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REPORT

ON

COLLECTION AND DISPOSAL OF REFUSE

COMMITTEE ON PLAN PROJECTS
(Buildings Projects Team)
New Delhi.

May, 1964.

Composition of the Buildings Projects Team

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Leader

Shri S.K. Patil, M.P., Formerly.Minister for Food and Agriculture.

Members

Shri Sarup Singh, I.S.E.(Retd), Formerly Director, National Buildings Organisation.

Shri N.G. Dewan, I.S.E., Chief Engineer, Central Public Works Department.

Maj. Genl. Harkirat Singh, Engineer-in-Chief, Army Headquarters.

Shri N.V. Modak, Consulting Public Health Engineer, Bombay.

Shri C.B. Patel, Director, National Buildings Organisation (ex-officio).

Member-Secretary

Shri T.S. Vedagiri, Chief Industrial Engineer, Bhilai Steel Plant, Bhilai.

Engineer

Shri M. Thyagarajan.

Composition of the Panel of the 'National Water Supply & Sanitation Schemes'.

Chairman

Shri N.V. Modak, Consulting Public Health Engineer, Bombay.

Members

Shri P.C. Bose, Executive Director & Chief Engine Calcutta Metropolitan Planning Organisation, Calcutta.

Shri R.D. Verma, Member (P), Oil & Natural Gas Commission, Dehra Dun.

Shri S. Rajagopalan, Dy. Director General (P.H.E. Ministry of Health, New Delhi.

Member-Secretary

Shri T.S. Vedagiri, Chief Industrial Engineer, Bhilai Steel Plant, Bhilai.

S.K. Patil, M.P.,
Leader, Buildings Projects Team.

Committee on Plan Projects,
New Delhi.

May 19, 1964.

My dear Nandaji,

I have great pleasure in forwarding herewith the Report of the Buildings Projects Team on Collection and Disposal of Refuse. You will recall that the study of National Water Supply and Sanitation Schemes was undertaken by this Team at the instance of the Ministry of Health and the Planning Commission. The work was entrusted to a Panel of experts under the Chairman-ship of Shri N.V. Modak and the report brought out by the Team has already been published.

While the work was in progress, the Ministry of Health, in consultation with the Planning Commission, entrusted to the Panel the following additional items for study:

(a) Water resources conservation and pollution control;
(b) Collection and disposal of refuse.

The Report on the first item has been completed and published and the present Report is on the last item.

The Report deals with the subject of collection and disposal of refuse as an essential and indispensable service. It has brought out the several cardinal principles in regard to this service which need great emphasis. Firstly, as it is one of the most

costly services, efficiency and cost must be kept in proper perspective. Secondly, its modern technique is such that it requires properly qualified trained personnel; and thirdly, it needs to be dealt with strictly on commercial lines.

For the past two decades, major cities in the advanced countries have been making strenuous efforts to make this service as hygienic and sanitary as possible, compatible with economy. This resulted in considerable changes in the method of collection and disposal of refuse. The present emphasis is on

(1) Building up a sound organisation under a unitary control;

(2) Suitable changes in the method of collection, storage and transport to meet the ever changing character of the town refuse; and

(3) More hygienic and economical methods of disposal.

In order to make themselves acquainted with the prevailing conditions of this service in the country, the Panel visited a few towns and had discussions with the local officers and collected information from various municipal authorities by issuing a questionnaire. The spot study and the scrutiny of the information revealed that the importance of this service in the promotion of public health was not fully realised by the local bodies. In the last two or three decades, many advances have been made in the foreign countries

and these have been touched upon in the body of the Report. In view of the importance of the problem, the Panel has felt that the Central and State Governments should take steps to urge the local authorities to pay more attention to these services with a view to tackling it with sincerity and urgency it demands.

The study of the Panel has not been so deep as to warrant an all-India acceptance of its recommendations. The Panel feels, that for this purpose, a special Committee with all-India representation should be appointed to go into the details and make suitable recommendations for application in different parts of the country. It has not also gone into the financing implications of the entire question in view of the limited scope of its assignment. It has, however, emphasised that the collection and disposal of refuse is an essential amenity for urban communities just as water supply and sewerage and that all these should receive equal priority.

