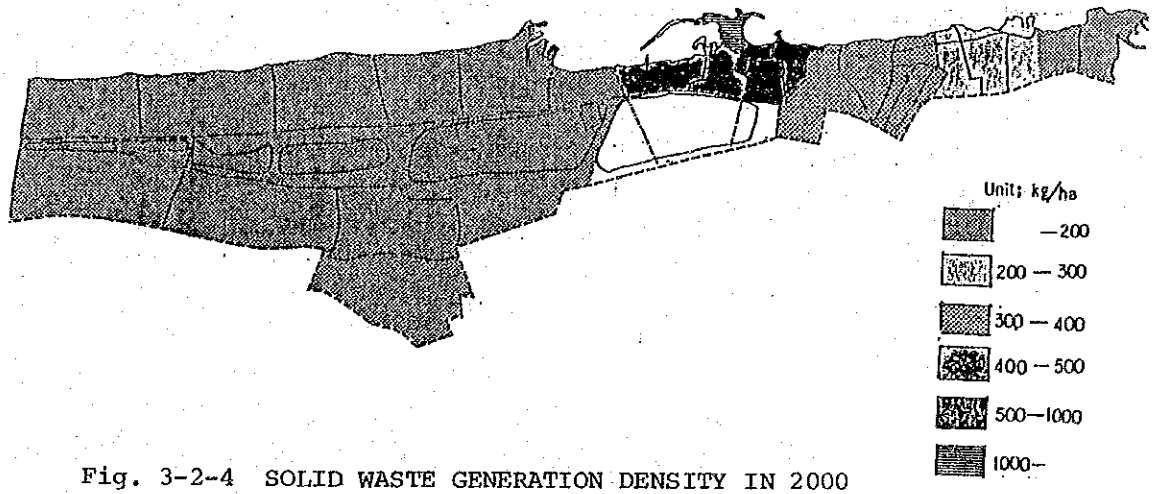



Fig. 3-2-4 SOLID WASTE GENERATION DENSITY IN 2000

2) Waste discharge station and collection frequency

(1) Location of station

Waste discharge stations will be provided on sidewalks of main streets and alleys accessible by collection vehicles, and residents will not be allowed to discharge their wastes at places other than the said stations.

At present, the locations of the stations are not indicated in a clearly visible way, with exception of the places where the large-size containers are installed. However, open stations are observed on the sidewalks of the main streets and alleys along the collection routes.

From the view point of residents' convenience, the service level of the collection station and container system is lower compared with the door-to-door collection system, but it has the advantage of higher collection efficiency. Therefore it seems recommendable to maintain it unchanged also in the future. It must be borne in mind however, that the adoption of the fixed waste station system will be indispensable for the residents to discharge their wastes in a regular way based on a regular waste collection service.

(2) Station placement density and collection frequency

The stations will be placed in such a way that the waste carrying distance by the residents is more or less 50 to 60m, and that the weight of waste kept at the station is limited within 100 to 300kg. In principle, three stations per hectare with daily collection will be provided in high-density generation areas while two stations per hectare with twice a week collection will be provided in low-density generation areas.

The collection frequency and the station placement density by collection zone is shown in Fig. 3-2-5.

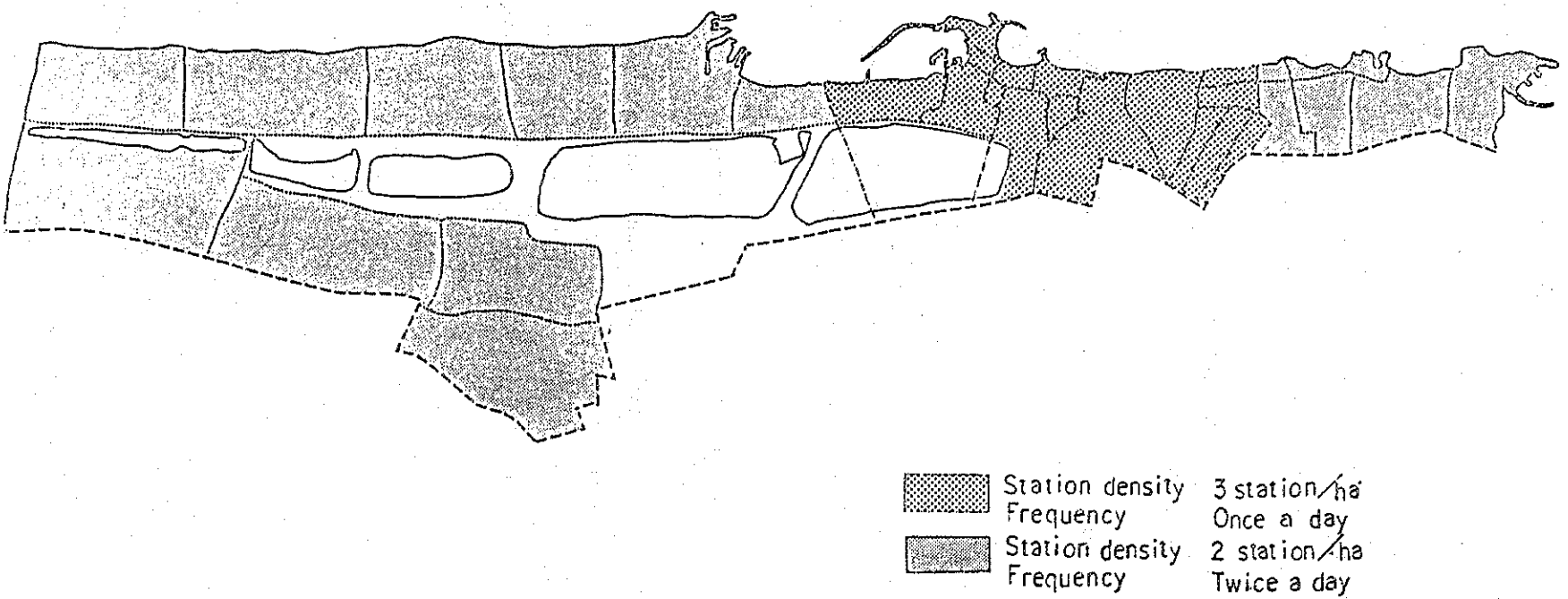



Fig. 3-2-5 COLLECTION FREQUENCY AND STATION PLACEMENT DENSITY BY COLLECTION ZONE

The station distribution density will be determined by taking into consideration the following points:

- Collection frequency
- Service level to be provided
- Collection efficiency
- Road conditions (road width and road network)
- Population density
- Concentration of business establishment
- Amount of waste per station

The basic policy for provision of the waste discharge station is examined in the following.

a. Station placement density

This section examines the station placement density, collection frequency and amount of waste per station of each district classified in terms of generation density.

i. Districts with high generation density (700 kg/ha)

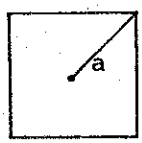
Districts with high generation density (Middle and Gomrok Districts) are presumed to have generation density of 700 kg/ha or more. The results of the calculations to determine the station density and the weight of waste per station, classified in terms of collection frequency, are shown in Tab. 3-2-2.

Tab. 3-2-2 WASTE ACCUMULATION AMOUNT PER STATION IN AREAS GENERATING 700KG/HA BY STATION PLACEMENT DENSITY AND COLLECTION FREQUENCY

(kg)

| STATION DENSITY \ FREQUENCY | DAILY | THREE TIMES A WEEK | TWICE A WEEK | ONCE A WEEK |
|---|---|---|---|---|
| 1/ha | 700 | 2,100 | 2,800 | 4,900 |
| 2/ha | 350 | 1,050 | 1,400 | 2,450 |
| 3/ha | 233 | 700 | 933 | 1,633 |
| 4/ha | 175 | 525 | 700 | 1,225 |
| 5/ha | 140 | 420 | 560 | 980 |

Note: 1. The maximum waste carrying distance is 84m when the station density is 1/ha, 60m when 2/ha, 50m when 3/ha, approx. 40m when 4/ha and 5/ha.




The maximum carrying distance is supposed to be 1.2 times the dimension a of the figure.

As can be seen from Tab. 3-2-2, when the station placement density is 1/ha. the weight of waste per station becomes 700 kg, and consequently if the collection frequency is lowered a huge amount of waste will remain at the station resulting in the risk of overflow of waste on the street.

Currently the stations are placed as shown in the example of Fig. 3-2-6, and in this case it is approximately 1.2/ha. The amount of waste per station is not so large in this case due to daily collection, but in reality there are some stations with considerable accumulation of waste. Furthermore, since the maximum carrying distance to the station is relatively long with the order of 75m to 100m, street sweepers are required to collect waste scattered on the alleys.

It is necessary to increase the station placement density above the current level in order to prevent the waste from scattering on the streets and alleys.

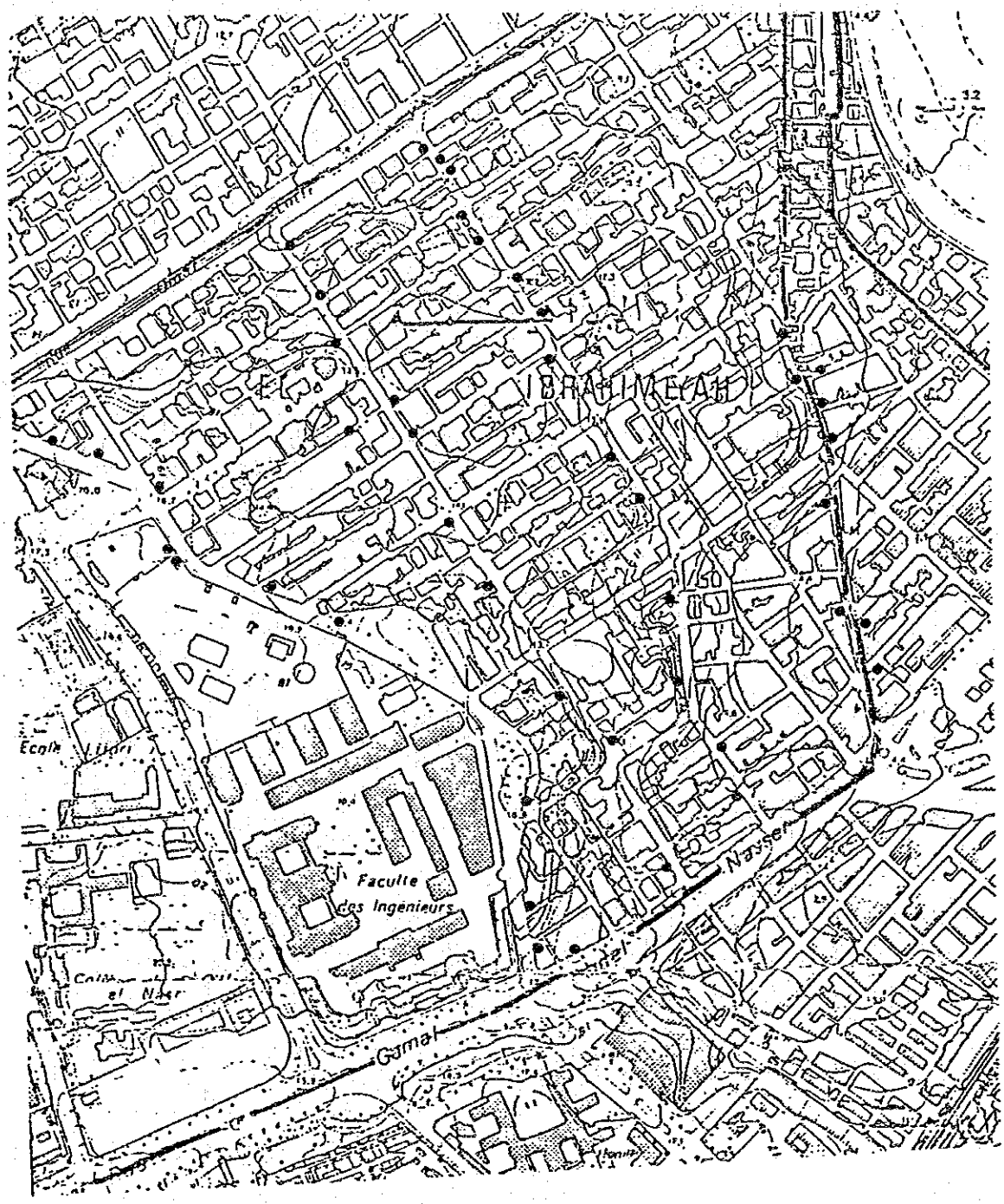
ii. Districts with medium generation density (300kg/ha)

The East District is an example of an area with this type of generation density. This district has a very high population density, but on the other hand it is characterized by the existence of many apartment buildings of 3 to 5 storeys. The amount of waste per station, classified in terms of station placement density and collection frequency, is shown in Fig. 3-2-3. As can be seen, the quantity per station in weight becomes very large if there is no daily collection.

Tab. 3-2-3 WASTE ACCUMULATION AMOUNT PER STATION IN AREAS GENERATING 300KG/ha BY STATION PLACEMENT DENSITY AND COLLECTION FREQUENCY

(kg)

| FREQUENCY / STATION DENSITY | DAILY | THREE TIMES A WEEK | TWICE A WEEK | ONCE A WEEK |
|---|---|---|---|---|
| 1/ha | 300 | 900 | 1,200 | 2,100 |
| 2/ha | 150 | 450 | 600 | 1,050 |
| 3/ha | 100 | 300 | 400 | 700 |
| 4/ha | 75 | 225 | 300 | 525 |
| 5/ha | 60 | 180 | 240 | 420 |




● Location of waste stations

Fig. 3-2-6 STATION PLACEMENT EXAMPLE
(MIDDLE DISTRICT - IBRAHIMEYAH)

iii. Districts with low generation density (100kg/ha)

The Ameriyah District is an example of an area with low generation density. It is presumed that the generation density falls under 100kg/ha. The waste amount classified in terms of station placement density and collection frequency is shown in Tab. 3-2-4.

Tab. 3-2-4 WASTE ACCUMULATION AMOUNT PER STATION IN AREAS GENERATING 100KG/HA BY STATION PLACEMENT DENSITY AND COLLECTION FREQUENCY

(kg)

| FREQUENCY / STATION DENSITY | DAILY | THREE TIMES A WEEK | TWICE A WEEK | ONCE A WEEK |
|---|---|---|---|---|
| 1/ha | 100 | 300 | 400 | 700 |
| 2/ha | 50 | 150 | 200 | 350 |
| 3/ha | 33 | 100 | 133 | 233 |
| 4/ha | 25 | 75 | 100 | 175 |
| 5/ha | 20 | 60 | 80 | 140 |

It is presumed that a station placement density of 2/ha and a frequency of twice a week are appropriate, taking into account the service level, the collection efficiency and waste amount per station.

b. Station placement density and cost for collection

Provided that the station placement density is low, the carrying distance to the station becomes longer, and street sweeping becomes necessary, as a consequence of accumulation of waste in the alleys and streets. In this study it is considered that the 50m carrying distance to the station (station placement density of 3/ha) is not so far for the residents. The improvement of the service level by increasing the station placement density slightly lowers the collection efficiency, but on the other hand it has the advantage of requiring less number of sweepers.

In this connection, two model cases, one with the present station placement density as it is requiring street sweepers, the other with higher station placement density without requiring street sweepers, are examined comparatively in terms of operation cost.

The cost estimation conditions and the estimation formula are as follows:

- Daily generation amount : 100t
- Generation density : 100kg/ha, 300kg/ha and 700kg/ha
- Station placement density : 3/ha

$$N_0 = \frac{W \times G \times S \times R}{Q \times D}$$

$N_0$: Number of stations per trip
W: Carrying capacity of a vehicle per trip (3 ton)
G: Waste generation amount (t/day), 100t
S: Station placement density (number/ha)
R: Collection area rate (-) (R=1.0 when the collection frequency is daily, R=0.5 when 3 times/week, R=0.33 when twice a week, R=0.17 when once a week)
Q: Designed daily collection amount (t/day)
D: Generation density (kg/ha)

$$T_0 = [(T_1 + T_2) \times N_0 + T_3] \times F$$

$T_0$: Time required per trip
$T_1$: Loading time
$T_2$: Travelling time
$N_0$: Number of stations per trip
$T_3$: Round trip time to the dump site
$F_1$: Safety factor (1.2)

$$N_1 = \frac{T_4}{T_0}$$

$N_1$: Number of trips (-)

$T_4$: Operation time (min)

$T_0$: Time required per trip (min)

$$N_2 = \frac{Q}{W \times N_1} \times F_2$$

$N_2$: Required number of vehicles (no.)

Q: Designed daily collection amount (t/day)

W: Carrying capacity of a vehicle per trip (3 ton)

$N_1$: Number of trips (no.)

$F_2$: Safety factor for number of vehicle (1.3)

$$N_3 = \left(\frac{N_2}{F_2} + \frac{N_2}{7 \cdot F_2}\right) \times F_3$$

(The second term in the parenthesis is applicable only for the case of daily collection)

$N_2$: Required number of vehicles

$N_3$: Number of drivers

$F_2$: Safety factor for number of vehicle (1.3)

$F_3$: Safety factor for number of drivers (1.2)

$$N_4 = \left(\frac{N_2}{F_2} \times n + \frac{N_2 \times n}{7 \cdot F_2}\right) \times F_4$$

(The second term in the parenthesis is applicable only for the case of daily collection)

$N_4$: Number of workers

n : Number of workers per vehicle

$N_2$: Required number of vehicles

$F_2$: Safety factor for number of vehicle (1.3)

$F_4$: Safety factor for number of workers (1.3)

. Collection frequency: daily, 3-times/week, twice/week and once/week.

. In the case of daily collection, the collection work will be carried out seven days per week and the working holidays will be guaranteed by increasing safety factor for number of drivers and workers. Accordingly, waste amount to be collected will be 1.0 G/day in the case of daily collection.

. Waste amount to be collected (6 working days per week)
  - 3 times per week: 1.5G/day (peak day)
  - twice a week : 1.33G/day (peak day)
  - once a week : 1.17G/day
. Carrying capacity of the vehicle is assumed to be 3 ton/vehicle per trip.
. The vehicle price: LE 45,000/vehicle
. Driver's wage: LE 200/M
. Collector's wage: LE 100/M
. Depreciation of vehicle: the straight-line method in 5 years, with a residual value of 10%.

The results of the estimation carried out on the aforestated conditions are shown in Tab. 3-2-5.

Tab. 3-2-5 STATION PLACEMENT DENSITY AND COLLECTION COST (CASE OF DAILY COLLECTION)

| GENERATING DENSITY / STATION DENSITY | 100KG/ha | | 300KG/ha | | 700KG/ha | |
|---|---|---|---|---|---|---|
| | 1/ha | 3/ha | 1/ha | 3/ha | 1/ha | 3/ha |
| Service area (ha) | 1,000 | 1,000 | 333 | 333 | 143 | 143 |
| No. of stations | 1,000 | 3,000 | 333 | 1,000 | 143 | 429 |
| No. of vehicles | 23 | 32 | 17 | 20 | 16 | 16 |
| Collection manpower (person) | 104 | 145 | 78 | 89 | 73 | 73 |
| No. of sweepers (once every 3 days) | * 166 | ** 35 | * 56 | ** 12 | * 24 | * 5 |
| Collection cost (LE/ton) | 10.0 | 13.8 | 7.6 | 8.6 | 7.2 | 7.2 |
| Total cost (LE/ton) | 15.5 | 15.0 | 11.9 | 9.0 | 8.1 | 7.4 |

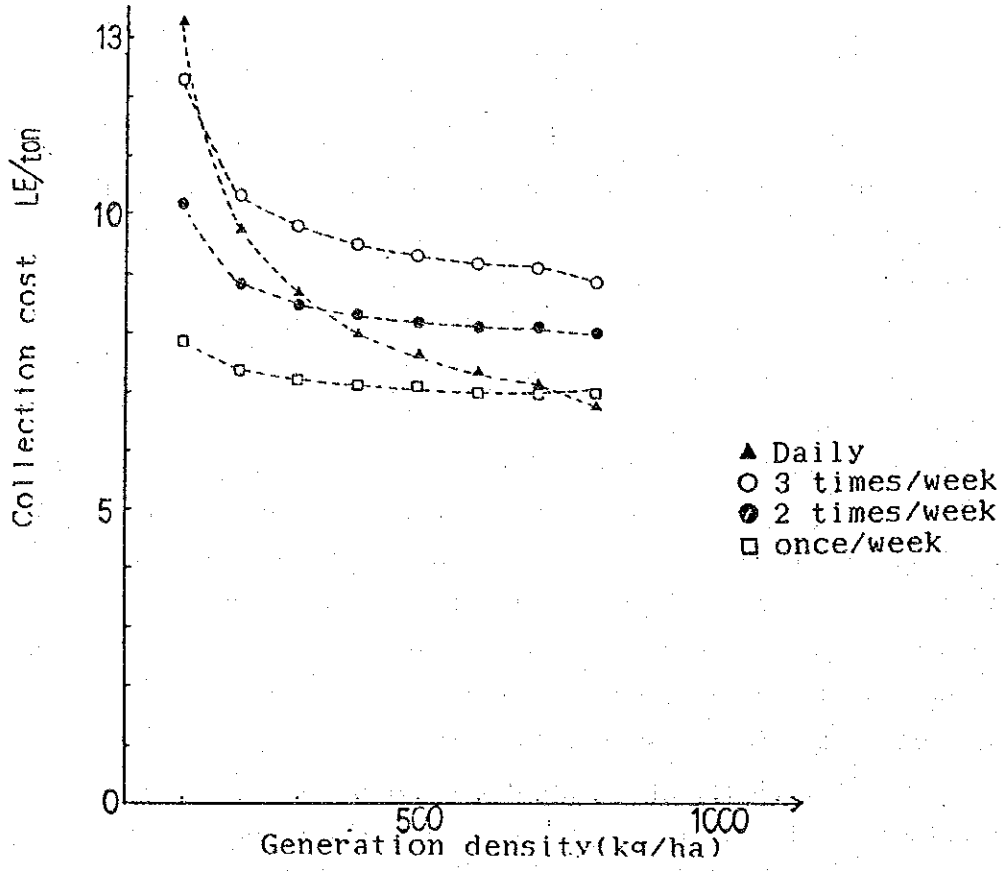
Note: * Once every 3 days
** Once every 2 days

As can be seen, from the cost standpoint it is more advantageous to increase the station density and decrease the number of sweepers. It is presumed that increasing the station density will become further advantageous if the sweeper wage will increase in the future. In principle, this study assumes a station placement density with the carrying distance to the station of 50 to 60m. The station density will be 3/ha in districts with high generation density and 2/ha in districts where the generation density is low.

C. Collection frequency and cost

The collection cost is examined on the basis of the aforesaid model, in order to identify the relation between waste generation density and collection cost. Number of vehicles, manpower, and collection cost, corresponding to generation densities and frequency, are shown in Tab. 3.1.5. Relation between the waste generation density and the collection cost is also shown in Fig. 3-2-6.

As can be seen, the cheapest collection cost takes place when the collection frequency is once/week, but it seems prudent to avoid this alternative, because the waste accumulated in the stations becomes very large, which is an unacceptable situation and furthermore there will be resistance by residents to store the waste of 7 days in their households. The daily collection scheme is the second cheapest alternative in districts with high generation density. It is concluded as a result of this trial calculation that the daily collection scheme is the most advantageous alternative in districts where the generation density is 500kg/ha or more. On the other hand, in districts with lower generation density, the twice/week collection scheme is the second cheapest alternative if the daily collection frequency is discarded in view of problems related to the storage of waste in the household.




Note: In the case of daily collection, the collection vehicles are in use 7 days/week. On the otherhand, in the case of 3-times, 2-times or 1-time per week collection, they are used only 6 days/week.

Fig. 3-2-6 GENERATION DENSITY AND COLLECTION COST

Tab. 3-2-6 COLLECTION COST, NUMBER OF VEHICLES AND MANPOWER

(Daily generation amount = 100 ton/day, Station placement density = 3/ha)

| | 100KG/ha | | | | 300KG/ha | | | | 700KG/ha | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FREQUENCY/WEEK | | | | FREQUENCY/WEEK | | | | FREQUENCY/WEEK | | | |
| | 7 | 3 | 2 | 1 | 7 | 3 | 2 | 1 | 7 | 3 | 2 | 1 |
| Vehicles (No.) | 32.4 | 29.8 | 24.5 | 18.9 | 19.8 | 23.5 | 20.4 | 17.2 | 16.3 | 21.7 | 19.2 | 16.7 |
| Manpower (Person) | 145.2 | 116.8 | 96.3 | 74.3 | 89.0 | 92.2 | 80.0 | 67.4 | 73.0 | 85.1 | 75.4 | 65.4 |
| Cost (LE/ton) | 13.8 | 12.3 | 10.2 | 7.9 | 8.6 | 9.8 | 8.5 | 7.2 | 7.2 | 9.1 | 8.1 | 7.0 |

Examining the collection frequency on the basis of the aforestated results, taking into consideration the present and future generation densities, it is concluded that daily collection, which is being carried out currently, is appropriate for Gomrok, Middle, West and East Districts, while the twice a week collection frequency seems appropriate for the other Districts.

3) Storage

In connection with the waste discharge vessel, the present situation, that is, the discharge of loose garbage coexists with the one discharged in containers, will be abolished in favour of the plastic-bagged discharge scheme. However, for the people that can not afford to buy plastic bags, appropriate measures should be considered to allow for discharge when the collection vehicle comes by.

(1) Types of storage container

The following types are considered for storage container of solid waste.

a. Stationary storage bin
b. 200-liter drum
c. Container for mechanized collection
d. Metallic or plastic can with 70 to 100-liter capacity
e. Paper bag, plastic bag
f. None

The characteristics of these storage schemes are summarized in Tab. 3-2-7. Types "a" and "f" are not recommendable from the standpoint of collection work efficiency and sanitation, while type "b" is not recommendable in view of the workability and safety.

Tab. 3-2-7 CHARACTERISTICS OF THE STORAGE SCHEME

| | WORK EFFICIENCY | SANITATION | SAFETY | ECONOMY | SPACE REQUIREMENT | OUTER APPEARANCE | COMPATIBILITY WITH COLLECTION AND MANAGEMENT SYSTEM |
|---|---|---|---|---|---|---|---|
| Stationary bin | Low efficiency and the waste handling requires much time because the worker must take out the waste from the vessel. | It is difficult to keep the storage vessel clean. | There is no problem in particular with regard to safety. | --- | Road surface is permanently occupied. | Not desirable from the aesthetic standpoint. | --- |
| 200-liter drum | This system takes time to load the vehicle with the waste. | Very bad from the standpoint of health of the workers, because the drum becomes too heavy. | There is problem because the drum becomes too heavy. | --- | Road surface is permanently occupied. | Not desirable from the aesthetic standpoint. | --- |
| Container | High efficiency by means of mechanical loading device. | It is possible to keep the cleanliness through an appropriate management scheme. | There is no problem in particular from the safety standpoint. | The container installation cost is expensive. But it is economical in terms of manpower and vehicle requirement. | The container occupies only a small space. | Appropriate management is required in order to keep a satisfactory sight. | The container is used in combination with a special vehicle. |
| 70 to 100 liter metallic or plastic bin | Efficiency is relatively high, but the opening/closing of the lid takes some time. | This system has superior sanitary characteristics. | There is no problem in particular regarding work safety. | The residents must buy bins. | Relatively large space is required, because bins are placed on the street. | Regular collection is required to keep a satisfactory sight. | --- |
| Paper and plastic bag | Efficiency is improved. | This system has superior sanitary characteristics. | There is no problem in particular regarding work safety. | It is necessary to buy bags, but the collection efficiency is improved. | This system requires relatively small space. | Appropriate management is indispensable to maintain a satisfactory sight. | It is necessary to tear the bags in the compost plants and other facilities. |

| | WORK EFFICIENCY | SANITATION | SAFETY | ECONOMY | SPACE REQUIREMENT | OUTER APPEARANCE | COMPATIBILITY WITH COLLECTION AND MANAGEMENT SYSTEM |
|---|---|---|---|---|---|---|---|
| Unpacked discharge | Efficiency is very low. | Very bad from the sanitary standpoint. | Serious problems from the safety standpoint because workers are compelled to touch waste directly. | Not economical because the work efficiency becomes low. | This system requires considerable space on the road surface. | Very bad from the aesthetic standpoint. | |

It must be borne in mind however, that there is a strong opposition by the people against the idea of installing a container in front of the building where they are living, and as a consequence it is not possible to install one at places regarded as convenient for the sake of waste collection. In view of the above facts, the idea of introducing the container collection scheme through the whole city of Alexandria, based exclusively on its economical advantages, is not necessarily a realistic plan. Container collection is being carried out at the present time, but in reality there is no reason to maintain this container collection scheme, which incurs problems of some kind or other, if the plastic bag collection scheme is implemented in full scale.

As things now stand, in Alexandria there is no regulation in particular regarding storage container, with the exception of the $2m^3$ container being used, and in reality plastic bags are being used in some areas such as the East, Middle and Gomrok Districts. In this connection, in the East District there is a factory for production of plastic bags to pack waste, and furthermore another plastic bag factory is being constructed in Gomrok as well. Anyway, from the standpoints of hygiene, stability, work efficiency, and urban aesthetic, it is recommendable to abolish the discharge of waste without storage container, and to carry out the collection by using storage container of any kind. Example of storage containers to be taken into consideration in this connection are containers, small-sized metal or plastic bins, paper bags and plastic bags.

(2) Comparison of the container and plastic bag

The characteristics of the various systems are compared in Tab. 3-2-8. Only the container system and the plastic bag system are examined further, because both of metal and plastic containers can not be necessarily regarded as appropriate from the standpoint of the workability and user's convenience. Container collection is the most advantageous alternative from the standpoints of economy and efficiency. As for the collection by means of plastic bags, it incurs approximately the same cost as the

Tab. 3-2-8 CHARACTERISTICS OF THE COLLECTION BY MEANS OF THE CONTAINER SYSTEM, METALLIC OR PLASTIC CAN, PLASTIC BAG SYSTEM

| | CONTAINER | METALLIC/PLASTIC CAN | PLASTIC BAG |
|---|---|---|---|
| Conditions of the road | It is desirable to avoid this system in the areas with high generation density, where many containers must be permanently placed on the streets, and in narrow alleys where the containers obstruct the traffic of pedestrians and vehicles. | Take up considerable space in areas with high generation density.<br><br>It is desirable to avoid this system in narrow alleys, in the same way as the container system but the vessels are not permanently installed on the street. | The same considerations as those referring to the two previous systems are applicable to this one in districts with high waste generation density, but is more advantageous because nothing is left after the collection. |
| Cooperation of the residents | There is a strong resistance against the installation of the container in front of residences and buildings. | Large-sized vessels are expensive. | The handling is easy, and furthermore it is easy to obtain the cooperation of the residents regarding the location of the stations. |
| Quality of service | The service quality is better, because people can dump at any time, but the carrying distance becomes long depending on the container distribution. | Waste can not be discharged freely. | Waste can not be discharged freely, but on the other hand stations can be allocated at places with relatively short distance to carry out the waste. |
| Operation | Flexible management is easy, if the containers are designed with reserve storage capacity. | A regular collection service is required, because waste must be collected at fixed day and time. | A regular collection service is required, because waste must be collected at fixed day and time. |
| Economy | The daily collection scheme is more economical than other schemes, because its cost in the 300kg/ha generation density district is LE6.4/ton in the case of 6-ton vehicles (truxmor) and LE5.5/ton in the case of 3-ton vehicles. | The loading time is longer compared with the bagged scheme, but there is practically no difference regarding the cost. If the plastic vessel with 2-year service life is assumed to cost LE10, the additional cost becomes approximately LE7.8/ton. | The cost of daily collection in 300kg/ha generation density districts is LE9.6/ton for 3-ton compactor vehicles and LE5.8/ton for 2.5-ton dump trucks. If each household uses 20 plastic bags per month, the additional cost becomes approximately LE19/ton. |
| Workability | The handling is easy. | It is troublesome to take off and to put down the lid. Furthermore, the contained waste may spill out in some cases. | The handling is easy. The waste can be collected without noise. Furthermore, there is no risk of waste spilling out. |
| Sight and smell | The container gets dirty. This system is not appropriate from the aesthetic standpoint when the container becomes old. There is a problem of bad odor. The waste spills out of the container. The waste may be discharged around container when it becomes full. | The vessel gets soiled. Furthermore, this system is not appropriate from the aesthetic standpoint. | The outward appearance is good. The station is clean after the collection. |
| Sanitation | There is generation of flies and other problems. | The chance of the worker touching the waste can be reduced. | The number of flies can be reduced. The chances of the worker touching the waste can be reduced. |

container collection, if the plastic bag cost is not taken into consideration. And it is rather expensive if the plastic bag cost is borne by the residents, but on the other hand it is preferred by both residents and workers in view of the easy handling of the plastic bags in the households and its advantage to keep bad odor out. The results of the interview survey, carried out in connection with the discharge of waste (refer to Fig. 3-2-7), indicate the high popularity in the use of plastic bag, especially among middle and high income people. Therefore, the cost burden itself is not a sufficient reason to discard this alternative.

On the other hand, from the collection side it is undebatable that the container alternative is the most advantageous one from the standpoints of economy and workability, but it must be borne in mind that the largest obstacle against its satisfactory implementation is the difficulty to obtain the cooperation of the local people regarding the placement of containers and furthermore this alternative is not recommendable from the aesthetic standpoint.

In particular, the results of the interview survey carried out in connection with this matter (refer to Fig. 3-5-4) reflects the unsatisfaction of the absolute majority of the residents, expressed in terms of inconvenient location of the containers (too distant), insufficient disposition of collection, lack of punctual collection and scattering of waste around the container.

Fig. 3-2-7 STORAGE USED BY THE RESIDENTS

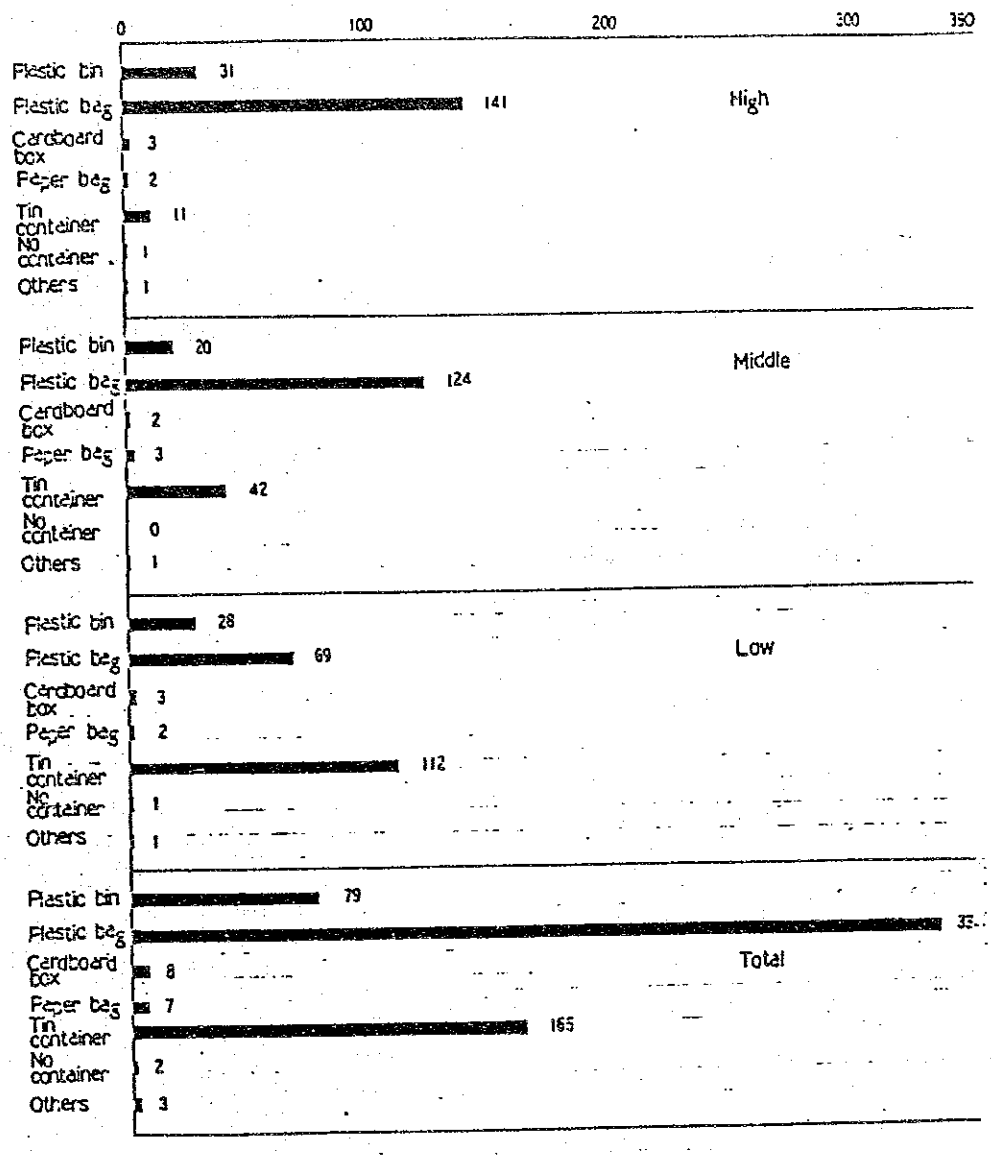
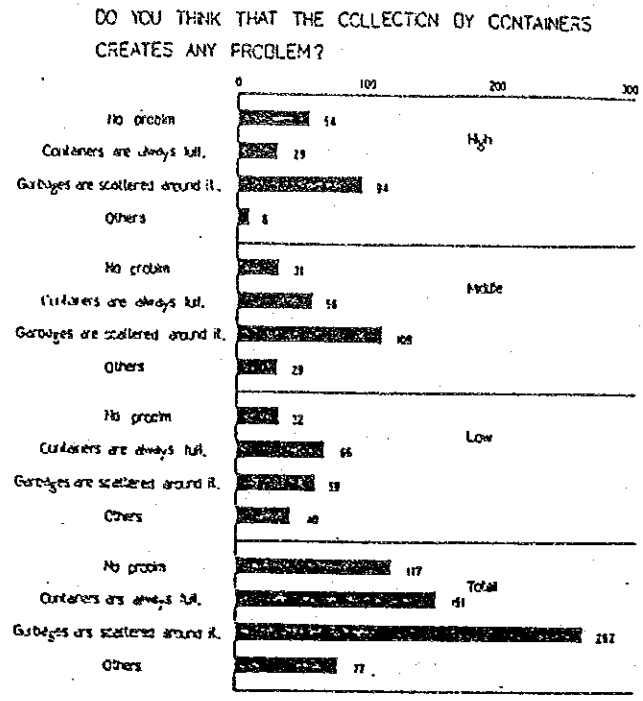
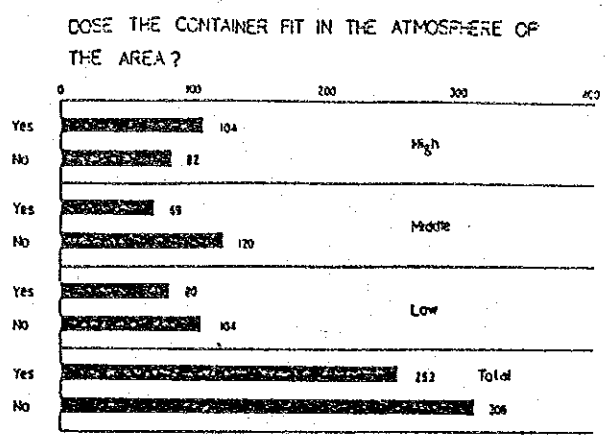


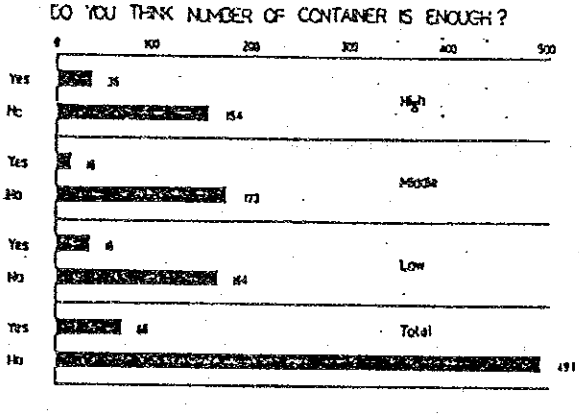

*Figure is no.of household

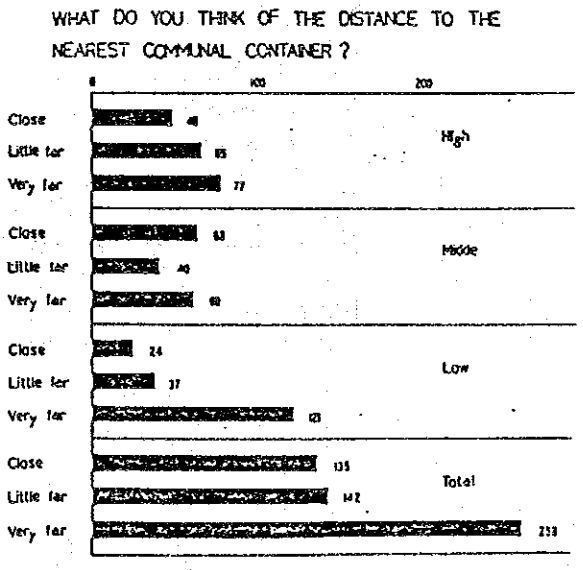
Note: The figure presents the results of the interview survey carried out by picking up 200 samples of high, middle and low income classes in each one of the 6 Districts.

Fig. 3-2-8 OPINION OF THE RESIDENTS REGARDING THE CONTAINER



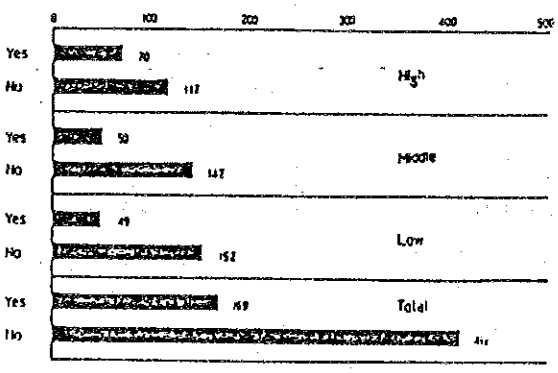




*Figure is no.of household

The other problem to be examined is the possibility of the plastic bag system being accepted by citizens of all areas. It may be safely said that the practicability of this alternative depends on the future upgrading of the income level of the citizens of Alexandria and the existence of the plastic bag supply capacity. In particular, as things now stand, the cost of LE 1.00 required to purchase 20 plastic bags is by no means negligible for the citizens, but it seems to be an appropriate goal to assume that plastic bags will be accepted by the year 2000 because further increases are expected in their incomes, the use of plastic bags is making a favourable impression on the people even at the present, and therefore a considerable popularization can be expected in the future.

4) Time of collection

In principle, the time of collection will be from 7:00AM to 2:00PM.

As things now stand, the Districts are carrying out the waste collection from 7:00AM to 2:00PM, and the ADS is carrying out its service from 3:00PM to 7:00PM, and there is virtually a 2-shift system in operation. The collection work extends over a long time, but the current scheme is not desirable because the waste is left on the streets for a long time. Furthermore, the collection vehicles are warned very rapidly in this scheme. Therefore, it is desirable to unify the collection work in one shift.

In general, the collection efficiency becomes lower when traffic congestion takes place during the time of collection. In Alexandria the traffic congestion in the central area occurs from 8:00AM to 3:00PM, and this congestion is expected to worsen further in the future. It must be borne in mind however, that Alexandria is a narrow and long city in its urbanized form, and therefore the traffic congestion becomes a serious obstacle when moving in the E-W direction, but on the other hand the congestion can be bypassed with ease when moving to the south. In this connection, all solid waste management facilities will be located on

the south side of the city. In view of the aforestated reasons, the traffic congestion is not taken into consideration in particular in connection with the determination of the collection time.

Therefore, in principle it seems appropriate to maintain unchanged in this project the collection time presently adopted in the various Districts.

5) Collection vehicles

Compactor trucks and open dump trucks will be used as collection vehicles. Open dump trucks will be used in areas where bag-packed discharge is possible and even in unpaved areas, while compactor trucks will be arranged in paved areas where discharge schemes other than bag-packing are permitted. The collection vehicle fleets will be equipped mainly with medium-sized trucks able to pass through streets with 4 to 5m width, in order to make it possible to improve collection service in narrow street areas.

(1) Types of collection vehicles

The collection vehicles used at the present time in Alexandria consist of container collection vehicles, compactor vehicles and open-type deep body dump trucks, and their types and quantities are shown in Tab. 3-2-8. Generally speaking, there are four basic types of collection vehicles.

- Compactor vehicles
- Container vehicles
- Dump trucks equipped with crane
- Open-type dump trucks

The container vehicles being used in Alexandria are large-sized side loading type ones with 6 ton loading capacity and handling $2m^3$ containers. These container vehicles are unable to access the alleys of the districts because their body is too large. The compactor vehicles have $9m^3$ volume or 4 ton carrying capacity, and are rear-loading type ones. The dump trucks have 2.5 ton and 1 ton capacity, both with deep body.

Tab. 3-2-9 NUMBER OF COLLECTION VEHICLES

| TYPE | TOTAL | IN USE | OUT OF ORDER |
|---|---|---|---|
| Container collection vehicle<br>Truxmore | 42 | 33 | 9 |
| Compactor vehicle<br>Fiat (84) Leach | 51 | 42 | 9 |
| Rotary compactor vehicle<br>Fiat Mince | 6 | 2 | 4 |
| Large open dump vehicle<br>Isuzu, Fuso, Mitsubishi, Nissan | 45 | 39 | 6 |
| Small open dump vehicle<br>Mazda, Daihatsu | 44 | 21 | 23 |
| Total | 188 | 137 | 51 |

If the implementation of the plastic bag collection is regarded as the ultimate goal for the year 2000, the container vehicle will not be the appropriate type to be used in the future. Therefore, compactor vehicles, dump trucks equipped with cranes and open dump trucks will be examined as types of collection vehicles. All of these types of vehicles are being used at present in Alexandria.

(2) Comparison of the compactor vehicle and open type dump truck

The characteristics of the compactor vehicle and open type dump truck are shown in Tab. 3-2-10. Both types of vehicles have merits and disadvantages, and the collection cost will be the basic factor to be taken into consideration when deciding the type to be adopted.

Such being the case, the collection cost is tentatively calculated by means of models. The collection cost is examined for various cases of loading volume, the $9m^3$ case for the compactor vehicle (4 ton carrying capacity), the 7 to $8m^3$ case (3 ton carrying capacity) for compactor vehicle with smaller size, and cases of 6 ton vehicle (2.5 ton carrying capacity) and 2 ton vehicle (1.1 ton carrying capacity) for open dump trucks.

Tab. 3-2-10 CHARACTERISTICS OF COMPACTOR VEHICLES AND OPEN-TYPE DUMP TRUCKS

Compactor vehicles

- Advantage:
  . There is no conflict between the loading and unloading functions.
  . The loading height is low, and this is a favourable characteristic from the standpoint of workability.
  . The work safety is high.
  . Can be identified as a waste collection vehicle at a glance.
  . The collection efficiency is high.

- Disadvantage:
  . Very expensive.
  . Troublesome in their maintenance.
  . Has access only to paved streets.
  . The rear tires of the vehicle are worn out very rapidly.

Open-type dump trucks

- Advantage:
  . The vehicle is relatively cheap.
  . The maintenance is easy.

- Disadvantage:
  . The loading height is high.
  . The loading work is very hard.
  . The collection efficiency is relatively low.

Conditions for tentative calculation of the collection costs in the case of using compactor vehicles and open-type dump trucks are shown in Tab. 3-2-11.

Tab. 3-2-11 CONDITIONS OF THE COMPACTOR VEHICLE AND DUMP TRUCK

| | COMPACTOR VEHICLE | | OPEN-TYPE DUMP TRUCK | |
|---|---|---|---|---|
| Loading weight (ton) | 4 | 3 | 2.5 | 1.1 |
| Loading time (min./100 kg)* | 1 | 1.5 | 2* | 2* |
| Workers per vehicle (person) | 3 | 3 | 3 | 2 |

Note * Assuming efficient collection of bag-packed garbage

The results of the preliminary calculation are shown in Tab. 3-2-12. In districts where the generation density is 300kg/ha or more, the open-type dump truck (2.5 ton vehicle) is the cheapest, followed by the small-sized open-type dump truck (1.1), while the compactor vehicle results are considerably more expensive than the open-type dump truck.

From the standpoint of collection efficiency, the compactor vehicle is obviously more advantageous, but the compactor vehicle costs 2 to 3 times the open-type dump truck. The open-type dump truck results are more economical in spite of the larger crew per vehicle because the personnel expenditure of the required manpower is relatively cheap.

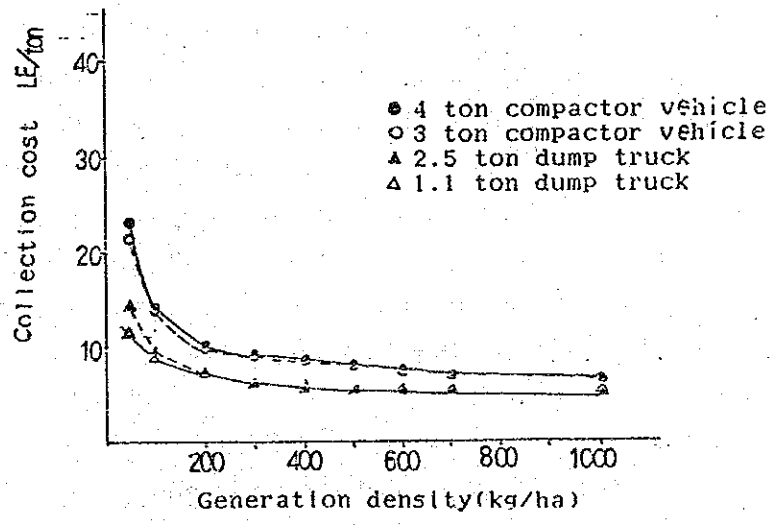



Fig. 3-2-9 COLLECTION COST COMPARISON OF THE COMPACTOR VEHICLE AND OPEN-TYPE DUMP TRUCK

Tab. 3-2-12 COMPARISON IN THE CASE OF 300KG/ha GENERATION DENSITY
- EFFECT OF WAGE LEVEL -

(Daily generation amount = 100 ton/day,
Station placement density = 3/ha, daily collection)

| VEHICLE TYPE | COMPACTOR VEHICLE | | OPEN-TYPE DUMP TRUCK |
|---|---|---|---|
| Carrying capacity (ton) | 4 | 3 | 2.5 |
| No. of vehicles | 16.7 | 19.8 | 21.2 |
| Manpower (persons) | 74.9 | 89.0 | 94.9 |
| Collection amount efficiency (ton/person) | 1.33 | 1.12 | 1.05 |
| Cost (LE/ton) | 8.7 | 8.6 | 6.4 |
| Cost (1) (LE/ton) | 11.0 | 11.8 | 9.8 |
| Cost (2) (LE/ton) | 13.3 | 15.0 | 13.2 |

Note:

Cost (1): When the personnel expenditure is doubled.