I hope that this Report will go a long way towards clarifying technical assessment of the system of refuse storage and collection.

Yours sincerely,

S.K. Patil

Shri G.L. Nanda,
Minister for Home Affairs &
Chairman, C.O.P.P.,
New Delhi.

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0.1 It was in the fitness of things that the Planning Commission and the Union Ministry of Health have entrusted the Panel for National Water Supply and Sanitation Schemes to study the existing practices in the country in regard to collection and disposal of refuse and to suggest ways and means to make them more effective and economical. This is because, 'public cleansing' which is mainly concerned with the collection and disposal of house and trade refuse and cleansing of streets, plays the same role in the promotion of public health as the provision of protected and adequate supply of drinking water and the hygienic disposal of excreta and the 'spent' waters of the community.

0.2 The problem of collection and disposal of refuse has been associated with man from the beginning of community living to the present time. It has become more acute with advancement of civilisation.

0.3 Public cleansing is an essential and indispensable sanitary service and is one of the most costly services provided out of the rates. In the United States of America, some 400 million

pounds of refuse are produced every day by urban populations. To collect and dispose of this refuse, the communities in the United States, are spending more than one million dollars annually. In Bombay the cost of collection and transport of refuse to the railway siding and therefrom to the place of disposal is over 16 Rupees per ton. With a production of about 2,000 tons of refuse per day, the cost per day works out to 32000 Rupees. In Calcutta, the cost per ton is about Rs.11. In England & Wales, the quantity of refuse dealt with annually is around 13½ million tons from a population of about 47 million persons and its cost in 1961-62 was £ 40 million for collection and disposal. In terms of rate poundage the cost of this service in urban areas, outside London, ranged between 1s-3d and 1s-4d as compared with 1s-4d to 1s-6d for sewerage and sewage disposal.

0.4 There are several cardinal principles in regard to this service which need great emphasis. Firstly, as it is one of the most costly services, efficiency and cost must be kept in proper perspective; secondly, its modern technique is such that it requires properly qualified and trained personnel; and thirdly, it needs to be dealt with strictly on

business lines and this can only be done by maintaining strict and accurate costing returns for each phase of its operation and utilising them, as a part of the ordinary routine management, for further improvement and reduction in cost.

0.5 For these reasons, all proposals connected with this service have to be decided on strict business lines and not judged on any general programme but according to the proved value of local conditions such as practical testing of different types of vehicles used for collection and transport of refuse, the adoption of particular method of disposal best suited to the locality and so on.

0.6 For the past twenty years or so, major cities in the advanced countries have been making strenuous efforts to make this service as hygienic and sanitary as possible compatible with economy. This has resulted in considerable changes in the method of collection and disposal of refuse. The present emphasis is (1) on building up sound organisation under a unitary control, (2) suitable changes in the method of storage, collection and transport, to meet the everchanging character of the town refuse and (3) more hygienic and economical methods of disposal.

0.7 To achieve these objectives, this service has been developed and is being developed on scientific lines. It is being highly mechanised demanding a high degree of technical skill for efficient and economical performance. In fact, this long forgotten service is rapidly maturing in stature to become a professional service and science, it deserves to be.

0.8 If this sanitary service is not properly planned and practised, it will result in creating insanitary conditons and help to create growth of flies and rodents. It has been estimated in the U.S.A. that proper refuse sanitation will do 90% of the job in fly control and 60% in rat control.

0.9 It is also the experience of a large number of cities abroad, that good refuse sanitation together with general maintenance of premises greatly reduces the pest mosquito population. Insect and rodent - infestation in houses and in business premises result from neglect of basic responsibility of cleanliness. Food, harborage and water - life essential for insects and rodents - occur frequently, in and around all types of buildings wherever these vermins prevail. Vermin prevalence increases rapidly as the standards of maintenance and living drop. Ill-maintained and sub-standard housing produces and helps to maintain more wide-spread vermin

population than well-kept and clean residential and business areas. The basic reasons for the existence of such conditions are lack of knowledge, carelessness and indifference on the part of the citizens. The only way to bring home to the citizens the necessity of keeping the houses, business places and their environments clean, is to educate them in sanitation and public health.

0.10 It would be evident from the foregoing that the main considerations in the methods employed for operation of public cleansing service, are cost, health, sanitation, convenience and aesthetics. An engineering evaluation of all these factors is necessary to determine which method or methods are more satisfactory.

0.11 This service has also to be treated as a major material handling project, where industrial engineering practices and time and motion study could help in increasing efficiency and reducing costs. Modern trends in foreign cities are to find out practical means of destroying as much waste as possible on the premises and thereby reducing to the minimum the cost of labour for collection and ultimate disposal.

0.12 Public cleansing service includes four inter-dependent phases of (a) storage (b) collection (c) haulage and transport to the site of disposal and (d) disposal proper.

0.13 In order to make themselves acquainted with the prevailing conditions of this service in the country, the Panel visited some towns and collected information from various Municipal authorities by issuing a questionnaire. The spot study and the scrutiny of the information revealed that the importance of this service in the promotion of public health was not fully realised either by the municipal authorities or by the citizens and that it was being rendered in a very perfunctory and unsatisfactory manner even in cities like Bombay, Delhi and Calcutta, let alone smaller cities like Lucknow, Jabalpore, Madras etc.

0.14 In big Cities, street and gully sweepings are generally collected by municipal sweepers and either deposited into mobile vehicles visiting the locality or taken to stationary trailers or communal bins. Stationary trailers are cleared by a mechnaical horse or jip in order to save the manual labour for loading. Areas which are served by mobile traction are manned with labourers attached to the vehicles for loading and unloading.

0.15 House refuse is deposited and stored in small dust bins and is collected from the houses by Municipal labour staff, in areas where house to

house refuse collection system is in operation. In other areas private sweepers or domestic servants are directed to deposit the daily refuse in stationary trailers or bottomless bins from where it is cleared by the mechanical horse or by trucks to the dumping ground. Where communal bins are not provided, the householders pile the refuse on the roads creating insanitary conditions and this refuse is picked up by mobile trucks or carts.

0.16 The stationary trailers and communal bins are a source of nuisance in the existing Cities because there are no convenient sites for them. The collection vehicles leave much to be desired. They are open and their number is inadequate to handle the daily volume of refuse. They are not properly looked after and maintained in good condition. This results in frequent breakdowns and dislocation of the service. Enough stand-by vehicles are also generally not available and in Cities like Bombay and Calcutta a large number of vehicles have to be hired daily from other authorities. As such hired vehicles are a make shift arrangement, they are not suitable for refuse collection work and consequently they consume more time during loading and unloading operations.

This ultimately results in lesser number of trips to the dumping ground and in loss of efficiency which means higher cost for the service.

0.17 As skilled labour is not available for doing this type of work, a large number of unskilled labour has to be employed which results in higher cost and reducing efficiency. In India, 10 men are required to do the work which is handled by two persons in Europe due to high mechanisation. For this reason, mechanisation of the service is desirable to the fullest possible extent, in suitable stages, to meet local conditions.

0.18 The disposal of refuse is usually done in the form of open dumps which cause a lot of smoke, fly and rodent nuisance to the residents of the new residential developments in the vicinity of the open dumps. In Bombay, it will be very difficult to make use of Deonar dumping ground, in a few years from now, as a result of fast pace of development of surrounding areas. Other suitable methods of disposal may have to be thought of pretty soon. The site of dumping at Delhi will have to be shifted as the present site being on

the upstream side of the water-works intake of the Capital is contaminating the Capital's water supply.

0.19 The problem of refuse collection, transport and disposal is very complex from the public health point of view. In the last two or three decades, many advances have been made in foreign countries in these fields and these have been touched upon in the body of the report. Looking to the importance of the problem, the Panel feels that the Central and State Governments should take steps to urge the local authorities to pay more attention to this service with a view to tackling it with sincerity and urgency it demands.