Cost (2): When the personnel expenditure is tripled.

As can be seen, the compactor vehicle (4-ton) becomes advantageous from the cost standpoint as well, even when the personnel expenditure becomes approximately 3 times as much as the current one. From the aforestated considerations, it is concluded that the open-type dump truck is the most appropirate type of vehicle except for the collection cost, but it must be borne in mind that this evaluation can be reversed depending on the extent of rise of the wage level of the workers by the year 2000. As for the collection vehicles, they are renewed at intervals of about 5 to 7 years, and therefore they can be choosen appropriately in accordance with the conditions prevailing at the time of the renewal. Such being the case, in this study the problem is examined in conformity with the line of reasoning described in the later case, and the composition of the collection vehicle fleet is discussed by taking into consideration the possibility of introducing the compactor vehicles, that are presumed to become advantageous if the wage level should rise by a substantial extent in the future, in addition to the open-type dump trucks. The differential cost between compactor vehicle and open-type dump truck is LE 2 per ton of collected waste, and it can be regarded as differential cost required to improve the degree of sophistication of the collection equipments.

(3) Specifications of the vehicles

The specifications of the compactor vehicles with 4-ton and 3-ton carrying capacities, and open-type dump trucks with 2.5-ton and 1.1-ton carring capacities, are shown in Tab. 3-2-13.

Tab. 3-2-13 SPECIFICATIONS OF THE COLLECTION VEHICLES

| | COMPACTOR VEHICLE | | OPEN-TYPE DUMP TRUCK | |
|---|---|---|---|---|
| CARRING CAPACITY (ton) | 4 | 3 | 2.5 | 1.1 |
| Overall length (m) A | 8.50 | 6.56 | 5.78 | 4.36 |
| Overall width (m) B | 2.50 | 2.20 | 2.13 | 1.70 |
| Wheelbase (m) C | 5.15 | 3.80 | 3.20 | 2.50 |
| Tread (m) D | 2.00 | 1.70 | 1.90 | 1.50 |
| Overhang (m) E | 1.82 | 1.86 | 1.20 | 1.20 |
| Minimum road width (m) F | 5.40 | 4.40 | 4.00 | 3.10 |

Minimum required width is calculated in the following formula for a 12m turning radius.

$$F = \frac{(A - E)^2}{2 \times \text{turning radius}} + B + (0.5 \times 2)$$

It is concluded, by taking into consideration street conditions, location of the stations, discharging manners etc., that the recomendable vehicles are compactor vehicles with 3-ton carrying capacity and open-type dump trucks with 2.5-ton and 1.1-ton carrying capacity. In reality, the collection vehicle fleets with combination of compactor vehicles with 4-ton carrying capacity and other vehicles of smaller size, can be utilized flexibily depending on the various conditions of the area. In principle however, this study is carried out by assuming the use of 3-ton compactor vehicles and 2.5-ton open-type dump trucks, and the Districts where the conclusions regarding the most appropriate types of vehicles are obvious, in view of the conditions prevailing therein, are examined separately.

6) Crew

It is assumed that in principle, the crew of each collection vehicle consists of one driver and three workers.

In general, it is desirable that the volume of waste collected by each worker increase as the personnel expenditure of the workers rises. When the personnel expenditure is not so high, the work efficiency can be improved by assigning more workers to shorten the loading time. This is particularly true in the case of open stations where waste is discharged in unpacked condition. In the case of Alexandria however, it is not desirable to assign so much workers by taking into consideration the future popularization of bag-packed discharge and the rise of personnel expenditure. Therefore, the maintaining of the present worker number per vehicle is preferable.

7) Separate collection

The separate collection system is desirable from the standpoint of recovery of reusable materials, but this is an issue to be considered after the improvement plan of the collection system is realized.

The recovery of reusable materials is required due to the difficulty to secure final disposal sites, and the necessity of saving natural resources.

Currently bottles are recovered by means of the deposit system, and newspaper is recovered by firms specialized in this matter. Furthermore, materials such as paper, bottles, metals, etc., are recovered by scavengers at stations and dump sites. It is presumed that bottles and newspaper will continue to be separated at the source also in the future and collected for recovery by firms specialized in the matter. When considering the recovery of reusable materials through the production of compost, it is more desirable to separate the waste suited for composting.

The influence of the separation of waste suited for composting on such aspects as number of collection vehicles, manpower and cost, is examined in the following. The preconditions upon which the study is carried out, the form of waste collection, and other relevant factors are shown below.

a. The daily collection amount is assumed to be 100 ton/day.

b. Waste suited for composting
   Garbage and paper are regarded as appropriate for composting, and all other types of waste are regarded as unsuitable for that purpose.

c. Amount of waste
   (1) Amount of appropriate waste (70 ton/day, density 0.29 ton/$m^3$).
   (2) Amount of unsuitable waste (30 ton/day, density 0.15 ton/$m^3$).

d. Form of collection
   It is assumed that waste will be collected packed in plastic bags.
   Planned collection amount: 100 ton/day
   (1) Appropriate waste 70 ton/day
   (2) Unsuitable waste 30 ton/day

The results of preliminary calculations regarding number of vehicles, manpower, cost, etc., are shown in Tab. 3-2-14. Compared with the combined collection, the separate collection scheme results are approximately 30% more expensive in terms of number of vehicles, approximately 20% in terms of manpower, and approximately 20% in terms of collection cost per ton.

As can be seen, the shift to separate collection incurs additional cost, but its future introduction can be aimed at when the advantages regarding solid waste management and recovery of reusable materials are sufficiently great even after taking into consideration the additional cost.

For the successful separate collection, it is indispensable to have the strict cooperation of the people to the end that the waste will be discharged exclusively on the specified discharge day because the collection is carried out only on those days, and furthermore from the operational standpoint it is indispensable to carry out a reliable collection on the fixed day and at the fixed time.

For the time being, the satisfactory implementation of the separate collection is presumed to be extremely difficult, in view of the current conditions regarding the operation of the collection service and level of cooperation of the people regarding waste discharge. It will not be too late to shift to the separate collection after attaining sufficient maturation of the objective conditions making it practicable.

Such being the case, the separate collection as a future goal is not denied at all, but for the time being it is not included in the project, and the consolidation of a regular discharge and collection of waste is regarded as primary objectives of the project instead.

Tab. 3-2-14 COMBINED COLLECTION AND SEPARATE COLLECTION

(Daily generation amount = 100 ton/day,
generation density = 500 kg/ha)

| | COMBINED COLLECTION | | SEPARATE COLLECTION | |
|---|---|---|---|---|
| | Daily | Twice a week | Appropriate waste: daily Unsuitable waste: Twice/week | Appropriate waste: Twice/week Unsuitable waste: Once/week |
| No. of vehicles | 12.6 | 13.6 | 16.2 | 16.4 |
| Manpower (persons) | 56.6 | 53.5 | 69.0 | 64.4 |
| Collection cost (LE/ton) | 5.7 | 5.9 | 7.0 | 6.9 |

Note: In this table "appropriate" means appropriate for composting and "unsuitable" means unsuitable for that purpose.

8) Transfer station

The construction of the transfer station is hardly of any advantage when the final disposal site is located at a distance of the order of 20km from the center area of Alexandria. Therefore, its construction is not recommendable. However if the final disposal site is located at a greater distance (e.g. in the desert, at a distance of 70km from the center area), the transfer station is of considerable advantage, and its construction becomes desirable.

When the distance from the collection zone to the disposal site becomes greater, its hauling cost increases due to the necessity of larger numbers of vehicles and cleansing workers. However these cost increases can be alleviated by installing transfer stations.

The transfer station is the facility which has the function of reloading waste collected by small size collection vehicles to large size transportation ones. Barge, railway, large truck, trailer, etc., are the principal equipments of transportation used for this purpose. Use of truck is examined in connection with our study, because final disposal sites to be constructed will be located in inland areas having no access for barges, and are furthermore difficult to link with the available railway network.

The construction of the transfer station makes it possible to restrain growth in number of vehicles and workers, but on the other hand it requires investment for its construction. In general, the idea of its construction is regarded as appropriate when the advantages related to savings in manpower and vehicles surpass the cost required for constructing and maintaining transfer stations.

(1) Transfer system

The truck transfer system is well developed all around the world, and is seen very frequently also in Japan. Typical configurations of the truck transfer system are shown in Tab. 3-2-15 and Fig. 3-2-10. Of these configurations, the plane system is a very simple case, and is used when the volume of waste to be handled is not very large. On the other hand, the pit-and-crane system, the container reloading system, the shredding system, etc., are regarded as special cases within the transfer facilities. The remaining two systems, the plane system with hopper and the compactor system, are more commonly used.

The characteristics of the two systems are shown in Tab. 3-2-16, and as can be seen, each one has advantages and disadvantages. In particular, the plane system has rather low efficiency but investment amount for its construction is small. On the other hand the compactor system provides efficient reloading but the construction of the required facilities is very expensive.

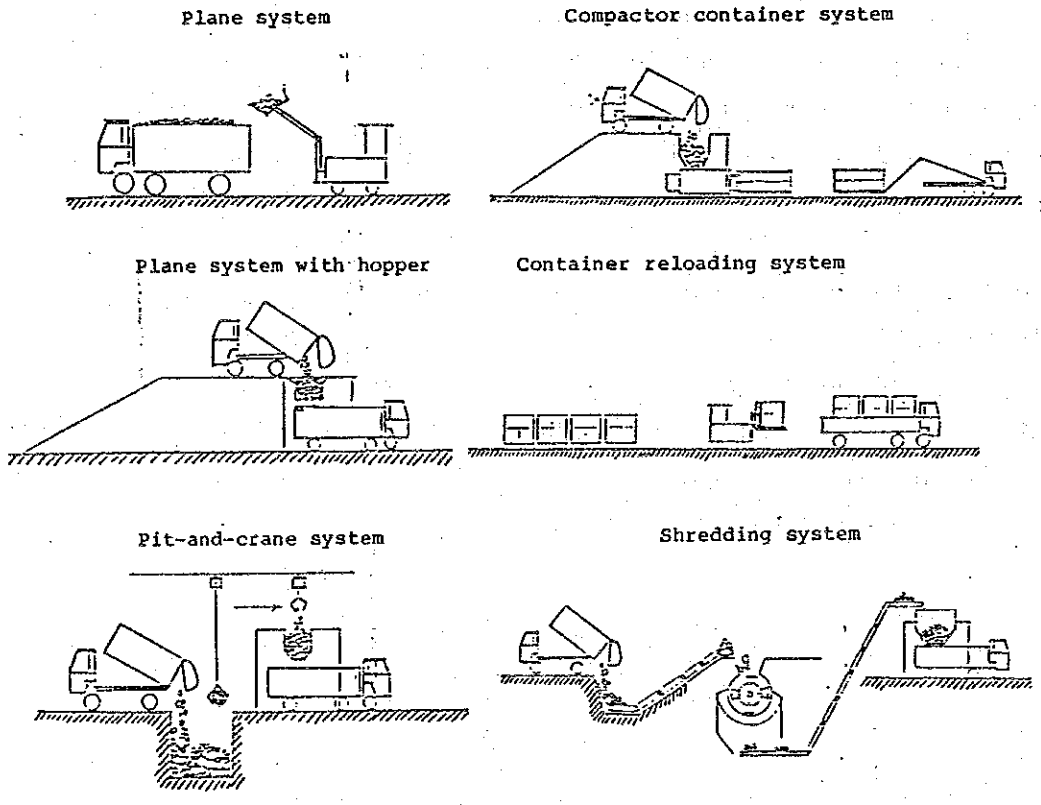



Fig. 3-2-10 TRANSFER STATION SYSTEMS

Tab. 3-2-15 OUTLINE OF THE TRANSFER SYSTEMS

| SYSTEM | OUTLINE |
|---|---|
| Plane system | The waste collected by the collector vehicle is dumped on a plane concrete-paved yard, and then it is loaded in the haulage vehicle by means of bucket loaders or cranes equipped with bucket. |
| Plane system with hopper | The collector vehicle is driven up the platform and dumps the waste in the hopper, then waste is transshipped to the haulage vehicle waiting under the hopper. |
| Pit-and-crane system | The collected waste is dumped in the storage pit. Then, the waste is dropped in the hopper and reloaded from the hopper to the haulage vehicle waiting under it. |
| Container transshipment system | This system is used when container collection vehicles are used. The container vehicle leaves the container in the transfer station, and then the container is loaded in the container haulage vehicle by means of the fork lift. |
| Compactor container | The collector vehicle is driven up and dumps the waste in the hopper. The compacting machine installed under the hopper packs the waste into the container. The packed container is hauled by means of the haulage vehicle equipped with container loading/unloading device. |
| Shredding system | This is a transfer system equipped with a shredding plant for large size of incombustible waste. It is possible to reduce the volume by shredding and to recover reusable materials. |

Tab. 3-2-16 CHARACTERISTICS OF PLANE SYSTEM AND COMPACTOR CONTAINER SYSTEM

| EVALUATION FACTORS | PLANE SYSTEM | COMPACTOR CONTAINER SYSTEM |
|---|---|---|
| Operational reliability and other factors of the system | | |
| Reliability | The system reliability is high, because it has an extremely simple configuration. | This system is rather complicated. There is a risk of clogging when the waste is being sent to the compactor, but reliability is high, because the equipment itself is simple. |
| Efficiency | This system lags behind the compactor one, because it consists of a mere reloading. | If the compaction effect and the capacity of the container are adequate, the haulage efficiency becomes high. |
| Handling capacity | It takes 7 to 8 minutes to load each haulage vehicle. Handling capacity is 40 ton/hr (one loading line) of waste at most. | It takes 10 to 15 minutes to pack into one container. This system has capacity to handle 30 to 50 ton/hr of waste in each loading line. |
| Operation and maintenance | Loading equipment only. | Particular care is required in connection with the loading control (monitoring of large-sized wastes and long objects that could get caught in the hopper) and other relevant details. |
| Flexibility | | |
| Operation time | This system has low flexibility because the operation is restricted by haulage time to the disposal site. | This system can be considerably flexibility. |
| Hourly fluctuation of waste volume to be received | Easy to handle if the transfer station has sufficient storage area. | The handling capacity will be designed in such a way to make it possible to cope with hourly fluctuations. In some cases this system is not appropriate because the feeding to the compactor must be carried out evenly. |
| Flexibility in terms of waste volume to be stored. | If the site is very large, it is possible to store considerable volumes of waste. But normally it is necessary to forward the received waste within the same day in view of environmental problems. Therefore, this system is not relevant in terms of storing waste. | The waste can be stored packed in the container, and therefore the haulage of the waste received in one day can be postponed to the next day. |

| EVALUATION FACTORS | PLANE SYSTEM | COMPACTOR CONTAINER SYSTEM |
|---|---|---|
| Compatibility with the collection system | There is no problem in particular regarding compatibility. | Same as plane one. |
| Compatibility with long-range planning | This system has good compatibility with long-range planning, because its facilities can be abolished and removed with ease. | This system should be constructed on the basis of a long-range prospect taking into consideration the compatibility with enlargement and improvement plans, because the construction of the relevant facilities requires investment of considerable sums. |
| Economy | | |
| Construction cost | Small. | The plant and equipment cost, consisting of such items as compaction equipment, container handling equipment, environment protection facilities, central control panel, etc., is large. |
| Maintenance and repair cost | The maintenance and repair cost of this system is very small. | This system incurs considerable power rates, because the electric power requirements of the compaction equipment is large. Furthermore, considerable sums are required for maintenance and inspection of the equipments. |
| Manpower (personnel expenditure) | Manpower is required for guidance of the vehicles within the transfer station and other relevant purposes. The required manpower slightly increases proportionally to the waste volume. | This system requires the least manpower compared with the plane system, because most of the work in the transfer station is automated. Furthermore, the increase in the waste volume does not exert so much influence on the required manpower. |
| Total cost | Medium | Large |
| Safety | It is necessary to be careful of accidents due to the contact between the collector vehicle, haulage vehicle, bucket loader, etc., and the workers. | It is necessary to take particular care when loading dangerous materials. |

| EVALUATION FACTORS | PLANE SYSTEM | COMPACTOR CONTAINER SYSTEM |
|---|---|---|
| Maintenance and management<br>Ease of maintenance | Very easy. | This system falls behind the other one, but its maintenance is easy because of relatively simple equipment. It must be borne in mind, however, that this system requires assignment of technically qualified personnel. |
| Durability | High | Medium |
| Ease of management | High (This system can be operated without installing any control equipment in particular). | Monitoring by means of the central control panel, an operation system is required. |
| Space requirement<br>Area of the required site | The transfer station itself does not require so much space, but sufficient leeway is required in connection with the environmental consideration. | A relatively large area is required in view of such factors as traffic line of the equipment within the shed, place for installation of anti-pollution facilities, sound proofing measures, etc. |
| Space for installation of the equipment | Practically no space is required in this connection. | Large space is required to accommodate the equipments. |
| Environment preservation<br>Hygiene | There is possibility of contact between workers and waste. Scattering of waste may happen. | This system is hygienic because the waste is promptly packed in the containers. |
| Noise | Noise caused by bucket loaders, etc., is relatively small. | It is necessary to consider appropriate sound proofing measures for the blowers and compressors. |
| Odor | It is necessary to transfer the waste as soon as possible. | Obnoxious odor is not a very serious problem in this system, but in some cases it is necessary to spray chemicals and to consider measures for deodorization of the exhaust air of the blower. |
| Atmosphere | It is necessary to consider the exhaust gas discharged by reducing the number of haulage vehicles. | Same as left. |

The results of the cost comparison of these two alternatives if constructed in Moharam Bey, are shown in Tab. 3-2-17. It is obvious that the compactor system is more expensive than the plain one for the reason of equipment cost of the compactor system. And the effect of the compaction is relatively small, because the waste undergoes considerable compaction by the compactor collection vehicles.

Tab. 3-2-17 COST COMPARISON BETWEEN PLANE SYSTEM AND COMPACTOR CONTAINER SYSTEM

| | PLANE SYSTEM | | COMPACTOR CONTAINER SYSTEM | |
|---|---|---|---|---|
| Final disposal Site | Green belt disposal site (20 Km) | Desert disposal site (70 Km) | Green belt disposal site (20 Km) | Desert disposal site (70 Km) |
| Transference & haulage amount (t/day) | 900 | 900 | 900 | 900 |
| Haulage distance (km) | 10 | 82 | 10 | 82 |
| Transfer station cost (LE/t) | 0.6 | 0.6 | 1.4 | 1.4 |
| Haulage cost (LE/t) | 1.3 | 5.4 | 1.3 | 9.3 |
| Total cost (LE/t) | 1.9 | 10.0 | 2.7 | 10.7 |

The preconditions of the preliminary calculation are shown in the following;

a. Assuming that the waste is collected from the Middle, Gomrok and West Districts and transferred to the Green belt disposal site or to the Desert disposal site.

b. The facilities to be provided are as shown in Tab. 3-2-18.

Tab. 3-2-18 FACILITIES TO BE PROVIDED IN EACH TRANSFER SYSTEM

| ITEM | PLANE SYSTEM | COMPACTOR SYSTEM |
|---|---|---|
| Waste acceptance facilities | Charging hopper (1 unit) | Charging hopper (2 units) |
| Reloading facilities<br>a. Compactor | Not provided | Hydraulic compactor Reloading capacity: 60t/h x 4 units |
| b. Container facilities | | Container handling facilities |
| c. Reloading equipment | Shovel loader (2 units) | Not required |
| Weighing facilities | Truck scale | Truck scale |
| Haulage equipment | Open-type dump truck (6 ton capacity) | Special vehicle for container haulage (10t capacity) |
| Building structure | Reinforced concrete, 2 story | Reinforced concrete, 2 story |
| Building area | 6,750 $m^2$ | 6,750 $m^2$ |

c. It is assumed that the transfer station will be constructed in Moharam Bey.

Middle District
Gomrok District — Transfer Station
West District

Green Belt Disposal Site
Desert Disposal Site

d. Manpower

o Plane system

- Technical personnel: 2 men
- Worker: 30 men

o Compactor system (An electrical engineer is required in this system)

- Technical personnel: 4 men
- Worker: 15 men

e. Wage

- Technical personnel: LE150/month
- Driver: LE200/month
- Worker: LE100/month

f. Working hours and number of days: 7 hours, 365 days

g. Depreciation period

- Buildings and structures: 25 years
- Plant and equipment: 15 years
- Machines: 5 years

h. Maintenance cost (% borne to yearly depreciation cost)

- Buildings and structures: 15%
- Utilities: 15%
- Machines: 15%
- Vehicles: 15%

i. Haulage vehicle speed

- Long distance: 50km/h
- Short distance: 30km/h
- Haulage trip time: $\frac{\text{Haulage distance x 1.2}}{\text{Haulage speed}}$

1.2 = Safety factor

j. Vehicle cost

- Open-type dump truck (6t): LE 42,000
- Special vehicle for container (8t): LE 97,500
- Bucket loader: LE 42,000

k. Fuel

- Fuel consumption: 3.0km/liter
- Diesel oil cost: LE 0.15/liter

(2) Study of the necessity of transfer station

Results of studies in this connection indicate that transfer stations bring about considerable advantages when the disposal site is located in the desert area at approximately 70km from the city center. Therefore, it is realistic to take measures to promote its construction. On the other hand, when the disposal site is at a distance of approximately 20km from the city center, the economic effects brought about by its construction are negligible.

In this connection, the cheapest total cost is realized in the following cases of waste haulage via transfer station, when the disposal site is located at a distance of 70km.

| | |
|---|---|
| Ameriyah District | Ameriyah Transfer Station |
| East District | Airport Transfer Station |
| Middle District | |
| Gomrok District | Moharam Bey Transfer Station |
| West District | |
| Montazah District | Montazah Transfer Station |

a. Location of transfer station

The following points will be taken into consideration for selecting the most appropriate location.

i. Site acquisition conditions: The sites will be available. The sufficient area to accommodate the facilities of the transfer station will also be available.

ii. Collection and transportation efficiency: The station will be located as close as possible to the collection area.

iii. Waste reception and delivery conditions: The station will be located near by an arterial road, and free from the influence of traffic congestion.

v. Surrounding environment: The station will not be located nearby schools, hospitals, and residences.

In accordance with the above conditions, the following locations, shown in Fig. 3-2-11, are selected for the candidate sites. The Gate No. 8 in Ameriyah district was eliminated from the candidate sites. This is because in view of traffic conditions it is not realistic to transport the waste from the eastern Districts to the Gate No.8 site, and it seems more rational to locate the transfer station at a place closer to the center of the Ameriyah District when handling waste generated in its area.