0.20 Further, this service requires a large number of labour force and its cost is on the increase due to the continuous rise in the wage bill. It may be difficult in the near future to get the requisite well-trained personnel for this service as it is being considered degrading and is not attractive to the skilled labour. Emphasis must therefore be placed on making it more pleasant and less tiresome by providing facilities like bathing places for cleaning after work and by mechanising the same to the fullest possible extent in suitable stages with a view

to reducing the number of staff to the minimum. Insistence must also be placed on the municipalities to keep proper costing account of every phase of this service to enable review being made at intervals to assess the standard of service and the cost incurred with a view to improvement.

0.21 Unfortunately, the study of the Panel has not been so deep as to warrant all-India acceptance of its recommendations. The Panel feels that for this purpose a special Committee with all-India representation should be appointed to go into the details and make recommendation suitable for application in different parts of the country as has been done in the case of collection and disposal of night soil from hand served latrines both in sewered and unsewered areas of the towns and cities. This report does not touch on the collection aspect of night soil but it does deal with the question of its disposal by mixing it with refuse for converting it into a good compost.

0.22 It would not be irrelevant to mention that the British Government have recently appointed a Working Party to examine local authorities refuse collection service. The terms of reference

of this Working Party are "to examine the facts of refuse collection; to what extent it is unsatisfactory; what their difficulties are; what methods are proving most successful; and to consider what advice can be given to the local authorities how to obtain best results". The working party has started work on this difficult and complicated job involving many technical considerations which are not always apparent to the inexperienced observer. This report, when published, will go a long way towards clarifying technical assessment of the systems of refuse storage and collection. It is quite likely that the Minister of Housing and Local Government may be persuaded to appoint another Working Party to consider the problems of refuse disposal when the present Working Party completes its work.

0.23 The Committee has not gone into the financing implications of the entire question in view of the limited scope of its assignment. There is, however, unanimity of opinion that refuse collection and disposal is an essential amenity for urban communities just as water supply and sewerage, and that all these three facilities should receive equal priority. Local finance is a problem bristling with difficulties and local bodies may feel inability to discharge any or all of these obligations because of their financial limitations. It is necessary that this problem is examined in detail by the appropriate authorities, so that appropriate and adequate resources are made available to the local authorities.

0.24 The Panel have pleasure in expressing their gratitude to the officers of the local authorities and others for supplying the information asked for and for arranging visits to the sites of disposal works. The Panel also records its appreciation of the help given by Shri R.N. Vasudeva, Secretary of the Committee on Plan Projects.

SUMMARY OF RECOMMENDATIONS

1. The bins placed in the houses should be standardised. Their weight and the material of which they are made should be light, fire resisting and should be provided with hinged lids. Whether these should be provided by the local authority by charging fixed rent will depend upon the financial resources of the authority and local conditions.

2. House to house collection, which is costlier may not be within the means of small & medium size municipalities but such a service could be introduced in larger municipalities in stages. It is sanitary but costly.

3. If house to house collection is introduced, a question may arise whether it should be of the kerb collection or the back yard collection type. The latter costs more. For the introduction of such a service the houses from which collection is made must be suitable as to facilitate easy removal of the household dustbin from the house to the kerb. If back yard collection is practised, the site of the dust bin in the yard must be easily accessible to the refuse collector. This is not possible in row houses unless provided with a service lane.

4. Communal or public dust bins will continue to be used in almost all the cities and towns. Their location and design demand serious thinking. The design should be such that it creates no insanitary conditions in its vicinity. It should also not be accessible to vagrants and stray animals.

5. Special sites for communal or public dust bins must be created in suitable positions in the built up areas of the town because with the increase in traffic it should not be desirable to continue them in their present positions on the streets. Their number should be sufficient to prevent householders piling the refuse on the streets.

6. It will be advisable for the municipality to insert a bylaw in the building-byelaws that while submitting building plans to the municipality for approval of site or sites, the household dust bins or bins should be shown on the plans.

7. In preparing development plans for the undeveloped areas of the town or city, sites for communal dust bins should be earmarked in advance.

8. The provision of good, clean, unobstrusive and accessible storage on the premises is a great asset.

9. Samples of refuse from a few Cities should be regularly analysed to determine their composition and weight after evolving a standard method for the sampling and analysing.

10. Correct assessment should also be made of the quantity of refuse production per capita per year.

11. In any system of refuse collection, the collection vehicles are the most important factor. Hence standardisation of two or three types of vehicles to suit refuse collection work is necessary. Suitable vehicles for refuse collection are not being manufactured in the country.

Indigenous manufacture should be encouraged.

12. A Committee of experts should be appointed to prepare standard specifications for refuse collection vehicles.

13. The question of changing the body of the vehicle from mild steel to alluminium should also be considered by the expert Committee as such a vehicle may prove economical in the long run.

14. It is desirable to make suitable arrangements for garaging, servicing and repairing of the vehicles.

15. Preventive maintenance should be enforced upon rigorously. This increases the life of the vehicles.

16. It may be necessary to give a subsidy, or loan to the local authorities for purchase of vehicles as many local authorities are not in a position to purchase them with-in the means at their disposal.

17. As the life of the vehicle depends upon the manner it is driven competent mechanic drivers should be engaged. It is worthwhile to consider the grant of certain incentive bonus to the drivers, who keep their vehicles on the road in good working condition.

1. STORAGE AND COLLECTION OF REFUSE

1.1 What constitutes Municipal Refuse

1.1.1 Municipal refuse collected in Indian towns is an extremely heterogenous material. It contains things of various sizes from the dust of the road to large metal drums, from vegetable leaves to fragments of wood, from pieces of waste paper to large cartons , from glass bottles to worn-out tyres, from fragments of bones to a carcase of a dog, from bits of clothing to bundles of cotton wool or gauze used for dressings and discarded. It also contains night soil. In short, municipal refuse in Indian towns includes every thing that a man rejects or emanates from his activities and what has to be removed from the place where he lives, works or moves for recreation and other purposes.

1.1.2 Under the municipal Acts, the work of scavenging removal, and disposal of excrementitious and other filthy matter, including ashes refuse and rubbish is one of the obligatory duties of the Municipal authority.

1.1.3 Some Municipal authorities have included the definition of house refuse in the municipal Acts. In Bombay Municipal Corporation Act, there is no definition of 'house refuse' but the definition of trade refuse reads as follows:-

"Trade refuse means and includes the refuse of any trade, manufacture or business".

Under the Public Health Act of London (1891), the expression house refuse means ashes, cinders, breezes, rubbish, night soil and filth but does not include trade refuse.

1.1.4 In U.S.A. refuse if defined as putrescible and nonputrescible solid wastes (except body wastes) including garbage, rubbish, ashes, street cleansing, dead animals, abandoned automobiles and solid market and industrial wastes.

1.1.5 Garbage, on the other hand, is defined as putrescible animal and vegetable waste, resulting from the handling, preparation and consumption of food.

1.1.6 Again, rubbish, as per American definition, consists of nonputrescible combustible and non-combustible materials, such as, paper, card board, tin cases, yard chip ings wood, glass, bedding, crockery, metals and similar objects.

1.1.7 Ashes according to the American definition are the residue from the burning of wood, coal, coke or other solid combustible materials.

1.2 Character and composition of refuse

1.2.1 Over a quarter of a century or so there have been vast changes in the character and composition of house hold refuse all over the world. Numerous factors such as geographic location, weather, season of the year, social and economic character of the community influence the character and composition of refuse as also the quantities of refuse produced.

1.2.2 Very few local authorities in India regularly analyse the refuse collected by them. Consequently, correct information regarding the composition of refuse collected in Indian towns is not available. The following table gives the composition of Bombay's refuse -

Constituents	Percentage
1. Hay & Straw	17.57
2. Paper & dry rags	6.46
3. Vegetable dry matter	53.60
4. Vegetable wet matter	5.77
5. Tin & metal	0.13
6. Dust & ash	13.90
7. Glass & Crockery	0.52
8. Offal - fish	2.05
Total:	100.00

The refuse of Bombay contains more paper & straw than that of Calcutta.