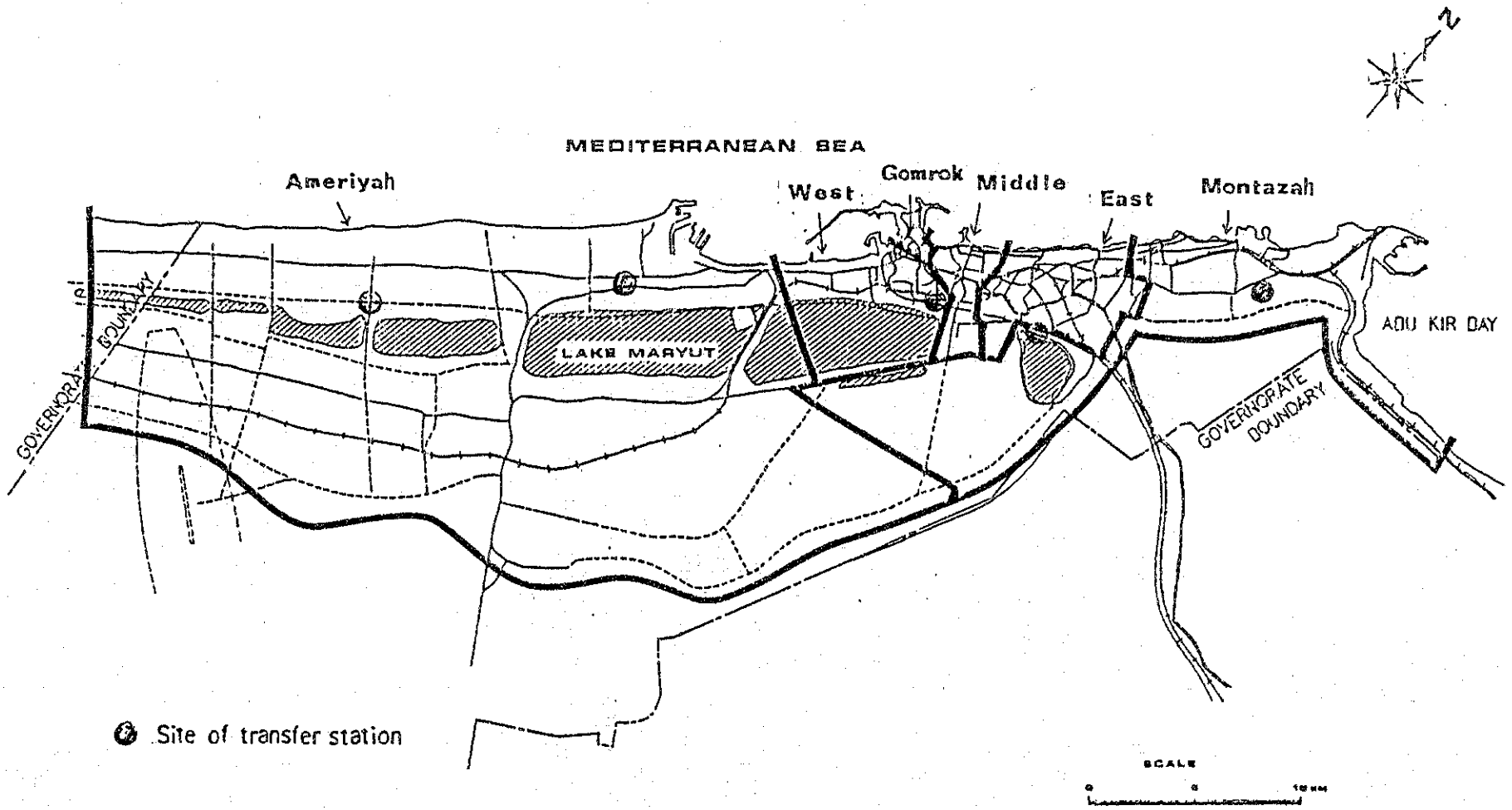



Fig. 3-2-11 PROPOSED SITES FOR CONSTRUCTION OF THE TRANSFER STATIONS (Places bearing the "o" mark).

The characteristics of the proposed sites are summarized in Tab. 3-2-19.

Tab. 3-2-19 CHARACTERISTICS OF THE PROPOSED SITES FOR CONSTRUCTION OF TRANSFER STATIONS

| | |
|---|---|
| No. 1 Ameriyah District --------- | This is an area with considerable development potentiality, and it is presumably possible to secure the construction site if planned in a proper way. |
| No. 2 Moharam Bey ---------- | This is a former waste dump site, and it has no problem at all in connection with available lot size, surroundings and access roads. |
| No. 3 Airport ---------- | The existing disposal site is taken into consideration here, and there is no problem at all regarding available lot size, surroundings and access road. |
| No.4 Montazah ---------- | This is an area with considerable development potentiality, and it is presumably possible to secure the construction of the transfer station if planned in a proper way. |

The 5 cases shown in Tab. 3-2-20 are taken into consideration in connection with the transportation of waste from the Districts to the transfer stations.

Case IV is considered in the case of transporting the entire waste to the transfer station of the Ameriyah, and the disposal site is located at a distance of 70km in the desert. When transporting wastes from eastern districts, it is necessary to travel in the East-West direction through the traffic bottleneck areas located in the West District. It is not practical to plan for the entire amount of waste generated from eastern areas to pass through the traffic bottle neck. Therefore it is concluded that this case is not appropriate.

In Case V, which consists of the plan of transferring the entire waste, the traffic problems are solved, but, on the other hand, the waste generated in the Ameriyah district must be transported to the opposite direction to the disposal site located in the district itself or in the desert area. Therefore, this is not a realistic case, either. Such being the case, these 2 cases of concentrating the transfer station at one place will be eliminated. The layout of the Cases I, II and III are shown in Figs. 3-2-12, 3-2-13 and 3-2-14.

Tab. 3-2-20 DISTRICT FROM WHICH WASTE IS HAULED TO THE TRANSFER STATIONS (Year 2000)

| CASE<br>LOCATION OF TRANS. STATION | I | II | III | IV | V |
|---|---|---|---|---|---|
| No. 1 Ameriyah station | Ameriyah | Ameriyah | Ameriyah | All districts | --- |
| No. 2 Abis station | West,Gomrok, Middle | --- | West,Gomrok, Middle,East | --- | All districts |
| No. 3 Airport station | East | West,Gomrok, Middle Montazah | --- | --- | --- |
| No. 4 Montazah station | Montazah | --- | Montazah | --- | --- |

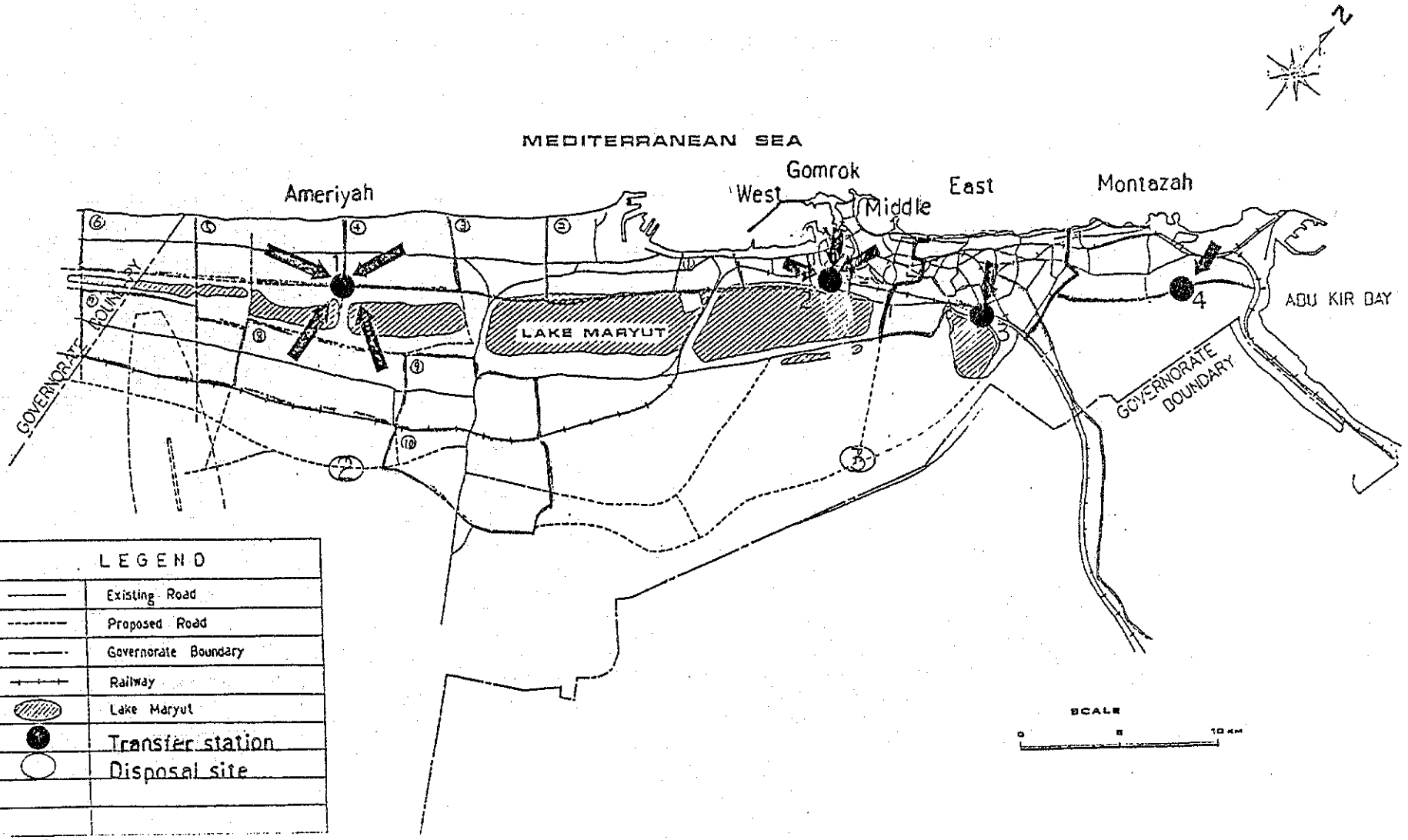



Fig. 3-2-12 WASTE TRANSPORTATION VIA TRANSFER STATION - CASE I

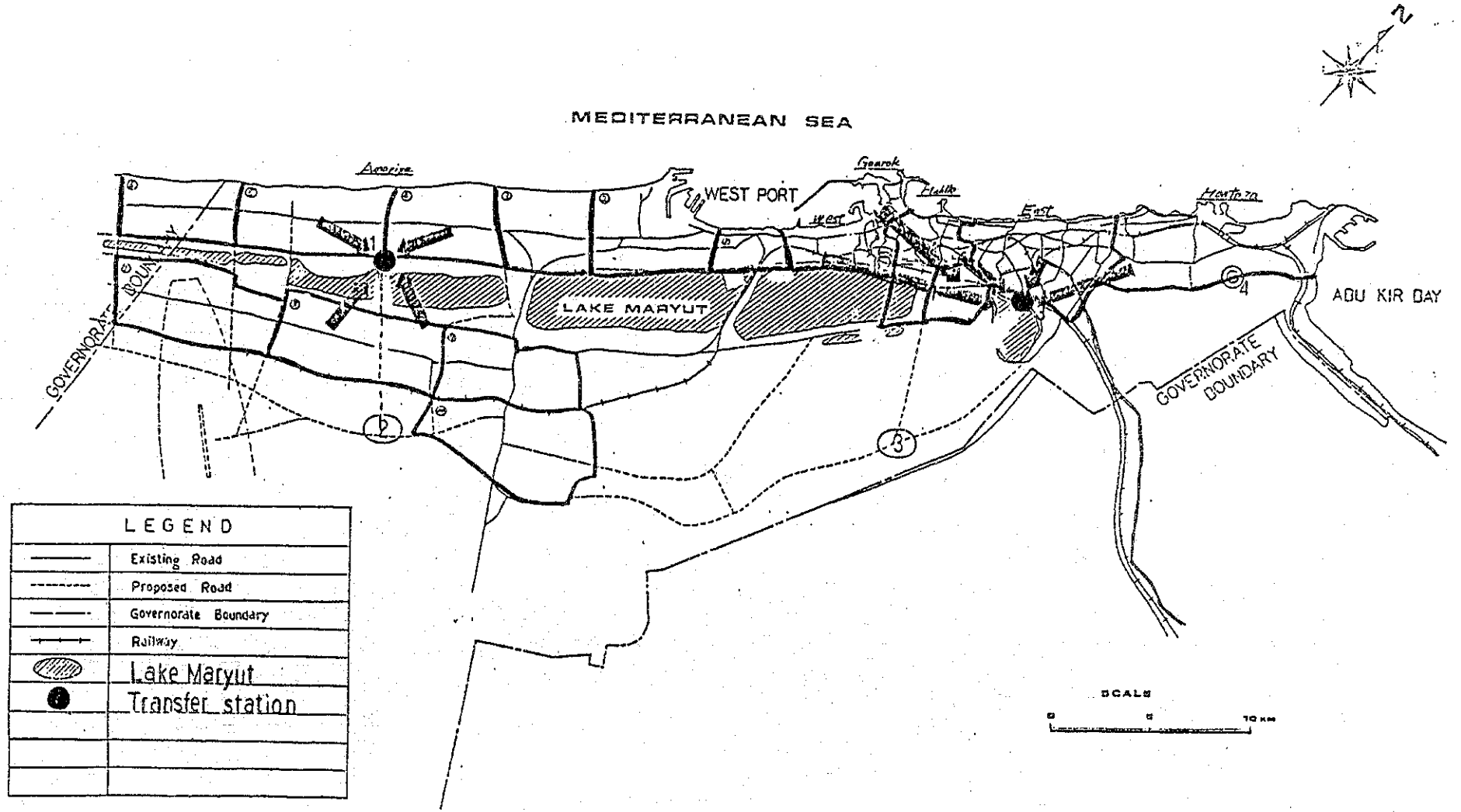



Fig. 3-2-13 WASTE TRANSPORTATION VIA TRANSFER STATION - CASE II

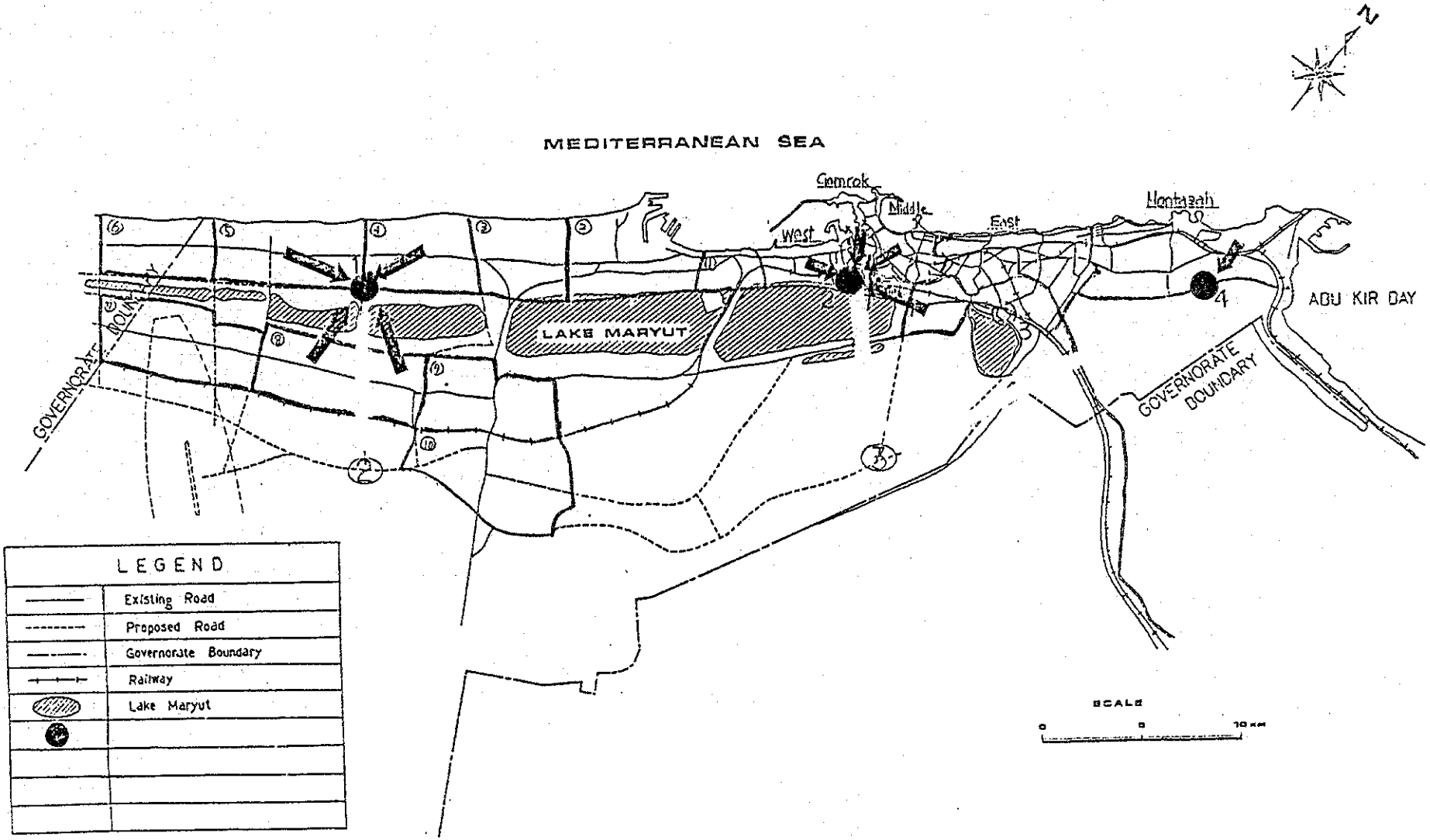



Fig. 3-2-14 WASTE TRANSPORTATION VIA TRANSFER STATION - CASE III

b. Study of the economical advantages

The results of the study referring to the various cases of waste transfer station stated above are shown in Tab. 3-2-21. The preconditions for these preliminary calculations are the same as those mentioned before. The results of the collection cost calculations obtained in the previous paragraph are used. It is assumed that the wastes will be transported through the trunk road located outside the old city. The distances from the transfer stations to the final disposal sites are shown in Tab. 3-2-22.

Tab. 3-2-21 COST CALCULATION RESULT OF DIRECT AND TRANSFER HAULAGE

(LE/t)

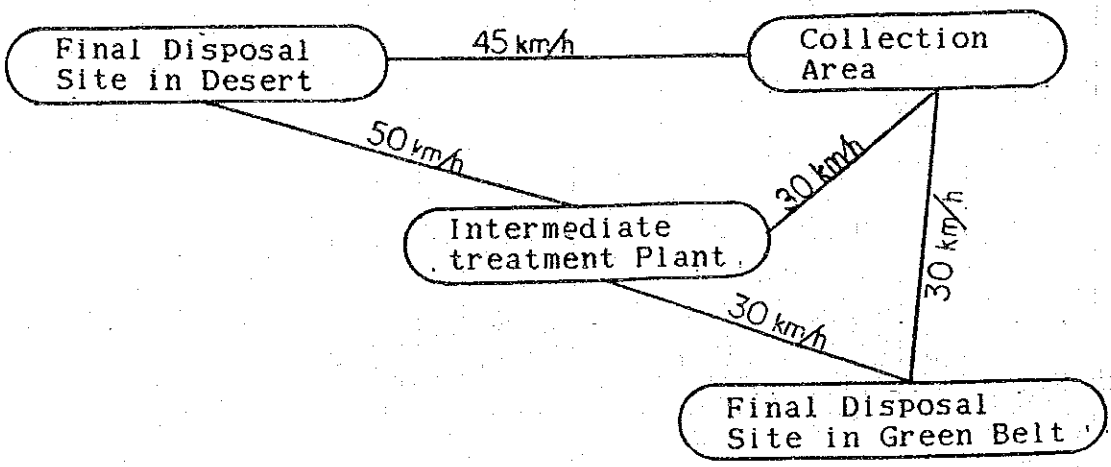
| | | ALTERNATIVE 1 | | | | ALTERNATIVE 2 | | | | ALTERNATIVE 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | GREEN BELT DISPOSAL SITE | | DESERT DISPOSAL SITE | | GREEN BELT DISPOSAL SITE | | DESERT DISPOSAL SITE | | GREEN BELT DISPOSAL SITE | | DESERT DISPOSAL SITE | |
| | | DIRECT | TRANS. | DIRECT | TRANS. | DIRECT | TRANS. | DIRECT | TRANS. | DIRECT | TRANS. | DIRECT | TRANS. |
| Ameriyah | Collection cost | 13.9 | 12.6 | 23.6 | 12.6 | 13.9 | 12.6 | 23.6 | 12.6 | 13.9 | 12.6 | 23.6 | 12.6 |
| | Trans. cost | - | 0.8 | - | 0.8 | - | -0.8 | - | 0.8 | - | 0.8 | | 0.8 |
| | Haulage cost | - | 1.3 | - | 3.6 | - | 1.3 | - | 3.6 | - | 1.3 | - | 3.6 |
| | Total | 13.9 | 14.7 | 23.6 | 17.0 | 13.9 | 14.7 | 23.6 | 17.0 | 13.9 | 14.7 | 23.6 | 17.0 |
| Moharam Bey | Collection cost | 7.9 | 6.9 | 21.0 | 6.9 | - | - | - | - | 8.4 | 6.7 | 21.6 | 6.7 |
| | Trans. cost | - | 0.6 | - | - | - | - | - | - | - | 0.5 | - | 0.5 |
| | Haulage cost | - | 1.3 | - | 5.4 | - | - | - | - | - | 1.3 | - | 5.4 |
| | Total | 7.9 | 8.8 | 21.0 | 12.9 | - | - | - | - | 8.4 | 8.4 | 21.6 | 12.6 |
| Airport | Collection cost | 9.4 | 6.1 | 22.9 | 6.1 | 9.4 | 7.1 | 23.2 | 7.1 | - | - | - | - |
| | Trans. cost | - | 0.8 | - | 0.8 | - | 0.5 | - | 0.5 | - | - | - | - |
| | Haulage cost | - | 2.2 | - | 6.0 | - | 1.9 | - | 5.9 | - | - | - | - |
| | Total | 9.4 | 9.1 | 22.9 | 12.9 | 9.4 | 9.5 | 23.2 | 13.5 | - | - | - | - |
| Montazah | Collection cost | 13.6 | 8.7 | 29.7 | 8.7 | - | - | - | - | 13.6 | 8.7 | 29.7 | 8.7 |
| | Trans. cost | - | 0.8 | - | 0.8 | - | - | - | - | - | 0.8 | - | 0.8 |
| | Haulage cost | - | 3.2 | - | 6.8 | | | | | | 3.2 | - | 6.8 |
| | Total | 13.6 | 12.7 | 29.7 | 16.3 | - | - | - | - | 13.6 | 12.7 | 29.7 | 16.3 |
| Total | Collection cost | 10.1 | 7.9 | 23.2 | 7.9 | 10.1 | 7.9 | 23.2 | 7.9 | 10.1 | 7.9 | 23.2 | 7.9 |
| | Trans. cost | - | 0.7 | - | 0.7 | - | 0.5 | - | 0.5 | - | 0.6 | - | 0.6 |
| | Haulage cost | - | 1.8 | - | 5.5 | - | 1.8 | - | 5.5 | - | 1.6 | - | 5.4 |
| | Total | 10.1 | 10.4 | 23.2 | 14.1 | 10.1 | 10.2 | 23.2 | 13.9 | 10.1 | 10.1 | 23.2 | 13.9 |

Tab. 3-2-22 DISTANCE FROM THE TRANSFER STATION TO THE PROPOSED FINAL DISPOSAL SITES

(km)

| | DESERT DISPOSAL SITE | WESTERN DISPOSAL SITE | EASTERN DISPOSAL SITE |
|---|---|---|---|
| Ameriyah transfer station | 53 | 8 | 40 |
| Abis transfer station | 82 | 30 | 8 |
| Airport transfer station | 91 | 39 | 13 |
| Montazah transfer station | 103 | 51 | 25 |

In connection with the driving speed, it is assumed that in the case of long distance trip to the disposal site (70km) the collection vehicle drives at 45km/h in direct haul, while the haulage vehicle drives at 50km/h, as shown in the figure below. In the case of disposal sites located at short distance (20km), it is assumed that the vehicles travel at the same speed of 30km/h both in the case of transferred and direct haul because the road conditions are the same.



c. Evaluation

According to the study referring to the economical advantages of the transferred haulage (refer to Tab. 3-2-19), it is obvious that the construction of the transfer station does not have so much advantages when hauling waste to disposal sites located nearby, except in the case of the Montazah District.

On the other hand, it is obvious that it has advantages in the case of long-distance haulage. In this project it is concluded that it is not necessary to construct transfer stations in case of the Green Belt disposal site, but when disposing the waste in the desert disposal site construction becomes necessary. As for the Montazah District, the transfer station brings about positive effect, because there is a considerable distance from district center to the Green Belt disposal site. Therefore, the transfer station is desirable in this case.

In general, the economical effect of the transfer station is more conspicuous when the distance between the transfer station and the collection area is short, and when the effective loading capacity of the collection vehicles is small. In the present study, the former factor is taken into consideration in the cases of transfer station location, while the later factor is taken into consideration by assuming the use of compactor collection vehicles with 3 ton capacity. The economical effect of the transferring haulage is not so conspicuous when the 6-ton and 4-ton capacity collection vehicles operating at the present time, but on the other hand it is expected to bring about substantial advantages when the effective carrying capacity of the collection vehicle becomes small as in the case of the open-type dump trucks.

It must be borne in mind that the study of the economical advantage described here is carried out on the condition of collection vehicles with an average carrying capacity of 3 tons. Furthermore, comparing with the direct hauling to the disposal site, the haulage via transfer station makes it possible to reduce the manpower requirement by a considerable extent. This manpower reduction brings about conspicuous economical effect when the labour cost is expensive. Therefore, the future increase of personnel expenditure must be examined with special care.

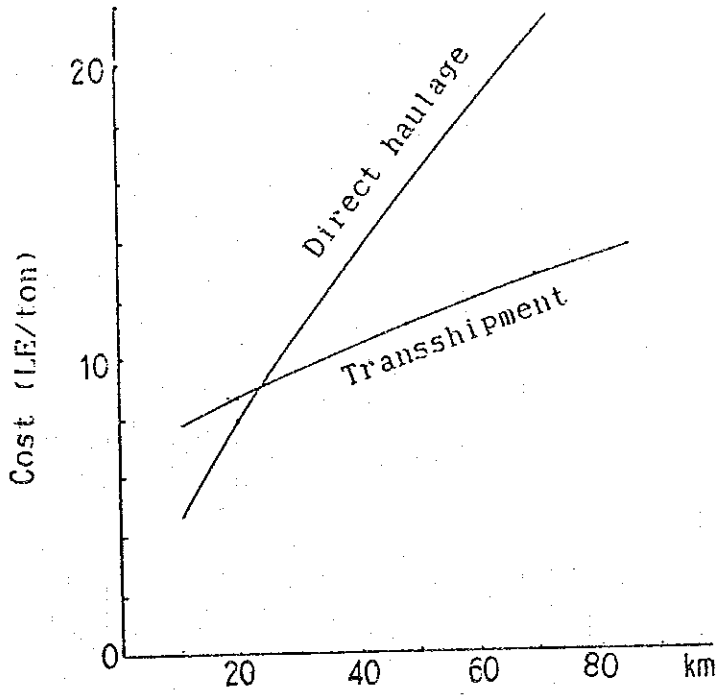
In cases of the haulage via transfer station to the final disposal site located within a 70km, Cases II and III are more economical in terms of total cost, while Case I becomes the more expensive. In reality however, the differential cost of LE0.2/ton between the various cases is very small.