1.2.3 The analysis of house refuse in England and Wales is tabulated below:-

	National average in 1962.
	%
Fine dust and small cinder (under ½")	30.72
Cinder 1½ to 1¾"	12.91
Vegetable and putrescible matter	10.98
Paper	21.26
Metals (ferrous & non-ferrous)	6.61
Rags	2.62
Glass	8.06
Unclassified debris	6.84
	100.00
Density of refuse lb/ft	15.36
Average weight per house per week (lbs.)	31.05
Volume per house per week (ft^3)	2.08.

1.2.4 During certain seasons of the year, considerable quantities of the residue of mangoes, melons and similar fruits form part of the refuse of most of the Indian towns. Besides, coastal-town-refuse contains coconuts from which the milk has been extracted. Broken pottery from tea vendors is also to be found in the refuse of some towns.

1.2.5 From the point of view of collection and disposal, probably the most important properties are unit weight, the total moisture content and the percentages of putrescibles and combustibles.

1.2.6 It is reported that one cube yard of refuse in Bombay weighs 360 to 400 lbs against 1000 lbs per cube yard of Calcutta refuse.

1.2.7 Refuse in India is much heavier per cube yard than that of foreign Cities because of the inclusion of street sweepings. This practice increases the total percentage of dust, cinders & ashes.

1.2.8 Some information regarding the composition of refuse in Europe, England & U.S.A. is tabulated in Appendices 1 & 2.

1.2.9 There are at present no standard methods of sampling and analysing the refuse. Tentative methods of analysing refuse and compost have been published recently in the New American Manual 'Municipal Refuse Disposal'. Similarly, in Europe, E.A.W.A.G. have published tentative standard methods for the examination of refuse. The Institute of Public

Cleansing, Great Britain, has brought out a 'memorandum on procedure for making quantitative analysis of seasonal dry refuse'.

1.2.10 There is an urgent need for laying down standard methods for the sampling and analysing of refuse collected in Indian towns.

1.3 Quantity of refuse per capita

1.3.1 In large Indian towns, the quantity of refuse produced per capita varies on an average between 1.2 to 1.8 lbs, while in small towns the quantity ranges between 1/2 and 3/4 lbs per capita per day. In the case of New Delhi, the average works out to over 2 lbs per capita per day. This is due to the fact that New Delhi has special problems during the months of July and September when there is a large amount of horticultural cuttings to be disposed of.

1.3.2 In Tokyo (Japan) (population about 9.3 millions) the quantity of refuse per capita per day is about 1.07 lbs.

1.3.3 In U.S.A., it is reported that each person produces refuse ranging between 2.05 to 4 lbs per day. The community refuse (commercial & industrial) in the same country averages between 3 to 5 lbs per capita per day. It is noticed that the volume of garbage per capita is decreasing with the increased use of frozen packaged foods but at the same time there is a corresponding increase in household rubbish such as paper containers, cases and bottles.

1.3.4 In European countries and on the Continent, the quantity of refuse and street litter is substantially less than that in America. There are indications that the quantity of refuse per capita is on the increase in France and Germany due to their progressively increasing economy and attendant rise in incomes and standard of living.

1.3.5 It is axiomatic that increase in living standards generate proportionate increase in the per capita production as well as changes in the character of refuse. With the progressive increase in the standard of living per capita production is bound to increase in our country together with changes in its composition. This factor should not be lost sight of when preparing long-range schemes for the collection and disposal of refuse.

1.3.6 For the sake of comparison, among different cities, countries and cultures, the present trend is to record production of refuse per capita per year, instead of per capita per day, to eliminate seasonable differences and local variations in operating practices. In European countries, the production per capita per year ranges between 480 to 650 pounds - which

may be said to be about 1/2 to 1/3 of the per capita production per year, in U.S.A. In India, the average production of refuse per capita per year in the cities like Bomay, Calcutta and Delhi may be taken to vary between 400 to 425 pounds and for the small cities between 225 to 300 pounds per capita per year.

1.3.7 The calorific value of refuse must also be known to arrive at an economical method of disposal. Bombay refuse though of low calorific value, is found to be suitable for being disposed of by incineration for eight dry months of the year without the use of any auxilliary fuel. It is not however suitable for burning by itself during the rainy season due to its wet condition.

1.3.8 The average calorific value of refuse in British Isles varies between 5500 to 3300 BTU per lb in winter and summer respectively. This heat value is low as compared with that of coal which ranges between 8000 to 14500 BTU per lb.

1.4 Storage of refuse on the premises

1.4.1 Household refuse cannot be removed from houses or premises as soon as it is produced. It must be stored on the premises for as short a period as possible. In our country, due to climatic

conditions, it must be removed daily. The way in which the refuse is stored in the houses or on premises has a bearing on the method employed for its final disposal. Further, poor storage before collection can nullify the best system of refuse collection. Storage on the premises or in the houses is the weakest link in the Public Cleansing Service.

1.4.2 In European countries, collection is not made daily. The frequencies of collection vary from two or three times per week. The collection is bcombined. There is no attempt for any separation of segregation at the sources of collection as used to be the case in the U.S.A. until very recently where 'garbage' was stored in a separate bin or container and 'rubbish' in another.

1.4.3 In our country, there is only one common receptacle for the storage of houschold refuse on the premises though in a majority of cases, the house-wife does not place in the receptacle, salvagable materials like old newspapers, bottles etc. which fetch some price.

1.5 <u>Responsibility for refuse storage</u>

1.5.1 Adequate refuse storage on the premises is the

individual responsibility of the occupant. However, the local health authority has the authority to require sanitary refuse storage at all premises. Proper refuse storage involves more than merely providing a sufficient number of bins to hold the volume of refuse produced between collections. It also involves selection of an approved type of bin. The size of the bin should be such that it should be possible to carry it comfortably, when full, without straining the dustman. If too small, additional bins would be required - resulting in the increase in the cost of 'carrying' unnecessarily.

1.6 Receptacles used for storage

1.6.1 Receptacles of various sizes and shapes are used not only in our country but in some parts of the world. It is necessary to standardise the size and shape of the receptacle to increase the ease and efficiency of collectors and to ensure sound fly and rat-proof storage. The design of the receptacle must be such that its cover cannot be removed by animals and the dustman can lift it automatically without having to study its size and shape in advance.

1.6.2 In general, the receptacles used for storage of refuse should be water-tight, provided with a tight fitting lid, rust resistant, structurally strong to withstand handling stress, capable of being easily filled, emptied and cleaned and of such a size that when full can be conveniently handled by one man. It should be furnished with side handles or a bail. Usually galvanised iron is used in the manufacture of household receptacles.

1.6.3 The containers or bins used in Europe are of galvanized heavy guage metal construction with sound deadening replaceable rubber gaskets. In some cases, they are made completely of rubber or non-inflamable plastics. Noiseless containers are being standardised in Paris.

1.6.4 In England, the bin or container has a capacity of 2½ Cft. for average domestic refuse but when more paper cartons are involved the capacity is increased to 3½ Cft.

1.6.5 In Bombay, and Calcutta where daily collection is made, the capacity of the container approved by the Corporation for household is 2 Cft. There are over one lakh bins in use in Bombay City. The Corporation has the power to lay down standards

as regards size and shape and have powers also to enforce their instalment in the household. These bins are to be provided by the owner and not by the Corporation.

1.6.6 In Europe, capacities of containers range from 15 to 25 gallons with corresponding weights when empty of 20 to 28 pounds each. In U.S.A. the container has a capacity of 20 to 30 gallons. When used for 'garbage' alone its capacity ranges between 5 to 12 gallons.

1.6.7 Paper racks for the storage of refuse in the household are also coming to the forefront in England and European countries.

1.7 Public or communal dust bins

1.7.1 In Indian towns, in addition to individual container or dust bin, public or communal containers or dust bins built of masonry or galvanised iron sheets are located at convenient points in a street of an alley to allow the householder to empty his refuse therein. It creates insanitary conditions, harbours rats and flies and is a menace to public health. Most designs of such receptacles do not allow for easy emptying which is also pronounced disadvantage. Communal bins being a necessity in Indian towns, their design needs considerable thinking with a view to improvement.