On the other hand, Case I, which has the transfer stations in various places throughout the widest area, proves to be the most advantageous if the advantages brought about by preventing excessive concentration of vehicles, as well as the integration of each individual district, are taken into consideration. Therefore, in case of disposal site located within a 70km sphere, this study recommends the implementation of Case I, which consists of constructing transfer stations in various places.

d. Location of the final disposal site and transferring haulage

Two cases regarding location of the final disposal site, 20km sphere and 70km, have been examined so far. In this connection, the results of the evaluation referring to the relation between distance to the final disposal site and the transfering haulage cost, focusing on the Middle, Gomrok and West Districts are shown in Fig. 3-2-15. The critical distance, where the transfering haulage starts to bring about economical effect, is of the order of 20 to 30km. The location of the final disposal site on the Green Belt, taken into consideration in the present study, is approximately at the said critical point. The construction of the transfer station should be examined when the final disposal site is located at further distant places.

Fig. 3-2-15 RELATION BETWEEN DISTANCE TO THE FINAL DISPOSAL SITE AND HAULAGE COST




(3) Facilities construction cost

The transfer station facilities, required manpower, plant and facilities construction cost and operation cost referring to the Case I (70km), are shown in Tab. 3-2-23, and as can be seen the total investment of the transfer station amounts to approximately LE 4,885,000. Furthermore, when the transfer station operation cost and the haulage cost are added, the overall cost per ton becomes LE 6.2.

Tab. 3-2-23 CONSTRUCTION AND OPERATION COST OF THE TRANSFERRING HAULAGE PLAN

| | TRANSFER STATION | | | | |
|---|---|---|---|---|---|
| | MONTAZAH | AIRPORT | MOHARAM BEY | AMERIYAH | TOTAL |
| Volume of waste to be transferred (t/day) | 365 | 452 | 902 | 340 | 2,059 |
| Manpower requirement | | | | | |
| Transfer station manpower (person) | | | | | |
| Administrative personnel | 4 | 4 | 4 | 4 | 16 |
| Workers | 19 | 19 | 19 | 19 | 76 |
| Drivers | 42 | 46 | 83 | 21 | 192 |
| Number of transportation vehicles | 42 | 46 | 83 | 21 | 192 |
| Construction cost (LE) | | | | | |
| Buildings and structures | 821,250 | 1,017,000 | 2,029,500 | 765,000 | 4,632,750 |
| Machinery cost | 50,500 | 50,500 | 101,000 | 50,500 | 252,500 |
| Total | 871,750 | 1,067,500 | 2,130,500 | 815,500 | 4,885,250 |

| | TRANSFER STATION | | | | |
|---|---|---|---|---|---|
| | MONTAZAH | AIRPORT | MOHARAM BEY | AMERIYAH | TOTAL |
| Operation cost (LE/year) | | | | | |
| Transfer station | | | | | |
| Buildings and structures depreciation | 32,850 | 40,680 | 81,180 | 30,600 | 185,310 |
| Facilities and equipment depreciation | 8,121 | 8,121 | 16,242 | 8,121 | 40,605 |
| Maintenance | 31,211 | 37,149 | 74,161 | 29,505 | 172,026 |
| Personnel expenditure | 30,720 | 30,720 | 30,720 | 30,720 | 122,880 |
| Sub-total | 102,902 | 116,670 | 202,303 | 98,946 | 520,821 |
| Haulage | | | | | |
| Vehicle depreciation | 510,300 | 558,900 | 1,008,450 | 255,150 | 2,332,800 |
| Maintenance | 69,255 | 76,545 | 136,688 | 34,627 | 317,115 |
| Fuel | 231,488 | 254,302 | 451,530 | 110,900 | 1,048,220 |
| Personnel expenditure | 91,200 | 100,800 | 180,000 | 45,600 | 417,600 |
| Sub-total | 902,243 | 990,547 | 1,776,668 | 446,277 | 4,115,735 |
| Total (LE/year) | 1,005,145 | 1,107,217 | 1,978,971 | 545,223 | 4,636,556 |
| Cost per ton (LE/ton) | 7.5 | 6.7 | 6.0 | 4.6 | 6.2 |
| Required area ($m^2$) | 912 | 1,130 | 2,255 | 850 | 5,147 |

9) Equipment, materials and manpower requirement

The equipment, materials and manpower requirement, obtained as a result of the study of the previous sections, are summerized as following:

a. Collection station

The collection stations will be arranged on sidewalks of the main streets and alleys.

b. Station arrangement density

The Middle, East, West and Gomrok Districts will be provided with an arrangement density of at least 3 stations per hectare. The Montazah and Ameriyah districts will be of at least 2 stations per hectare.

c. Collection frequency

Daily collection will be carried out in the Middle, East, West and Gomrok, while twice-a-week collection will be carried out in Montazah and Ameriyah Districts.

d. Storage for waste discharge

In principle, waste will be discharged in bag, and the system will be organized in such a way to make it possible to discharge at the time of collection vehicle arrival.

e. Collection vehicles

Compactor vehicles and open-type dump trucks will be provided, by taking into consideration the degree of diffusion of the bag-packed discharge and the road paving conditions.

The arrangement of the various facilities and the waste hauling routes of each district are shown in Figs. 3-2-16, 3-2-17 and 3-2-18. The arrangement of the facilities shown in the figures are decided on the basis of the study of the next chapter. As for the haulage routes, they will be constructed in the outer Green Belt of the street area or the trunk road included in the urbanization plan will be used for that purpose. The estimated waste collection amount and generation density referring to the years 1984 and 2000, and the collection frequency, loading weight of the vehicles, haulage distances, etc., required for preliminaly calculation of the equipment and manpower requirements, are shown in Tab. 3-2-24.

Fig. 3-2-16 ALTERNATIVES 1 AND 3

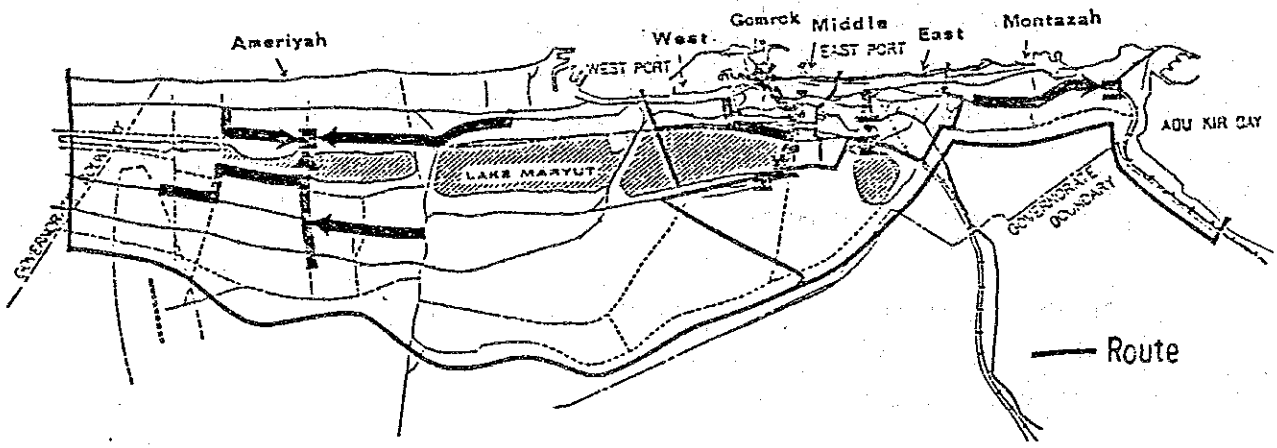


Fig. 3-2-17 ALTERNATIVES 2 AND 4

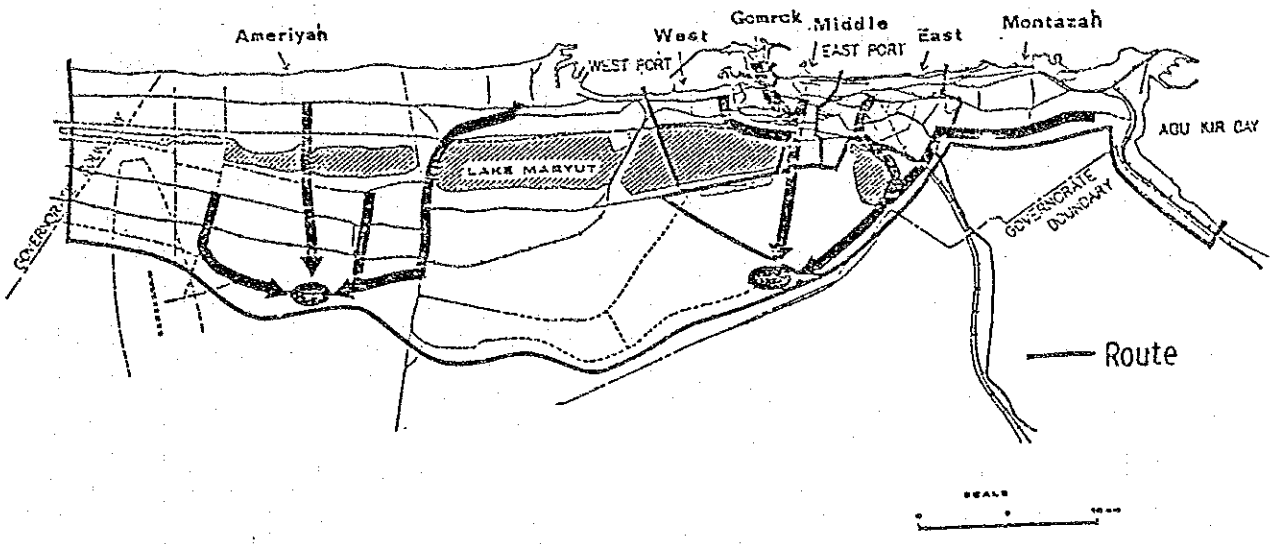
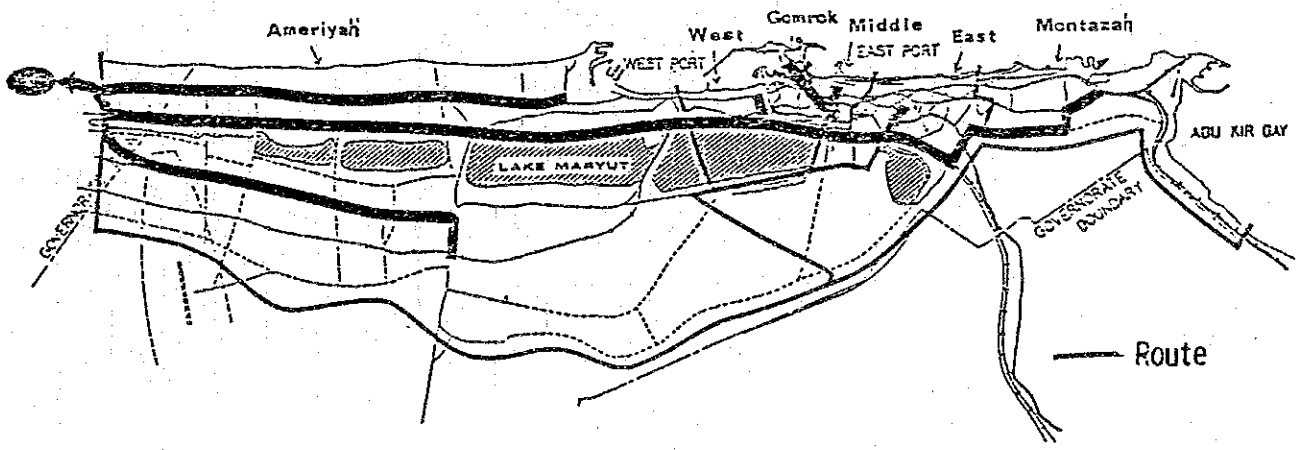



Fig. 3-2-18 DIRECT HAULAGE ROUTE TO THE DESERT DISPOSAL SITE




note:Alternative 5 is same as conbination of Altermative 1 for Middle,Gomrok and West District and Alternative 2 for Montazah,East and Ameriyah District.

Tab. 3-2-24 CONDITION FOR PRELIMINARY CALCULATION OF EQUIPMENT AND MANPOWER REARRANGEMENT

| DISTRICT AND SUB DISTRICT | ZONE NUMBER | ESTIMATED GENERATION AMOUNT (T/DAY) 1984 | 2000 | DESIGN COLLECTION AMOUNT (T/DAY) 1984 | 2000 | ESTIMATED GENERATION DENSITY (KG/HA.) 1984 | 2000 | FREQUENCY (PER WEEK) | CARRYING AMOUNT (T/VEHICLE) | TO THE NEAREST EXISTING DUMP SITE ( Km ) | TO THE NEAREST COMPOST PLANT ( Km ) | TO THE NEAREST PROPOSED DISPOSAL SIZE IN THE GREEN-BELT ( Km ) | TO THE PROPOSED DESERT DISPOSAL SITE ( Km ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Montazah Montazah | 1 | 34 | 78 | 45 | 104 | 150 | 200 | Twice | 3 | 7 | 9 | 20 | 94 |
| | 2 | 28 | 65 | 37 | 87 | 150 | 200 | " | 3 | 10 | 11 | 22 | 96 |
| | 3 | 40 | 61 | 53 | 81 | 150 | 200 | " | 3 | 7 | 10 | 20 | 93 |
| | 4 | 35 | 59 | 47 | 79 | 150 | 100 | " | 3 | 10 | 8 | 22 | 96 |
| | 5 | 0 | 61 | 0 | 81 | 0 | 100 | " | 3 | 12 | 4 | 24 | 98 |
| | 6 | 17 | 41 | 23 | 55 | 50 | 100 | " | 3 | 15 | 3 | 27 | 101 |
| Sub-total | | 154 | 365 | 205 | 487 | - | - | - | - | - | - | - | - |
| East Sidi Gabar | 1 | 45 | 79 | 45 | 79 | 400 | 500 | Daily | 3 | 3 | 3 | 12 | 80 |
| | 2 | 42 | 61 | 42 | 61 | 400 | 500 | " | 3 | 2 | 2 | 14 | 87 |
| Raml | 3 | 51 | 87 | 51 | 87 | 400 | 500 | " | 3 | 6 | 6 | 18 | 92 |
| | 4 | 46 | 62 | 46 | 62 | 400 | 500 | " | 3 | 5 | 5 | 18 | 91 |
| | 5 | 42 | 56 | 42 | 56 | 400 | 500 | " | 3 | 2 | 2 | 15 | 91 |
| | 6 | 30 | 41 | 30 | 41 | 400 | 500 | " | 3 | 3 | 3 | 16 | 92 |
| | 7 | 50 | 66 | 50 | 66 | 400 | 500 | " | 3 | 4 | 4 | 17 | 93 |
| Sub-total | | 306 | 452 | 306 | 452 | - | - | - | - | - | - | - | - |

| DISTRICT AND SUB DISTRICT | ZONE NUMBER | ESTIMATED GENERATION AMOUNT (T/DAY) 1984 | 2000 | DESIGN COLLECTION AMOUNT (T/DAY) 1984 | 2000 | ESTIMATED GENERATION DENSITY (KG/HA.) 1984 | 2000 | FREQUENCY (PER WEEK) | CARRYING AMOUNT (T/VEHICLE) | TO THE NEAREST EXISTING DUMP SITE ( Km ) | TO THE NEAREST COMPOST PLANT ( Km ) | TO THE NEAREST PROPOSED DISPOSAL SIZE IN THE GREEN-BELT ( Km ) | TO THE PROPOSED DESERT DISPOSAL SITE ( Km ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Middle | | | | | | | | | | | | | |
| Ataryn | 1 | 80 | 120 | 80 | 120 | 650 | 900 | Daily | 3 | 7 | 8 | 12 | 82 |
| Bab Sharki | 2 | 73 | 103 | 73 | 103 | 500 | 700 | " | 3 | 6 | 8 | 11 | 82 |
| | 3 | 53 | 74 | 53 | 74 | 500 | 700 | " | 3 | 4 | 7 | 11 | 85 |
| Moharam Bey | 4 | 30 | 40 | 30 | 40 | 500 | 700 | " | 3 | 8 | 7 | 12 | 81 |
| | 5 | 153 | 213 | 153 | 213 | 500 | 700 | " | 3 | 6 | 6 | 10 | 83 |
| Sub-total | | 389 | 550 | 389 | 550 | - | - | - | - | - | - | - | - |
| Gomrok | | | | | | | | | | | | | |
| Gomrok | 1 | 115 | 168 | 115 | 168 | 780 | 1,100 | Daily | 3 | 10 | 10 | 13 | 83 |
| Manshia | 2 | 26 | 36 | 26 | 36 | 840 | 1,200 | " | 3 | 9 | 9 | 12 | 82 |
| Labban | 3 | 51 | 72 | 51 | 72 | 600 | 1,100 | " | 3 | 9 | 9 | 12 | 82 |
| Sub-total | | 192 | 276 | 192 | 276 | - | - | - | - | - | - | - | - |
| West | | | | | | | | | | | | | |
| Karmauz | 1 | 84 | 112 | 84 | 112 | 400 | 500 | Daily | 3 | 9 | 8 | 12 | 80 |
| Mina el Basal | 2 | 91 | 124 | 91 | 124 | 400 | 500 | " | 3 | 11 | 11 | 16 | 77 |
| Sub-total | | 174 | 236 | 124 | 236 | - | - | - | - | - | - | - | - |

| DISTRICT AND SUB DISTRICT | ZONE NUMBER | ESTIMATED GENERATION AMOUNT (T/DAY) 1984 | 2000 | DESIGN COLLECTION AMOUNT (T/DAY) 1984 | 2000 | ESTIMATED GENERATION DENSITY (KG/HA.) 1984 | 2000 | FRE-QUENCY (PER WEEK) | CARRYING AMOUNT (T/ VEHICLE) | TO THE NEAREST EXISTING DUMP SITE ( Km ) | TO THE NEAREST COMPOST PLANT ( Km ) | TO THE NEAREST PROPOSED DISPOSAL SITE IN THE GREEN-BELT ( Km ) | TO THE PROPOSED DESERT DISPOSAL SITE ( Km ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ameriyah Dekhilah | 1 | 2 | 5 | 3 | 7 | 50 | 50 | Twice | 3 | 5 | 17 | 24 | 71 |
| Ameriyah | 2 | 21 | 29 | 28 | 39 | 50 | 50 | " | 3 | 3 | 14 | 24 | 67 |
| | 3 | 14 | 35 | 19 | 47 | 50 | 50 | " | 3 | 2 | 8 | 19 | 62 |
| | 4 | 0 | 37 | 0 | 49 | 1 | 50 | " | 3 | | 4 | 13 | 58 |
| | 5 | 0 | 29 | 0 | 39 | 1 | 50 | " | 3 | | 6 | 14 | 52 |
| | 6 | 0 | 30 | 0 | 40 | 1 | 50 | " | 3 | | 12 | 20 | 45 |
| | 7 | 0 | 69 | 0 | 92 | 1 | 50 | " | 3 | | 12 | 14 | 57 |
| | 8 | 0 | 37 | 0 | 49 | 1 | 50 | " | 3 | | 7 | 5 | 55 |
| | 9 | 0 | 32 | 0 | 43 | 1 | 50 | " | 3 | | 10 | 9 | 62 |
| | 10 | 0 | 37 | 0 | 49 | 1 | 50 | " | 3 | | 14 | 8 | 66 |
| Sub-total | | 37 | 340 | 50 | 454 | - | - | - | - | - | - | - | - |
| Total | | 1,252 | 2,219 | - | - | - | - | - | - | - | - | - | - |

The other conditions defined in connection with the preliminary calculation are as follows:

i. Vehicle carrying capacity

- Compactor vehicle 3 ton
- Open-type dump truck 2.5 ton

ii. Number of stations per trip [$N_o$]

$$N_o = \frac{W \times G \times S \times R}{Q \times D}$$

where;

W: Carrying capacity of a vehicle (ton)
G: Waste generation amount
S: Station placement density
R: Collection area rate
Q: Designed daily collection amount
D: Generation density

iii. Time required per trip (T) ($T_o$)

$$T = [(a + b) \times N_1 + (d \times 2)] \times e$$
$$To = [(T_1 + T_2) \times N_o + T_3] \times F$$

where;

$T_1$: Loading time

. 1.5 minute/100 kg of waste at station in the case of compactor vehicle, and

. 2.0 minute/100 kg of waste at station in the case of open-type dump truck

$T_2$: Travelling time

. 1.0 minutes; 3 stations/ha.

. 1.2 minutes; 2 stations/ha.

T3: Round trip time to the dump site

. Round-trip haulage distance (km) ÷ Average driving speed (km/hr)

Average speed = 30km/hr: to the Green Belt disposal site

= 50km/hr: to the desert disposal site

F: Safety factor C = 1.2

Note:

1. No reduction of speed due to the future increase of traffic volume is taken into consideration because in Alexandria it is relatively easy to drive out of the urban area.

2. Safety factor is 1.2 assuming 20% of allowance of the net required time taking into account the rest time and time loss.

3. The above-shown values $T_1$, $T_2$ and $T_3$ were estimated according to the result of the collection survey conducted by the JICA study team.

iv. Number of round trip of vehicle (N1)

N1 = (Operation time) ÷ ($T_o$: Time required per trip)

Note:
The operation time is assumed to be 420 minutes (7 hours) per day.

V. Required number of vehicles (N2)

$$N2 = \frac{\text{(Dasigned daily collection amount)}}{} \times \text{(Safety factor for number of vehicle)}$$

Note:

Safety factor rates are assumed to be follows;

Vehicle : 1.3
Drivers : 1.2 (except daily collection)
: 1.34 (daily collection)
Worker : 1.3

vi. Vehicle cost

- Compactor vehicle (3 ton): LE 45,000
- Open-type dump truck (2.5 ton): LE 21,000

These prices were estimated considering the past vehicle procurement record.

Vehicle depreciation: Depreciation period is assumed to be 5 years, and the remaining value being 10% of the purchase value.

Maintenance cost: 15% of the vehicle depreciation.

Fuel cost: The fuel cost is calculated by assuming LE 0.15/l and 3km/l.

These figures are determined by taking into consideration the operation record and other relevant data.

The results of the preliminary calculations regarding equipments and manpower cost, carried out on the aforestated preconditions, are shown in Tab. 3-2-25. Comparing the case where the totality of the collection vehicle fleet consists of compactors with the case where the totality of the collection vehicle fleet consists of open-type dump trucks, the cost of the latter one is 2 to 3LE/t cheaper. On the other hand, the compactor vehicle is more advantageous from the standpoint of work efficiency. The particulars of the systems and the results of the calculation of the annual cost of each alternative are shown in Tab. 3-2-26.

Tab. 3-2-25 REQUIRED VEHICLES, MANPOWER AND COST OF EACH ALTERNATIVE

| | ALT.-1, -3 | ALT.-2, -4 | ALT.-5 | DIRECT HAUL TO THE DESERT DISPOSAL SITE |
|---|---|---|---|---|
| Compactor vehicle | | | | |
| Required manpower (persons) | 1,653 | 2,032 | 1,951 | 4,092 |
| No. of vehicles | 392 | 483 | 462 | 960 |
| Waste amount collected by worker (ton/person/day) | 1.34 | 1.09 | 1.14 | 0.54 |
| Waste amount collected by vehicle (ton/day) | 5.66 | 4.59 | 4.80 | 2.31 |
| Cost (LE/ton) | 7.9 | 10.7 | 9.6 | 23.2 |
| Open-type dump truck | | | | |
| Required manpower (persons) | 1,732 | 2,188 | 2,081 | 4,657 |
| No. of vehicles | 410 | 519 | 495 | 1,091 |
| Waste amount collected by worker (ton/person/day) | 1.28 | 1.01 | 1.07 | 0.48 |
| Amount collected by vehicle (ton/day) | 5.41 | 4.28 | 4.48 | 2.03 |
| Cost (LE/ton) | 5.9 | 7.8 | 7.3 | 20.1 |

Tab. 3-2-26 (1) PARTICULARS OF THE COLLECTION SYSTEM AND PRELIMINARY CALCULATION RESULTS OF EACH ALTERNATIVE

| | Alt.-1, -3 | | | | | | | Alt.-2, -4 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Montazah | East | Middle | Gomrok | West | Ameriyah | Total | Montazah | East | Middle | Gomrok | West | Ameriyah | Total |
| Particulars of the system | | | | | | | | | | | | | | |
| - Waste collection amount (t/d) | 365 | 452 | 550 | 276 | 236 | 340 | 2,219 | 365 | 452 | 550 | 276 | 236 | 340 | 2,219 |
| - Collection frequency | 2/7 | Daily | Daily | Daily | Daily | 2/7 | -- | 2/7 | Daily | Daily | Daily | Daily | 2/7 | -- |
| - Number of stations | 7,069 | 2,712 | 2,243 | 745 | 1,416 | 13,600 | 27,785 | 7,069 | 2,712 | 2,243 | 745 | 1,416 | 13,600 | 27,785 |
| (Compactor system) | | | | | | | | | | | | | | |
| - Drivers (person) | 68 | 65 | 82 | 43 | 41 | 91 | 390 | 99 | 93 | 94 | 47 | 47 | 99 | 479 |
| - Crews (person) | 218 | 211 | 266 | 139 | 134 | 295 | 1,263 | 332 | 302 | 303 | 153 | 152 | 321 | 1,553 |
| - Fuel consumption (Kl/year) | 440 | 229 | 523 | 359 | 306 | 519 | 2,378 | 1,240 | 960 | 806 | 466 | 466 | 720 | 4,660 |
| - Number of vehicles | 73 | 62 | 78 | 41 | 39 | 99 | 392 | 108 | 89 | 89 | 45 | 45 | 107 | 483 |
| (Open-type dump truck system) | | | | | | | | | | | | | | |
| - Drivers (person) | 71 | 67 | 86 | 46 | 44 | 95 | 409 | 109 | 101 | 100 | 51 | 50 | 105 | 516 |
| - Crews (person) | 230 | 216 | 280 | 148 | 141 | 308 | 1,323 | 354 | 327 | 323 | 165 | 163 | 340 | 1,672 |
| - Fuel consumption (kl/year)) | 529 | 275 | 628 | 431 | 368 | 624 | 2,854 | 1,486 | 1,153 | 973 | 560 | 540 | 866 | 5,593 |
| - Number of vehicles | 77 | 63 | 82 | 43 | 42 | 103 | 410 | 118 | 96 | 95 | 48 | 48 | 114 | 519 |
| Maintenance cost (LE 1000/year) | | | | | | | | | | | | | | |
| (Compactor system) | | | | | | | | | | | | | | |
| - Vehicle depreciation | 588 | 496 | 628 | 326 | 314 | 795 | 3,149 | 867 | 713 | 714 | 360 | 357 | 866 | 3,878 |
| - Personnel expenditure | 421 | 407 | 515 | 268 | 257 | 570 | 2,441 | 622 | 584 | 585 | 294 | 292 | 621 | 3,003 |
| - Others | 154 | 108 | 172 | 102 | 92 | 196 | 828 | 316 | 250 | 228 | 124 | 120 | 237 | 1,280 |
| - Total | 1,165 | 1,012 | 1,316 | 697 | 665 | 156 | 6,420 | 1,806 | 1,549 | 1,529 | 780 | 771 | 1,727 | 816 |
| (Open-type dump truck system) | | | | | | | | | | | | | | |
| - Vehicle depreciation | 288 | 237 | 307 | 162 | 155 | 388 | 1,540 | 445 | 359 | 355 | 181 | 179 | 427 | 1,948 |
| - Personnel expenditure | 444 | 417 | 540 | 285 | 271 | 596 | 2,558 | 684 | 631 | 625 | 318 | 315 | 657 | 3,232 |
| - Others | 122 | 76 | 140 | 80 | 78 | 151 | 659 | 289 | 226 | 199 | 111 | 107 | 194 | 1,131 |
| - Total | 855 | 733 | 989 | 537 | 506 | 1,136 | 4,758 | 1,420 | 1,218 | 1,180 | 611 | 602 | 1,280 | 6,314 |
| Cost per ton (LE/ton) | | | | | | | | | | | | | | |
| - Compactor system | 8.7 | 6.1 | 6.6 | 6.9 | 7.7 | 12.6 | 7.9 | 13.6 | 9.4 | 7.6 | 7.7 | 9.0 | 13.9 | 10.1 |
| - Open-type dump truck system | 6.4 | 4.4 | 4.9 | 5.3 | 5.9 | 9.2 | 5.9 | 10.7 | 7.4 | 5.9 | 6.1 | 7.0 | 10.3 | 7.8 |

Tab. 3-2-26 (2) PARTICULARS OF THE COLLECTION SYSTEM AND PRELIMINARY CALCULATION RESULTS OF EACH ALTERNATIVE

| | Alt.-5 DIRECT HAULAGE OF THE WASTE TO THE DESERT DISPOSAL SITE | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Montazah | East | Middle | Gomrok | West | Ameriyah | Total | Montazah | East | Middle | Gomrok | West | Ameriyah | Total |
| Particulars of the system | | | | | | | | | | | | | | |
| - Waste collection amount (t/d) | 365 | 452 | 550 | 276 | 236 | 340 | 2,219 | 365 | 452 | 550 | 276 | 236 | 340 | 2,219 |
| - Collection frequency | 2/7 | Daily | Daily | Daily | Daily | 2/7 | -- | 2/7 | Daily | Daily | Daily | Daily | 2/7 | -- |
| - Number of stations | 7,069 | 2,712 | 2,243 | 745 | 1,416 | 13,600 | 27,785 | 7,069 | 2,712 | 2,243 | 745 | 1,416 | 13,600 | 27,785 |
| (Compactor system) | | | | | | | | | | | | | | |
| - Drivers (person) | 99 | 93 | 82 | 43 | 41 | 99 | 457 | 193 | 197 | 221 | 109 | 94 | 151 | 965 |
| - Crews (person) | 332 | 302 | 266 | 139 | 134 | 321 | 1,494 | 625 | 638 | 716 | 352 | 305 | 491 | 3,127 |
| - Fuel consumption (Kl/year) | 1,240 | 960 | 523 | 359 | 306 | 720 | 4,108 | 5,380 | 5,460 | 6,166 | 3,086 | 2,506 | 3,053 | 25,408 |
| - Number of vehicles | 108 | 89 | 78 | 41 | 39 | 107 | 462 | 209 | 186 | 209 | 103 | 89 | 164 | 960 |
| (Open-type dump truck system) | | | | | | | | | | | | | | |
| - Drivers (person) | 109 | 101 | 86 | 46 | 44 | 105 | 491 | 221 | 225 | 252 | 125 | 107 | 168 | 1,098 |
| - Crews (person) | 354 | 327 | 280 | 148 | 141 | 340 | 1,590 | 717 | 729 | 819 | 404 | 347 | 543 | 3,559 |
| - Fuel consumption (kl/year) | 1,486 | 1,153 | 628 | 431 | 368 | 866 | 4,932 | 6,453 | 6,546 | 7,400 | 3,706 | 3,006 | 3,660 | 3,073 |
| - Number of vehicles | 118 | 96 | 82 | 43 | 42 | 114 | 495 | 239 | 213 | 239 | 118 | 101 | 181 | 1,091 |
| Maintenance cost (LE 1000/year) | | | | | | | | | | | | | | |
| (Compactor system) | | | | | | | | | | | | | | |
| - Vehicle depreciation | 867 | 713 | 628 | 326 | 314 | 866 | 3,714 | 1,684 | 1,505 | 1,690 | 830 | 718 | 1,323 | 7,752 |
| - Personnel expenditure | 622 | 584 | 515 | 268 | 257 | 621 | 2,867 | 1,208 | 1,234 | 1,386 | 680 | 589 | 950 | 6,052 |
| - Others | 316 | 250 | 172 | 102 | 92 | 172 | 1,104 | 1,059 | 1,044 | 1,178 | 587 | 483 | 656 | 5,011 |
| - Total | 1,805 | 1,547 | 1,316 | 697 | 665 | 1,659 | 7,685 | 3,954 | 3,785 | 4,255 | 2,099 | 1,792 | 2,930 | 18,818 |
| (Open-type dump truck system) | | | | | | | | | | | | | | |
| - Vehicle depreciation | 445 | 359 | 307 | 162 | 155 | 427 | 1,855 | 902 | 803 | 902 | 444 | 381 | 683 | 4,118 |
| - Personnel expenditure | 684 | 631 | 540 | 285 | 271 | 657 | 3,068 | 1,388 | 1,411 | 1,586 | 780 | 670 | 1,051 | 6,891 |
| - Others | 289 | 226 | 140 | 80 | 78 | 194 | 1,007 | 1,103 | 1,102 | 1,245 | 622 | 508 | 651 | 5,236 |
| - Total | 1,418 | 1,216 | 989 | 537 | 506 | 1,280 | 5,950 | 3,396 | 3,318 | 3,734 | 1,848 | 1,561 | 2,388 | 10,247 |
| Cost per ton (LE/ton) | | | | | | | | | | | | | | |
| - Compactor system | 13.6 | 9.4 | 6.6 | 6.9 | 7.7 | 13.9 | 9.6 | 29.7 | 22.9 | 21.2 | 20.8 | 20.8 | 23.6 | 23.2 |
| - Open-type dump truck system | 10.7 | 7.4 | 4.9 | 5.3 | 5.9 | 10.3 | 7.3 | 25.5 | 20.1 | 18.6 | 18.4 | 18.1 | 19.2 | 20.1 |

10) Garage and maintenance

In order to cope with the increase in the number of collection vehicles, construction of new garages and establishing preventive maintenance system are required.

The existing garages located in the urban area of the city may be too small to accomodate all the future vehicles. Therefore, construction of a new garage and expansion of the existing garages are recommended.

- Garages for Middle, Gomrok, West and East districts that are being constructed will be further expanded in the future.
- A new garage will be constructed for Montazah district.

The location of the garages are marked in Fig. 3-2-19. The district garages have to be provided with machinery and equiment necessary for daily maintenance and simple repair as well as filling stations. It is necessary that the district garages provide daily checking of tyre pressure, brake oil and cooling water level.

The Central Workshop has to provide regular preventive maintenance to make possible the longer use of vehicles, and to reduce the number of out-of-order vehicles.

In order to execute regular preventive maintenance, preparation of manuals suitable to the vehicles and equiment used in Alexandria as well as preventive maintenance program is necessary. Manpower training is required as well. Establishment of regular preventive maintenance system is essential for execution of reliable collection service.

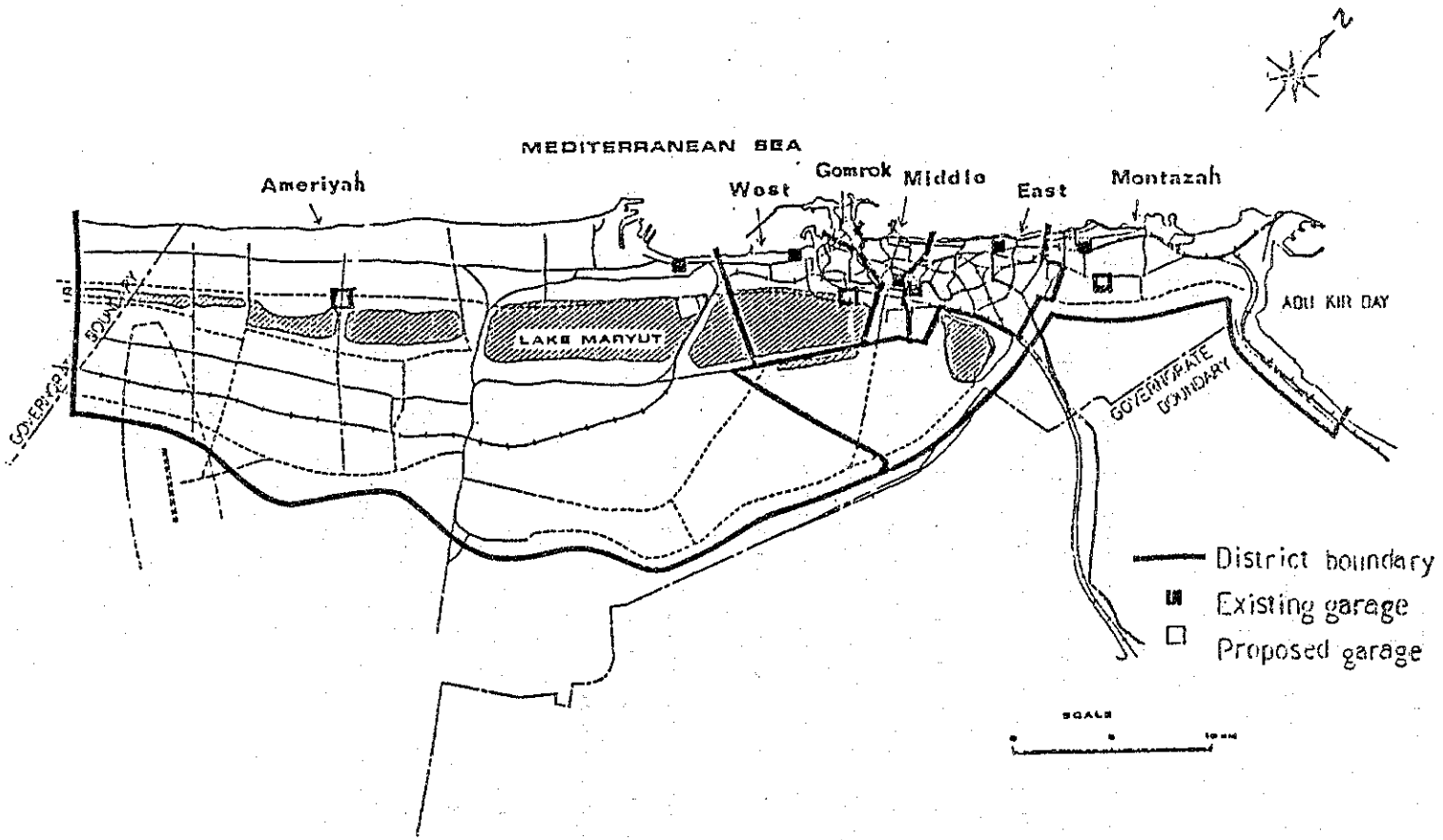



Fig. 3-2-19 LOCATION OF THE EXISTING AND PROPOSED GARAGES

3.2.2 Street sweeping

1) Condition of street sweeping study

(1) The study regarding sweeping of the alleys, excluding the main streets, will be planned on the basic policy that its frequency can be reduced by upgrading the collection service and through the cooperation of the residents.

The following problems are noticed in connection with the current street sweeping system.

1. Sweepers can hardly be recruited in view of the low wages.
2. The personnel expenditure of the many sweepers is pushing up the overall street sweeping cost.

It is necessary to upgrade the wage level in order to secure the required number of sweepers, but on the other hand it will increase furthermore the street sweeping cost. The said increase would be an unbearable burden on the current financial situation. If the existing street sweeping system will be kept unchanged, it is obvious that the recruitment of the sweepers and the raising of the sweeping cost required to cope with the demand in the year 2000 will become serious problems, because by that time the street area will be twice as large as the present one, requiring much more sweepers.

Such being the case, it may be clearly supposed that there is no alternative but upgrading the wage level and at the same time establishing a street sweeping system requiring less sweepers to solve the impasse. The main objectives of street sweeping are to preserve a sound living environment and to secure the public hygiene, as well as to realize them with the minimum of sweepers.

For the time being, the street sweeping system of Alexandria requires a very large number of sweepers, which account for 60% of the total of employees of the waste management sector. According to the results of the trial calculation of the waste collection and street sweeping cost, as

shown in Tab. 3-2-27, the overall cost mounts to LE9/ton, with the street sweeping cost according to an extremely high percentage (30%) of that total. Furthermore, of the actual street sweeping work carried out by the large number of sweepers, it is presumed that a considerable number is engaged in the sweeping of alleys and secondary streets besides main streets.

Observing the wastes composition scattered in the alleys and streets other than the main ones, it consists of waste discharged by households and commercial establishments, as well as waste scattered by the wind once it was discharged to the station. These street waste can be reduced with the cooperation of the residents, while the street waste generated in the main streets, consisting mostly of sand, whithered leaf, etc., is generally very difficult to control.

To realize the said objective it is necessary to elucidate in the first place the causes why the said street waste is generated. The causes are not so complicated, and in reality they can be reduced by improving the following two simple points.

- Uncooperative attitude of the residents.
- Insufficient collection service.

Of the said two reasons, it is difficult to come to a definitive conclusion about which one accounts for the larger weight. In connection with the latter one, the measure which consists of providing a collection system with service level better than the current one is pointed out in section 3-1. If the said measure would be implemented, it is presumed that in principle the number of sweepers that take charge of sweeping waste generated by households and commercial establishement will be reduced by a considerable extent.

Tab. 3-2-27 ESTIMATION OF THE CURRENT COLLECTION AND STREET SWEEPING COST

| | COST (LE1000) | % |
|---|---|---|
| Vehicle depreciation | 1,395 | 43.2 |
| Maintenance | 209 | 10.8 |
| Collection manpower | 480 | 14.9 |
| Sub-total | 2,224 | 68.9 |
| Sweeper | 1,007 | 31.2 |
| Total | 3,091 | 100.0 |
| Cost per ton | LE 9.2 | -- |

Note:

- Vehicle price

| | |
|---|---|
| Truxmore | LE 78,600 |
| Compactor (4 ton) | LE 66,800 |
| Other truck (average) | LE 10,500 |

- Personnel wage

| | |
|---|---|
| Driver | LE 200/month |
| Assistant | LE 100/month |
| Sweeper | LE 50/month |

- Maintenance cost

  15% of the vehicle depreciation

- Vehicle depreciation

  5 years with a residual value of 10%

(2) Street sweeping and collection are regarded as systems independent from each other.

At present, street sweeping is carried out in coordination with collection time schedule, and street waste is swept to the stations where it is collected together with the waste dumped therein. Therefore, street sweeping is regarded as subsidiary work of collection. The street sweeping system is drawn up on the condition that by the year 2000 the street sweeping frequency on the alleys and secondary streets other than main streets will be determined independently from the collection time schedule. Therefore, street sweeping and collection will be planned as independent systems.

(3) The street sweeping system covers only the streets.

In some cases, such facilities as parks, markets, beaches, etc., are included in the scope of service of the street sweeping system, but in Alexandria the street sweeping system covers exclusively the street area. In this study it is assumed that also in the year 2000 the street sweeping system will cover exclusively the street area.

(4) The service area of the street sweeping is limited to urban area shown in the land use plan of the year 2005 (refer to Fig. 3-2-1).

The service area to be covered is shown in Tab. 3-2-28.

(5) The streets to be swept are those of the aforementioned urbanized areas, focusing mainly on the existing trunk streets and the important streets of each district.

The road network consisting of the existing trunk road and main streets, as well as the streets regarded as the main ones in the future land use areas, is shown in Fig. 3-2-20.
Each road and street length are shown in Tab. 3-2-29.

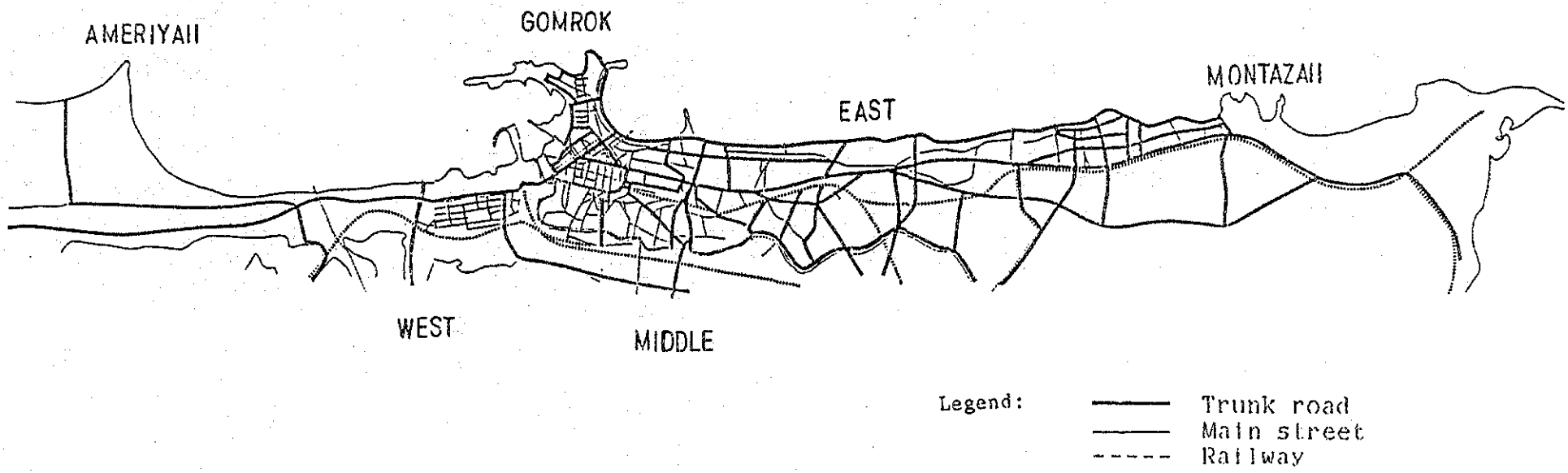



Fig. 3-2-20 ROAD & STREET NETWORK

Tab. 3-2-29 STREETS TO BE SWEPT

| | COLLECTION AREA ($km^2$) | RESIDENTIAL AREA ($km^2$) | STREETS TO BE SERVED | | STREETS OF RESIDENTIAL AND CENTER AREA (km ) |
|---|---|---|---|---|---|
| | | | MAIN STREET (km ) | SECONDARY STREET (km ) | |
| Montazah | 40.6 | 32.3 | 25.8 | 129 | 323 |
| East | 25.2 | 12.0 | 27.0 | 216 | 360 |
| Middle | 11.9 | 7.7 | 41.0 | 246 | 308 |
| Gomrok | 4.5 | 2.7 | 23.4 | 101 | 126 |
| West | 16.8 | 4.8 | 29.2 | 115 | 192 |
| Ameriyah | 238.6 | 175.3 | 100.0 | 450 | 876 |
| Total | 337.6 | 234.8 | 246.4 | 1,257.0 | 2,185 |

1. The length of the main streets is measured on the maps.

2. The total length of the main streets of Ameriyah is 200 km, including the future ones, of which 100 km are regarded as secondary.

3. The calculation is conducted by assuming the following.
   Secondary streets to be swept in the residential and center area are assumed as 40% in Montazah and Ameriyah Districts, 60% in East and West Districts and 80% in Middle and Gomrok Districts.

4. It is assumed that the streets of the residential and center area have the following densities, on the basis of the street survey results: 400 m/ha in Middle and West Districts, 300 m/ha in East and Gomrok Districts, 100 m/ha in Montazah District and 50 m/ha in Ameriyah District.

2) Sweeping method

Generally, there are two types of street sweeping methods. One is mechanical sweeping and the other is manual sweeping. From the standpoint of cost, it is more advantageous to use the manual method in Alexandria, instead of the mechanical method, because the mechanical one is very costly. Such being the case, it is concluded to be appropriate to maintain this manual method also in the future.

(1) Cost comparison of the manual method and mechanical method

The cost comparison when sweeping the trunk road every day is shown in Tab. 3-2-30. As can be seen, the manual method results are more advantageous than the mechanical one even when assuming a personnel expenditure of LE 100/month per sweeper, which will be considerably higher than the current wage level.

Tab. 3-2-30 COST COMPARISON

| | | MECHANICAL | MANUAL |
|---|---|---|---|
| Particulars | Required manpower (person) | 60 | 180 |
| | Driver (person) | 7 | 0 |
| | Mechanical (NO.) | 7 | 0 |
| Annual cost (LE 1,000) | | 230 | 216 |
| Cost per day-km (LE) | | 6.4 | 6.0 |
| Cost per day-km assuming LE 120/month of wage level (LE) | | 6.9 | 7.2 |

The mechanical sweeping method becomes more advantageous than manual one only when the personnel expenditure increases further. For example, when the personnel expenditure per sweeper becomes of the order of LE120/month, the mechanical sweeping method becomes more advantageous.

The conditions for calculation:

- Mechanical sweeper : Brush with scooping-up
- Average speed : 5 km/hr
- Actual working time : 7 hours
- Sweeping machine price : LE93,000/unit
- Personnel expenditure
  - . Sweeper : LE 100/month
  - . Driver : LE 200/month
- Fuel : Consumption: 2.0 km/liter
  Diesel oil: LE 0.15/liter
- Machine depreciation : 5 years, 10% remaining value

- Maintenance cost : 15% of the depreciation
- Manual sweeper efficiency : 700 m/person/day
- Assistant sweeper of mechanical sweeping : 2000 m/person/day
- Trunk road length : 98 km
- One reserve unit of the sweeping machine
- 20% reserve manpower

(2) Characteristics of the manual sweeping method and mechanical sweeping one

The comparative examination regarding characteristics of the two sweeping methods is shown in Tab. 3-2-31.

Tab. 3-2-31 CHARACTERISTICS OF SWEEPING METHOD

| | ADVANTAGE | DISADVANTAGE |
|---|---|---|
| Mechanical | . Efficient sweeping collection of waste. | . The training of drivers is difficult.<br>. Problems regarding cars parked on the streets and paving conditions.<br>. Problems of traffic jams.<br>. Problems of spare parts for maintenance. |
| Manual | . Applicable to any pavement condition.<br>. Convenient for sweeping of narrow streets.<br>. No investment.<br>. No maintenance.<br>. Easy training of the manpower. | . The operation cost rises with the increase of the personnel expenditure.<br>. There are risks of accidents.<br>. Problems of supervision |

3) Manual sweeping plan

The manual sweeping scheme will be discussed on reloading of the gathered street wastes, the streets to be swept, its frequency, the sweeping hours, the crew formation and the sweeping tools.

(1) System of keeping gathered street waste before loading to vehicles

At present, there are two systems; in one system, gathered wastes are put into containers, and in the other system gathered wastes are kept at waste stations. The former one is not appropriate for adoption in the year 2000, because there is no plan of future containerization of the collection system.

It is recommended that gathered wastes be packed in plastic bags and carried out to the stations, in order to avoid the risk of scattering by the wind and impoverishment of the collection efficiency. The additional cost of plastic bags must be taken into consideration, but it is negligible compared with the total personnel expenditure of sweepers as can be seen in the table below:

| | | |
|---|---|---|
| Sweeper | : | 1,400 persons |
| Wage | : | LE 100/month |
| Plastic bag | : | LE 1/20-bag |
| Personnel expenditure | : | LE 1,680,000/year |
| Plastic bag cost | : | LE 25,550/year |

(2) Sweeping frequency

Daily street sweeping will be carried out in the main streets, while it will be done once a week in other areas.

On the trunk roads interconnecting the various Districts and streets with concentration of commercial zones of the Districts, etc., at present, daily sweeping is being carried out. It seems appropriate to keep on with the daily sweeping scheme in the main streets also in future.

As for the sweeping of other streets, it becomes intrinsically unnecessary if the cooperation of the residents will be obtained in connection with the waste discharge from households and commercial establishments. Considering that most of the housing of Alexandria consists of apartment buildings, and as a consequence it is not realistic to expect street sweeping carried out by the residents themselves in front of these buildings, it is recommendable to sweep once a week on the secondary streets.

As things now stand there are main streets where sweeping is carried out twice a day. The first sweeping in carried out early in the morning and the second about noon, but in reality a very small volume is gathered at the second sweeping. Therefore, it seems appropriate to carry out sweeping once a day in the main streets, and to spend the remaining time for sweeping other secondary streets.

(3) Sweeping time

Sweeping of the main streets will be carried out from 6:00 AM to 10:00 AM, on the premise of finishing it before people begin their daily work in the morning. On the other hand, sweeping of streets other than the main ones will be carried out from 7:00AM to 2:00PM, in the same way as the present state.

In the main streets it is necessary to finish the sweeping work before 10:00AM in order to have them clean before the start of the daily work by the people. As for the starting time, 6:00 AM (same as the present scheme) seems realistic, taking into consideration the restrictions imposed by the commuting time of the sweeper. On the other hand, in connection with the sweeping of secondary streets, 7:00 AM seems realistic as starting time, taking into consideration the time for transportation of manpower and tools.

(4) Crew formation and allocation

Each sweeper will take charge of the street sweeping by himself. The length to be swept by each sweeper will be 0.7 km/day in the main streets and 1.0 km/day in other areas.

Street sweeping can be carried either individually or in group, but in general the work efficiency is higher in the individual case, and furthermore the individual sweeper scheme has already realized a satisfactory work record in Alexandria. Such being the case, the conventional individual sweeper scheme will be adopted also in future. As things now stand the length to be swept by each sweeper is approximately 0.7 km/day in the main streets, which makes it possible to finish the first sweeping by 10:00AM, and the allocation of an equivalent length is considered in this study. On the other hand, in streets other than the main ones, it is possible to allocate a longer length to each sweeper, because the working time can be made longer than in the main streets. In the secondary streets however, the work efficiency may decrease due to the pavement conditions. The sweeping length of 1.0 km/day, 40% longer than 0.7 km/day for main streets, with 7-hour working time, is adopted as a standard length considering the above factors.

(5) Tools

Each sweeper is given a broom and a green basket, both available in Alexandria. Push-cart is provided in accordance with the waste volume on the streets. In addition to the said tools, the sweepers will be given one plastic bag a day to pack the gathered wastes.

Currently, 0.3 $m^3$ metallic push-cart manufactured in the central workshop, are used mainly in Alexandria. The disadvantage of this push-cart compared with the two-barrel type one is the impossibility of discharging the waste directly in the collection vehicle, hence necessitating discharge at collection points and reloading into vehicle. However it seems appropriate since the said problem can be solved by packing the waste in plastic bags. If the amount of waste generated is of the order of 10 kg/km, it is possible to be collected by using only plastic bag.

Therefore, it seems appropriate to provide the pust-cart in accordance with the actual waste generation situation on the street.

(6) Manpower allocation

Considering Alexandria as a whole, in the year 2000 approximately 500 sweepers will be allocated in the main streets, and approximately 300 will be allocated in the secondary streets.

The number of sweepers of each district calculated on the basis of the aforestated conditions is shown in the Tab. 3-2-32. Only the Ameriyah District requires some reinforcement in street sweeper number compared with the current situation. In other districts the manpower can be slashed to 30% to 50% of the current level. The manpower allocation scheme differs considerably according to the sweeping frequency to be adopted. In this connection, it will be necessary to reinforce the current manpower by approximately 200 sweepers in case of daily sweeping on the secondary streets.

Street sweeping costs heavily as a public service, while no income can be expected from its implementation. It is desirable to slash as much as possible its manpower requirement in order to reduce financial burden, although the street sweeping service provides unemployed people with job opportunity.

Tab. 3-2-32 NUMBER OF SWEEPERS

(persons)

| | 1984 | 2000 AD | | | IN CASE OF DAILY SWEEPING | | |
|---|---|---|---|---|---|---|---|
| | | MAIN STREET | OTHER STREET | TOTAL | MAIN STREET | OTHER STREET | TOTAL |
| Montazah | 144 | 55 | 28 | 83 | 55 | 169 | 224 |
| East | 351 | 57 | 47 | 104 | 57 | 169 | 226 |
| Middle | 560 | 87 | 55 | 142 | 87 | 328 | 415 |
| Gomrok | 251 | 50 | 22 | 72 | 50 | 129 | 179 |
| West | 248 | 67 | 25 | 92 | 67 | 151 | 218 |
| Ameriyah | 74 | 212 | 98 | 310 | 212 | 1272 | 1484 |
| Total | 1,628 | 528 | 275 | 803 | 528 | 2,218 | 2,746 |

Conditions of calculation

. Reserve manpower for the holidays to keep daily sweeping at (30%).
. Secondary streets are divided in 6 zones and one fixed day of the week is assigned to each zone so that the frequency will be once a week.

(7) Cost

The annual cost of street sweeping will be LE 983,000/year in 2000.

The annual manpower costs will be LE 963,000 when the personnel expenditure of each sweeper is assumed to be LE 100/month. In addition other items, such as brooms, green baskets, push-carts, etc., are required, but their cost is assumed to be approximately 2% of the annual personnel expenditure.

## 3.3 Intermediate Treatment System

Among the many intermediate treatment systems, the ones considered to be applicable to Alexandria are the two systems; composting and sorting.

As stated in section 4.1, there are five alternatives including sanitary landfill having these two treatment systems incorporated. This clause will briefly review the composting facilities and sorting facilities suitable to Alexandria and formulate an intermediate treatment plan for each alternative proposed.

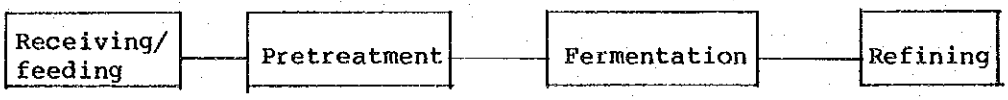
### 3.3.1 Outline of composting facilities

As described in Section 4.2.6, composting is a process to decompose and ferment compostable matters such as garbage, paper, etc. in the wastes in an aerobic condition to obtain stabilized end product. Compost is recycled into farmland by being utilized as soil conditioner or organic fertilizer.

(1) Fundamental flow of composting process

The fundamental flow of composting process is as illustrated below.

Fig. 3-3-1 FUNDAMENTAL FLOW OF COMPOST PROCESS




In the receiving stage, waste which has been hauled in is stored and fed to the treatment stage in controlled amounts. In the pretreatment stage, components which cannot be made into compost are segregated and removed. The residue is then adjusted in grain size and moisture content to obtain materials for composting. Fermentation is the principal stage of composting in which organic matters are decomposed and stabilized into coarse compost. In the refining stage, impurities contained in coarse compost are removed to obtain high quality compost.

(2) Comparative study of composting process

Concerning composting facilities for Alexandria, the basic policy is to emphasize inexpensiveness of construction cost, ease of operation and maintenance, and not to mechanize above the level of Abis compost plant (of windrow type) now under operation.

a. Receiving/feeding stage

There are two receiving methods; the pit and crane system, and the loader conveyor system. The pit and crane system, often utilized in incineration plants, has the advantage of requiring smaller space. However, as impurities must be removed in composting, the loader conveyor system which is more suited for this will be considered as a basis here. The storage quantity to be secured should desirably be of one or two days detention.

Tab. 3-3-1 COMPARISON OF RECEIVING/FEEDING

| | PIT AND CRANE SYSTEM | LOADER CONVEYOR SYSTEM |
|---|---|---|
| Principal facilities: | Storage pit<br>Overhead travelling crane | Front loader<br>Feeding conveyor<br>Storage area |
| Required floor space: | Small | Large |
| Workability: | Satisfactory | Rather poor |
| Construction cost: | Large | Small |
| Maintenance & operating costs: | Cost of the two systems are almost identical. | |
| Other: | | Impurities can be removed in the storage area |

b. Pretreatment stage

There are two treatment systems, one which performs sorting only and the other which is capable of simultaneous sorting and shredding. Equipment capable of simultaneous sorting and shredding has been developed in Japan. The advantages and disadvantages of each are shown in Table 3-3-2. As each has its respective features, either one can be adopted.

Tab. 3-3-2 COMPARISON OF PRETREATMENT SYSTEMS

| | | SHREDDING + SORTING | |
|---|---|---|---|
| | SORTING | SHREDDER + SORTER | SELECTIVE PULVERIZING CLASSIFIER |
| Principal facilities | . Trommel | . Shredder<br>. Trommel or vibrating sieve | . Selective pulverizing classifier |
| Advantages | . Shredding effect, to a certain degree, can be expected within trommel.<br>. Stirring is done within drum and classifying effect is relatively good. | . Able to cope with changes in waste quality and with bag collection.<br>. Most popular | . Shredding and sorting simultaneously accomplished in one step.<br>. Able to cope with changes in waste quality and with bag collection. |
| Disadvantages | . Needs bag breaker in case of bag collection.<br>. Fibrous materials become entangled within drum. | . Glass becomes commingled in compost.<br>. Riquires two steps, shredding and sorting. | . Glass becomes commingled in compost. |

c. Fermentation stage

The fermentation system may be broadly divided into two systems; the windrow system and the mechanical system, with the mechanical system being subdivided into a number of different systems by the turning method and other factors. Characteristics of each have been described in Section 4.2.6 which are summarized in Table 3-3-3. Since the system sought for in Alexandria must be easy to operate and maintain, the windrow type seems to be better suited. The detention period of fermentation is generally between 30 to 60 days, however for better compost, 60 days or so is desirable.

Tab. 3-3-3 FERMENTATION SYSTEMS AND CHARACTERISTICS

| | WINDROW SYSTEM | MECHANICAL SYSTEM | |
|---|---|---|---|
| | | VERTICAL SYSTEM | HORIZONTAL SYSTEM |
| Principal facility | Windrow area | . Digester (multistage) | . Digester |
| Fermentation period | About 60 days | . About 5 days and requires about 30 days of additional curing period | About 5 days and Same as left |
| Advantages | . Simple facility<br>. Small construction cost | . Small site<br>. Closed system capable of preventing offensive odor | . Relatively simple facility |
| Disadvantages | . Being an outdoor type, difficult to prevent offensive odor<br>. Requires large space | . Complicated facility<br>. Large construction cost | . Open type<br>. Requires large space |

d. Refining stage

There are a number of treatment systems for the refining process as shown in Table 3-3-4 and these may be combined as necessary for the treatment stage. The most popular system is treatment by vibrating screen. In cases where the compost product does not have to be of very good quality, the product which has been fermented may be shipped as coarse compost without going through this treatment stage.

Tab. 3-3-4 REFINING SYSTEMS AND CHARACTERISTICS

| | SCREENING | WIND SEPARATION | SEPARATION BY FRICTION OR REPULSION |
|---|---|---|---|
| Outline | . Separated by grain size<br>. Vibrating screen or trommel | . Separated mainly by weight through forcing air | . Separated by the defference in friction or repulsion.<br>. Inclined coveyor<br>. Ballistic separator, etc. |
| Advantages | . Most popularly used. | . Good separation efficiency<br>. Suitable for sepration of paper | . Simple structural design |
| Disadvantages | . Clogging of or adhesion to screen meshes. | . Large power consumption | . Separation efficiency not very satisfactory. |

e. Related processes

In the composting process, rejects generated in the pretreatment and post-treatment stages must be disposed of. Sorting is sometimes performed concurrently to salvage reusable materials. In the following lines these processes are discussed.

The amount of rejects generated in composting varies according to the waste composition and the standard of quality of compost product. The greater the presence of materials that cannot be composted in the physical composition of waste, and the higher the quality of compost requested is, the greater the amount of rejects is. The waste composition in Alexandria may lead to an increase in the amount of rejects. Judging from the physical composition of wastes, the amount of rejects is likely to be in the neighborhood of 30 to 40%. A storage area must be provided for these rejects from where they must be hauled by front loader and dump truck to the landfill sites to be disposed of.

Recovery of reusable materials will improve the feasibility of compost plant projects, and since it is incorporated in the process at Abis Compost Plant it will also be incorporated in the treatment process of

this plan. Objects of salvage are papers, textiles, plastic, bottles, metals and glass which are already being salvaged in Alexandria. Ferrous metals will be salvaged by a magnetic separator and the rest by manual sorting.

(3) Salvage efficiency of manual sorting and prices of salvaged materials

a. Salvage efficiency of manual sorting

The salvage efficiency of manual sorting varies according to the speed of belt conveyor, amount salvaged as well as a number of other factors. For salvage rate of each material, the actual records of Rio de Janeiro and Japan and the estimates for Abis Compost Plant shown in Table 3-3-5 may be referred to. The data of this table was referred to in establishing the recovery rates for the master plan which are shown in the rightmost column of the same table. The salvage rates for the master plan are somewhat lower than the salvage rates for the waste composition in 2000 which may be inferred from the estimates for Abis Compost Plant and the actual performance in Rio de Janeiro (Refer to Table 3-3-6). Since the salvage rate depends for instance on how much of the papers and plastics are worth sorting, this matter should desirably be investigated to enhance the accuracy of the estimated salvage rates.

Tab. 3-3-5 EFFICIENCY OF MANUAL SORTING

| | | ESTIMATES FOR *** ABIS COMPOST PLANT | RIO DE JANEIRO TEST PLANT | (Weight % in wet base) JAPAN * | ESTIMATES FOR MASTER PLAN |
|---|---|---|---|---|---|
| Paper | Carton box | 20 | 80 | 5 | 20 |
| | Others | 20 | 5 | 5 | 20 |
| Textile | | 50 | 60 | - | 48 |
| Plastic | Bottles | 40 | 70 | - | 16 |
| | Sheets | 40 | 60 | - | 16 |
| Metal | Ferrous | 70 | 90 | 64.7 | 72 |
| | Others | 70 | 70 | 66.6 | - |
| Glass | Bottles | 20 | 40 | 58.4 | 56 (40)** |
| | Cullets | 20 | 40 | 58.4 | 56 |
| Others | Bone | 20 | - | - | - |

Note: * For Ohme Recycle Center ... which has a fairly high overall recovery rate of about 30%.

** A low efficiency was assumed for the compost plant assuming that bottles have to be sorted.

*** The estimate value for Abis compost plant are quoted from the book entitled "The market for compost and recovered materials to be produced by the Abis composting plant."

Tab. 3-3-6 COMPARISON OF CALCULATED SALVAGE RATES FOR WASTE COMPOSITION IN 2000

(Weight Percentage)

| KIND OF WASTE | | COMPOSITION | ESTIMATES FOR ABIS | ACTUAL FOR RIO DE JANEIRO | ACTUAL FOR JAPAN | ESTIMATES ASSUMED FOR MASTER PLAN |
|---|---|---|---|---|---|---|
| Paper | Carton box | (4.6)* | | 3.7 | | |
| | Others | (18.4) | | 0.9 | | |
| | Subtotal | 23 | 4.6 | 4.6 | 1.2 | 4.6 |
| Textile | | 6 | 3.0 | 3.6 | - | 2.8 |
| Plastic | Bottles | (1.8)* | | 1.3 | | |
| | Sheets | (7.2) | | 4.3 | | |
| | Subtotal | 9 | 3.6 | 5.6 | - | 1.4 |
| Metal | Ferrous | (5.4) | | 4.9 | 3.5 | |
| | Others | (0.6) | | 0.4 | 0.4 | |
| | Subtotal | 6 | 4.2 | 5.3 | 3.9 | 4.3 |
| Glass | Bottles | (2.0) | | | | |
| | Cullet | (2.0) | | | | |
| | Subtotal | 4 | 0.8 | 1.6 | 2.3 | 2.2 |
| Others | Bone | (1.0) | | | | |
| | Others | - | | | | |
| | Subtotal | 1 | 0.2 | - | - | - |
| | Total | 49 | 16.4 | 20.7 | 7.4 | 15.3 |

* Salvage rates of carton boxes and plastic bottles are assumed to be about 20% of the rates for papers and plastics, respectively.

b. Prices of salvaged materials

Prices of salvaged materials vary depending on the source of information as shown in Table 3-3-7. This Table was used as a basis to arrive at the prices shown in Table 3-3-8 which are used for this master plan.

Tab. 3-3-7 PRICES OF SALVAGED MATERIALS

(LE/ton)

| MATERIAL | ACCORDING TO THE EGYPTIAN COUNTERPARTS | ESTIMATED FOR ABIS COMPOST PLANT * | HEARD FROM ZABBALEEN |
|---|---|---|---|
| Paper | 26 - 46 | 40 | 60 - 70 |
| Textile | 10 | 20 | 35 - 60 |
| Plastic | 60 - 80 | 100 | 100 - 300 |
| Glass | 8 - 30 | 27 | 15 - 80 |
| Metal (Ferrous) | 65 | 16 | 25 - 30 |
| (Copper) | 730 | - | 1200 - 1300 |
| (Aluminum) | 33 | - | - |
| Bone | 30 | 30 | 80 |
| Compost | - | 11 - 15 | - |

Note:
* Market prices of compost and salvaged materials to be produced by Abis Compost Plant.

Tab. 3-3-8 ASSUMED PRICES OF RECOVERED MATERIALS

| Material | Price |
|---|---|
| Paper | LE 30 /TON |
| Textile | LE 15 /TON |
| Plastics | LE100 /TON |
| Glass | LE 27 /TON |
| Metal | LE 16 /TON |
| Compost | LE 5 /M3* |

Note:

* Sales price of compost per ton is LE 12.5 on the basis of unit weight; 0.4 ton/$m^3$.

The amount salvaged will become tremendous when the compost facilities are constructed. It is uncertain how prices will change by the increase in the amount of salvage, but it should be kept in mind that a decline in prices is also possible.

(4) Outline of facilities

a. Scale of facility

Very few composting facilities are large in scale. When the scale becomes larger, troubles in the pretreatment stage tend to increase. When manual sorting is combined with composting, the treatment capacity of the former becomes a limiting factor. Thus, increase in the amount processed must be coped with by increasing the number of production lines, and in consideration of their interchangeability, the standard size of the production line shall be preferably 200 ton/16 hours a day.

b. Standard process flow

The standard process flow of the windrow system is as shown in Figure 3-3-2.

The manual sorting process and others were incorporated in consideration of the followings:

i. Manual sorting is added to the pretreatment stage to remove papers and glass. Glass must be removed as much as possible in this stage as otherwise it will be broken into pieces in the pretreatment stage and become commingled in the end product.

ii. Since the metals that will become commingled in the compost are anticipated to include used dry batteries and the like, these will be removed by adding a magnetic separation process.

iii. As a lot of ferrous metals and plastics, etc. will be contained in the rejects from the pretreatment stage, magnetic separation and manual sorting processes will be installed to recover reusable materials.

c. Material flow

The material flow in the standard process sequence is as shown in Figure 3.3.2. The material balance in each processing step will be as follows.

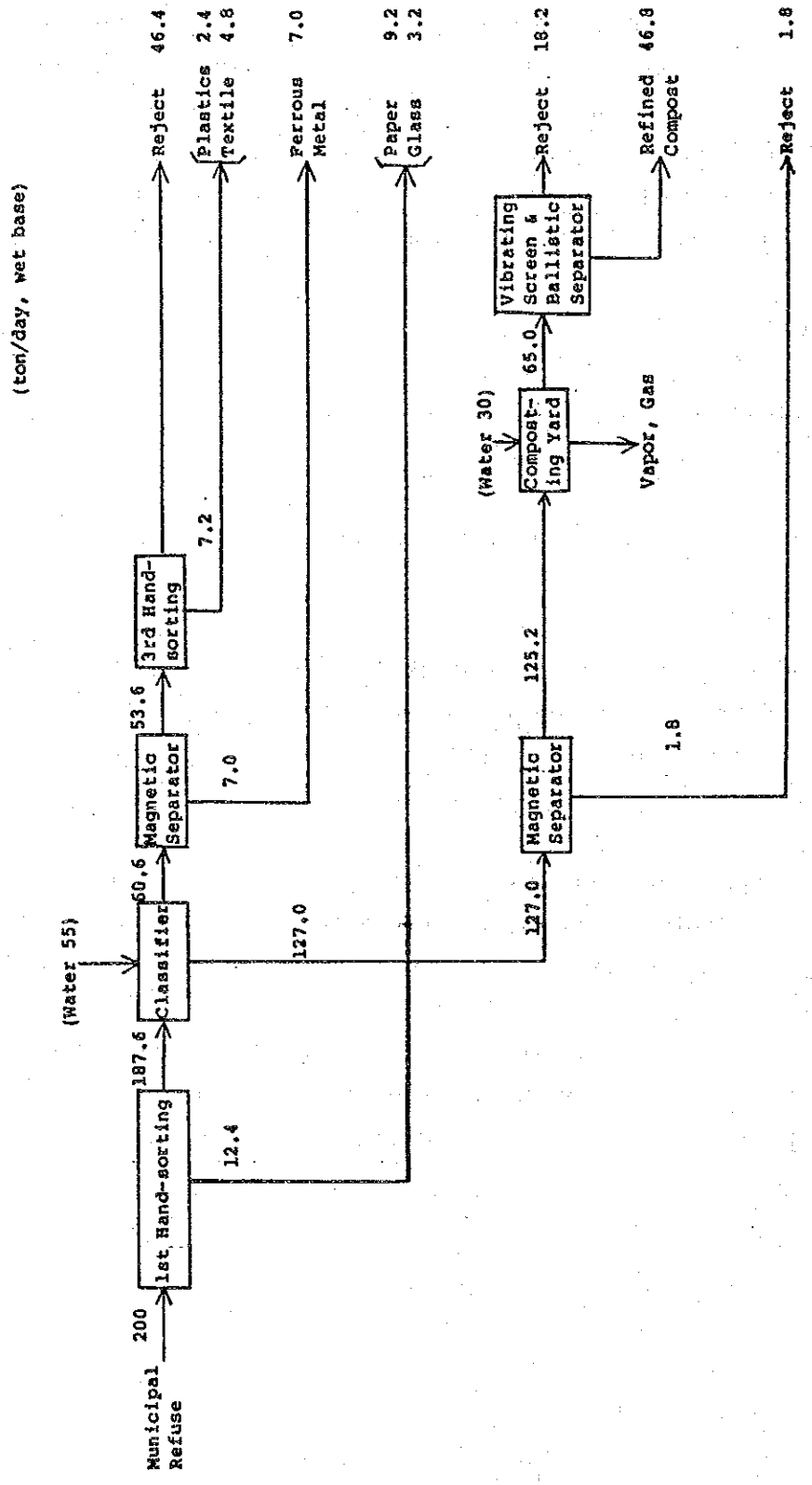



Fig. 3-3-2 STANDARD PROCESS FLOW OF WINDROW SYSTEM

i. Manual sorting stage

Paper and glass will be recovered. Paper such as large size corrugated cardboards, newspaper and magazines, and glass such as bottles are the major objects of salvage. As indicated in Table 3-3-5, 20% of papers and 40% of glass shall be salvaged during this stage.

ii. Pretreatment stage

90% of garbage/grass and glass, and 60% of papers are sorted for composting in Japan. Besides these, 20% of textiles, plastics, metals, etc. also become mixed into the materials for composting. To adjust moisture, about 55 tons of water a day is added to keep moisture content about 55%.

iii. Small sized metals and batteries and the like are removed in the magnetic separation stage. The removal rate is about 80% of magnetic substances.

iv. In the fermentation stage, about 30 tons of water per day are added to make up for moisture evaporated. In this stage, the volume of organic matter such as garbage/grass and papers will be reduced to about 60% by decomposition.

v. In the refining stage, about 90% of impurities will be removed. At this time, about 15% of compost is also removed.

vi. As a result, in terms of waste weight in Alexandria in 2000, 23.4% of waste will become compost, 13.3% will be recovered as reusable materials, and 33.2% will be rejected.

vii. With the change in waste composition, the production rate of compost and recovery rate of reusable materials will also change. The production rate corresponding to the waste composition of each year will be as shown in Table 3-3-9.

Tab. 3-3-9 PRODUCTION RATE OF COMPOST, REUSABLE MATERIALS AND REJECTS GENERATED

(Weight Percentage)

| | 1984 | 1990 | 2000 |
|---|---|---|---|
| Compost | 26.0 | 24.7 | 23.4 |
| Reusable materials | 9.3 | 10.8 | 13.3 |
| Reject | 29.4 | 31.6 | 33.2 |

d. Brief description of facilities

The process flow of a typical facility of one line with the processing capacity of 200ton/16 hours per day is shown in Figure 3-3-3. Layout of compost plant with 2 lines (400ton/day) is shown in Figure 3-3-4. Equipment list and operating staff for this facility are shown in Tables 3-3-10 and -11. Approximate construction cost of this facility is as shown in Table 3-3-12.

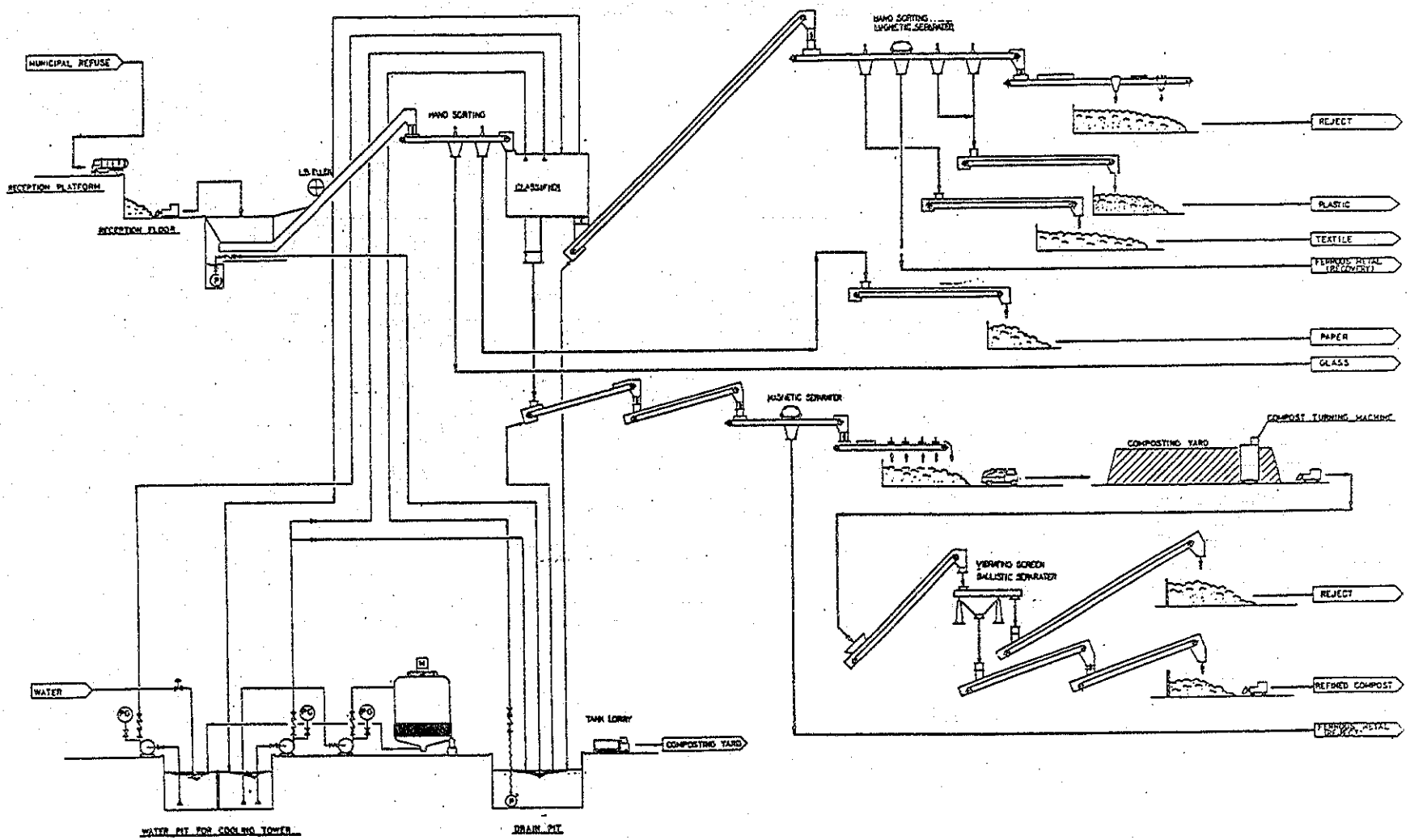
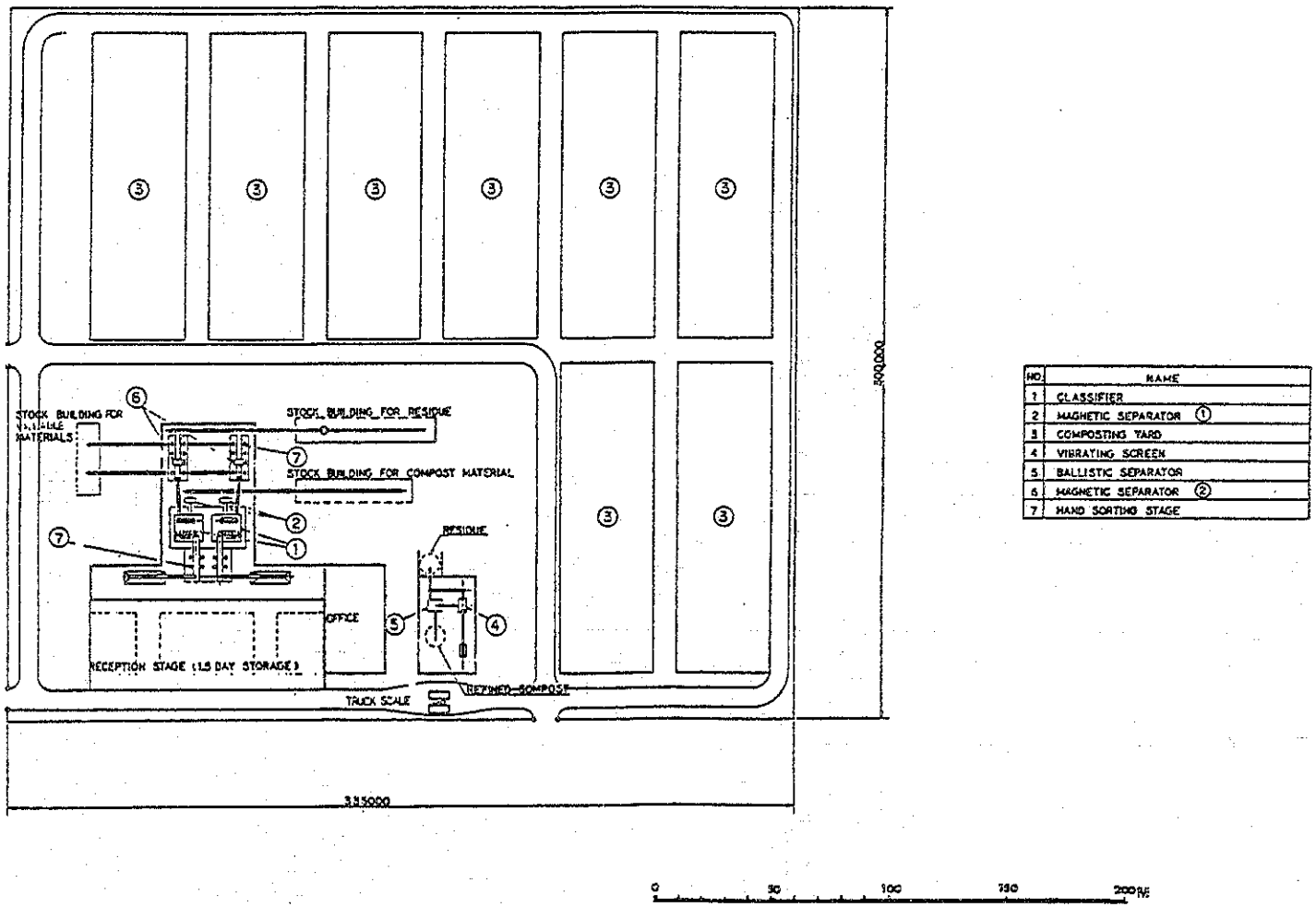



Fig. 3-3-3 PROCESS FLOW OF COMPOST PLANT (ONE PRODUCTION LINE: 200T/DAY)




| NO. | NAME |
|---|---|
| 1 | CLASSIFIER |
| 2 | MAGNETIC SEPARATOR ① |
| 3 | COMPOSTING YARD |
| 4 | VIBRATING SCREEN |
| 5 | BALLISTIC SEPARATOR |
| 6 | MAGNETIC SEPARATOR ② |
| 7 | HAND SORTING STAGE |

Fig. 3-3-4 LAYOUT OF COMPOST PLANT (400 T/DAY) (Cont.)

Tab. 3-3-10 SPECIFICATION OF COMPOST PLANT (400T/DAY)

| | | |
|---|---|---|
| Processing capacity | : | 400 t/day |
| Number of processing lines | : | 2 |
| Receiving/feeding | | |
| - Truck scale | : | 30t x 2 units |
| - Storage area | : | 2000$m^2$ |
| - Feeding conveyor | : | 1.5m width x 2 lines |
| - Shovel loader | : | 5.0$m^3$ x 2 units |
| Pretreatment facilities | | |
| - Hand sorting conveyor | : | 1.5m width x 2 lines |
| - Shredding and sorting equipment | : | 2 units |
| - Truck | : | 8t x 2 units |
| - Shovel loader for haulage | : | 5$m^3$ x 2 units |
| Fermentation facilities | | |
| - Windrow area | : | 63,000$m^2$ |
| - Turning machine | : | 6.6m width x 2 units |
| - Sprinkling vehicle | : | 3.8$m^3$ x 2 units |
| Refinning facilities | | |
| - Vibrating screen | : | 1 unit |
| - Repulsion separator | : | 1 unit |
| - Shovel loader | : | 5$m^3$ x 2 units |
| Rejects removing facilities | | |
| - Hand sorting conveyor | : | 0.9m width x 2 lines |
| - Shovel loader | : | 5$m^3$ x 1 unit |
| - Dump truck | : | 11$^t$ x 3 to 7 units |

Tab. 3-3-11 OPERATING PERSONNEL

| JOB CLASSIFICATION | NO. REQUIRED (PERSONS) | NUMBER OF SHIFT |
|---|---|---|
| Plant Director | 1 | 1 |
| Plant Manager | 2 | 2 |
| Operator, Maintenance Mechanic | 4 | 2 |
| Driver | | |
| Loader ($5m^3$) | 12 | 2 |
| Turning Machine (W=6.6m) | 4 | 2 |
| Tank Lorry (3-8t) | 2 | 1 |
| Truck (8t) | 4 | 2 |
| Loader (for haulage) ($5m^3$) | 1 | 1 |
| Truck (for haulage) (11t) | 3 | 1 |
| Sub-Total | 26 | - |
| Worker | | |
| Sorting 1 | 24 | 2 |
| Sorting 2 | 12 | 2 |
| Others | 6 | 2 |
| Sub-total | 42 | |
| Administrative | | |
| Entrance guard | 2 | 1 |
| Others | 7 | 1 |
| Sub-total | 9 | |
| Total | 84 | - |

Tab. 3-3-12 APPROXIMATE CONSTRUCTION COST OF 400 T/DAY COMPOST PLANT

| Description | QUANTITY | COST (IN LE 1,000) | REMARK |
|---|---|---|---|
| Machinery & equipment | 1 Unit | 6,256 | 200t/d/prod. line x 2 prod. lines |
| Building & foundation | 1 Unit | 5,120 | Plant site 10.0 ha |
| Sub-total | | 11,376 | |
| Heavy Eqt. vehicles | 1 Unit | 1,781 | Altogether 16 vehicles |
| Total | | 13,157 | |

(5) Sales revenues from compost and reusable materials

Sales revenues from salvaged reusable materials and compost per ton of processed amount are as follows.

Tab. 3-3-13 ESTIMATED SALES REVENUES FROM COMPOST AND RECOVERED MATERIALS (IN 2000)

| ITEM | RECOVERY RATE (%)* | SALES PRICE** | ESTIMATED SALES REVENUES*** |
|---|---|---|---|
| Recovered materials | | | |
| Paper | 4.6 | 30 LE/TON | LE 1.38 |
| Textile | 2.4 | 15 " | LE 0.36 |
| Plastic | 1.2 | 100 " | LE 1.20 |
| Glass | 1.6 | 27 " | LE 0.43 |
| Metal | 3.5 | 16 " | LE 0.56 |
| Sub total | 13.3 | - | LE 3.93 |
| Compost | 23.4 | 12.5 " | LE 2.93 |
| Total | 36.8 | - | LE 6.86 |

Note:

* Refer to Fig. 3-3-2

** Refer to Tab. 3-3-8

*** Sales revenues per one ton of waste

Estimated revenues from sale of salvaged materials are LE 3.93 per ton of waste, and revenues from sale of compost are LE 2.93, totalling 6.86 LE/ton of waste.

### 3.3.2 Sorting system

There are two methods to sort and then salvage such reusable materials as paper, glass, etc., either by using mechanical sorting methods after shredding, or by hand sorting. This study is conducted by focusing principally on hand sorting, because mechanical sorting requires plant and equipment investment and furthermore its maintenance and administration is not easy.

(1) Salvaged materials

At present, the following types of materials are being salvaged in Alexandria.

a. Paper

A considerable quantity of paper, including bad quality paper, is salvaged at the landfill sites.

b. Plastic

Some zabbaleen are salvaging plastic bins. Plastic sheets are salvaged only for use as household fuel, and they are not on the market.

c. Textile fibers

Textile fibers are expected to be salvaged at the Abis Compost Plant.

d. Glass

Glass is salvaged principally at home.

e. Metals

Scrap iron is scattered in the landfill after the open air burning of the waste, and it is salvaged by people specialized in the job.

f. Others

Bones are also salvaged, but their quantity is small.

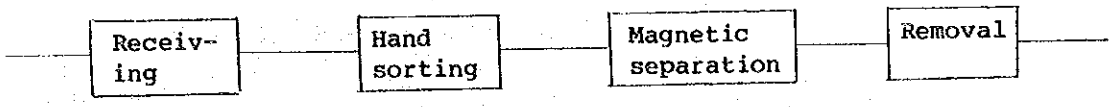
Therefore, paper, textile, plastic bin, metal and glass are to be salvaged in sorting plants.

(2) Outline of the facilities

a. Process flow

In the hand sorting system the process flow is very simple, as shown in the following figure.

Fig. 3-3-5 HAND SORTING BASIC FLOW




- Storage and volume control are carried out in the receiving stage.
- Useful materials are sorted and salvaged in the sorting stage.
- Scrap iron is salvaged by the magnetic separator in the magnetic sorting stage.
- In the removal stage, rejects are hauled to landfill sites.

b. Material process flow and sorting efficiency

The process flow in the hand sorting is shown in Figure 3-3-6. The sorting efficiency of each type of material is shown in Table 3-3-5, and the overall salvage rate is 15.4%.

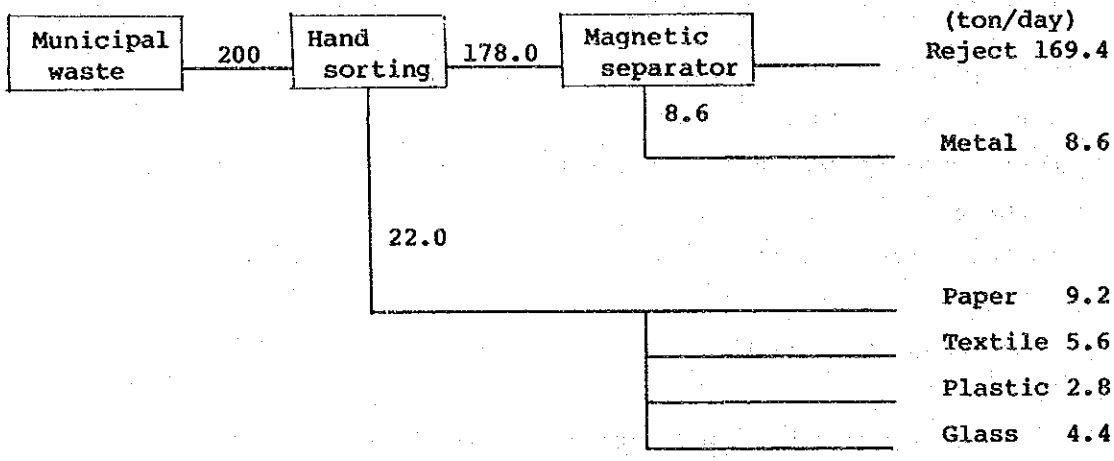
Tab. 3-3-14 SORTING EFFICIENCY BY KIND OF WASTE

| KIND | COMPOSITION x SALVAGE RATE | | A |
|---|---|---|---|
| Paper | 23% x 0.2 | = | 4.6% |
| Textile | 6% x 0.48 | = | 2.8% |
| Plastic | 9% x 0.16 | = | 1.4% |
| Scrap iron | 6% x 0.72 | = | 4.3% |
| Glass | 4% x 0.56 | = | 2.2% |
| TOTAL | | | 15.3% |
| Reject | | | 84.7% |

Note:

A: Salvage rate per unit weight of waste

Fig. 3-3-6 MATERIAL PROCESS FLOW




c. Scale of the facilities

The processing capacity of hand sorting is practically determined by the belt width and speed, but in general 10t/hr is regarded as the limit in a 900mm-width conveyor in Japan. On the other hand, the salvage rate depends on the amount of reusable materials contained in waste, its upper limit is regarded as 30% in Japan. This study assumes that reusable materials are salvaged from both sides of a 1.5m-width belt, and operating 16 hours a day.

The standard processing capacity is assumed to be of the order of 200ton/day.

d. Location of the facilities

The sorting facilities will be installed in landfill sites, because reusable material salvage rate is limited, and most of the reject must be landfilled.

e. Outline of the facilities

The outline of the hand sorting facilities is shown in Figure 3-3-7. The equipment and operation manpower of the sorting facilities are shown in Table 3-3-15 and Table 3-3-16, and the approximate construction cost is shown in Table 3-3-17.

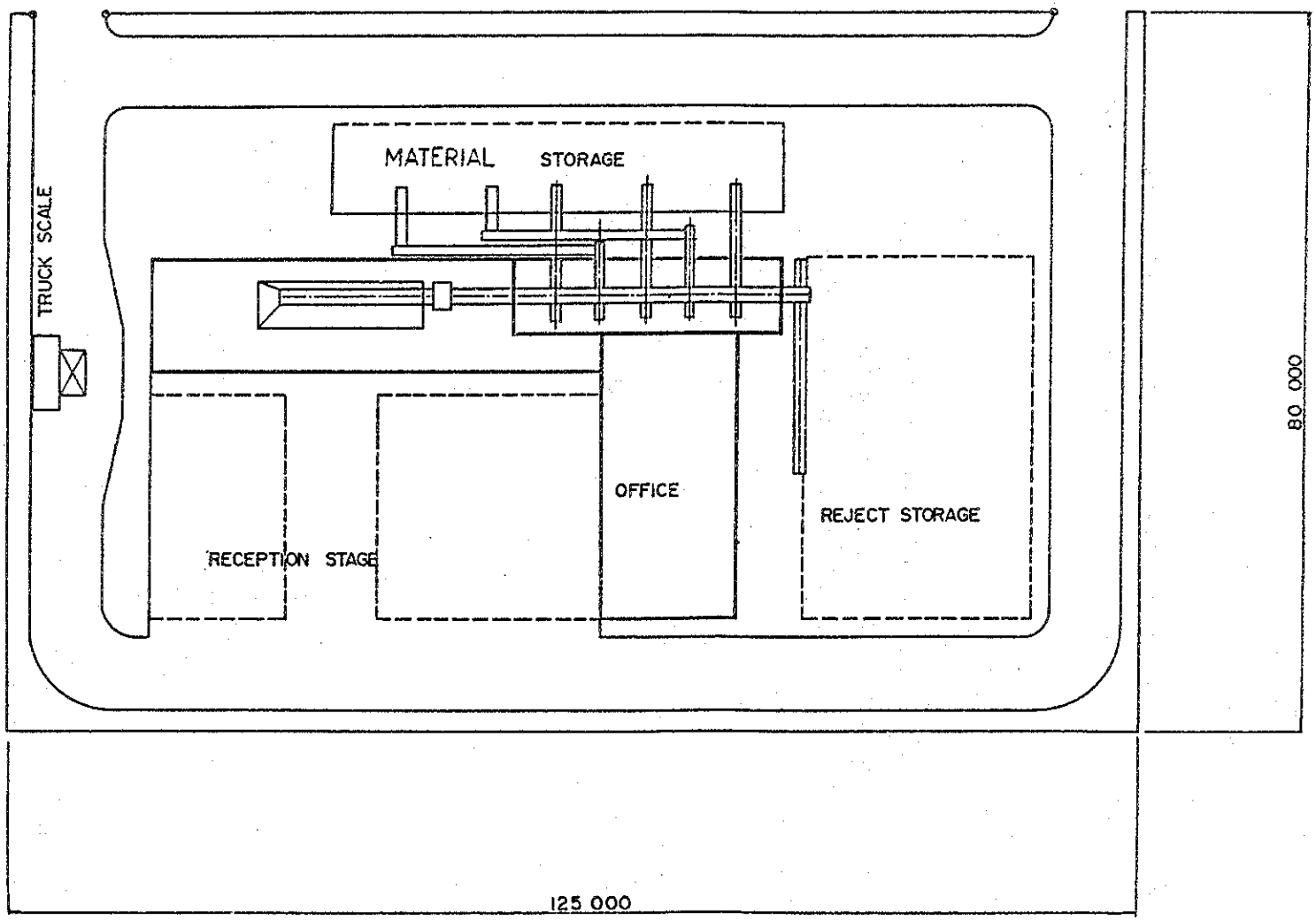



Fig. 3-3-7 SORTING FACILITY

Tab. 3-3-15 OUTLINE OF THE EQUIPMENT OF THE SORTING FACILITIES

| | | |
|---|---|---|
| Processing capacity | : | 200t/day |
| Number of processing lines | : | 1 |
| Receiving/feeding | | |
| - Truck scale | : | 30t x 1 unit |
| - Storage area | : | 1000m$^2$ |
| - Feeding conveyor | : | 1.5m width x 1 unit |
| - Shovel loader | : | 5m$^3$ x 1 unit |
| Hand Sorting facilities | | |
| - Belt conveyor | : | 1.5m width x 1 unit |
| Magnetic sorting facilities | | |
| - Magnetic separator | : | 2.0m width x 1 unit |
| Reject removing facilities | | |
| - Shovel loader | : | 5m$^3$ x 1 unit |
| - Dump truck | : | 11t x 3 units |

Tab. 3-3-16 MANPOWER REQUIRED FOR OPERATION

| | MANPOWER (PERSONS) | NUMBER OF SHIFTS |
|---|---|---|
| Plant director | 1 | 1 |
| Plant manager | 1 | 1 |
| Operator & maintenance | 2 | 2 |
| Driver | | |
| - Shovel loader (for receiving use) | 2 | 2 |
| - Shovel loader (for haulage use) | 1 | 1 |
| - Dump truck (for haulage use) | 3 | 1 |
| Sub-total | 6 | - |
| Worker | 20 | 1 |
| Sub-total | 30 | - |
| Administrative personnel | | |
| - Entrance | 1 | 1 |
| - Others | 2 | 1 |
| Sub-total | 3 | - |
| TOTAL | 33 | - |

Tab. 3-3-17 APPROXIMATE CONSTRUCTION COST OF SORTING FACILITIES (200T/D)

| | COST (LE 1000) | REMARKS |
|---|---|---|
| Mechanical equipment | 1,836 | 200t/d 1-line |
| Building and foundation | 1,824 | Site area 1 ha. |
| Sub-total | 3,660 | |
| Heavy machines & vehicles | 356 | Total 5 units |
| TOTAL | 4,016 | |

(3) Sales revenue of reusable materials

The sales revenue of reusable materials salvaged by sorting from each ton of municipal refuse is as shown in the table below:

Tab. 3-3-18 SALES REVENUE OF REUSABLE MATERIALS SALVAGED BY SORTING

| | RECOVERY RATE (%)* | SELLING PRICE (**) (LE/t) | SALES REVENUE (LE/t MUNICIPAL WASTE) |
|---|---|---|---|
| Paper | 4.6 | 30 | 1.38 |
| Textile | 2.8 | 15 | 0.42 |
| Plastic | 1.4 | 100 | 1.40 |
| Glass | 2.2 | 27 | 0.59 |
| Metal | 4.3 | 16 | 0.69 |
| TOTAL | 15.3 | --- | 4.48 |

Note:

* Based on Tab. 3-3-14

** Based on Tab. 3-3-8