1.7.2 In Bombay, 190 scamell and other trailers of 3 tons capacity each are used for this purpose but to keep them in a sanitary condition a man is required to be stationed at the site of the trailer for a longer part of the day to see that the householder empties the refuse in the trailer and not outside the trailer. This trailer when full is taken to the destination by a mechanical horse after replacing it by an empty trailer. There are 16 mechanical horses working in two shifts of eight hours each, in Bombay. The quantity of refuse collected by the system is about one third of the total collection.

1.7.3 Such stationary bins for bulk storage must be of rat proof construction with tight fitting lids or doors covered with sheet metal. They should also provide facilities for easy emptying without creating any nuisance.

1.7.4 Sunken communal bins should be discouraged. Their disadvantages are:

(1) the pit is difficult to be kept clean;

(2) greater lifting effort is required by the collection personnel;

(3) the method is not suitable where ground water level is high or rainfall is heavy;

(4) maintenance cost for hinges and cover is high and

(5) high initial cost.

1.7.5 Great care is required to be exercised in the siting of the communal bins. They should be within an easy reach of the householders. The housewife or her servant should not have to walk a distance of more than 300 to 400 ft. It is difficult to get suitable sites for the location of this facility in the built-up area of the cities. Due to this, the householders throw refuse on streets and create temporary dumps. They have to be removed by the local authorities and it requires double handling - loading and unloading. This adds to the cost of the service. With trailers loading is saved and the number of trips to the point of destination increases which further helps to reduce the removal cost.

1.7.6 It is suggested that while preparing plans for the development of any town, sites for community dust bins should be earmarked from the very commencement. No body likes to have a public dust bin by the side of his residence and consequently in an already developed area of a town it is difficult to site these dust bins due to objections raised by the residents.

1.7.7 These public dust bins should be in the form of robust trailers housed in a suitable building with a 'self' closing door through which the refuse can be placed in the trailer without spillage. This will result in removing the odour nuisance created by the refuse and prevent nuisance or insanitation caused by vagrants and stray animals.

1.8 Container racks:

1.8.1 In U.S.A., racks or stands are in use for the storage of refuse in the household. Types of holders that have proved adequate include (1) a single steel post with hooks to which the garbage cans are hung by the handle or bail and sometimes with a stirrup to support the bottom of the container, (2) pipe rack either of threaded or welded construction, (3) steel bars such as those used in reinforcing concrete or angle iron welded together and (4) single 1 or 2 case racks built of wood of either new or scrap timber.

1.8.2 Storage containers are in use in foreign countries for flats or apartment buildings and also for housing projects or business establishments.

Commercial firms in America provide movable bulk containers of various sizes that are efficient and serviceable. In some cases, these containers are hauled directly to the point of disposal, emptied and returned by a specially designed truck mounted hoist. To avoid the transportation of each individual container to the disposal site, containers are emptied directly into a large compacter type truck, capable of receiving the contents of a number of storage units.

1.8.3 An interesting container system now used on a modest scale in several European communities is a mobile or fixed metal stand or bracket having a top hinged cover and a special ring from which a disposable sack is hung. The two ply bag is made of wet strength reinforced paper and is quite tear-proof and moisture resistant. The favoured size hold about 2.5 Cft. and is capable of supporting upto 70 lbs. of combined refuse. It weighs about 6 ounces. Removal of the loaded bag and its replacement with a new bag is simple and quick. This type of container lends itself primarily to backyard

collection. Because of its lightness and reduced work effort and distance travelled by the collector its adoption may reduce labour costs upto 50 percent over the conventional backyard container system. Its disadvantage lies in the relatively high annual cost of the bags required and lack of resistance to fire from carelessly dumped hot ashes or to strong acid or alkali action.

1.8.4 Due to the over increasing bulk of combined refuse attempts are being made abroad, to develop improved standard larger containers. It is felt that the container of the future should be stronger, less noisy, fire resistant, non-corrosive and sanitary. The application of moulded reinforced fibre glass for this use is being studied. The U.S. Military have developed strong container of this material for long range, hermetic moisture and fire-proof packaging of sensitive instruments and other military paraphernalia. Adapting their experience to the manufacture of a new type of refuse container would seem to be a logical development.

1.9 Bulk storage containers:

1.9.1 Bulk containers speed up work of handling large quantities of refuse at a given time. In England, the bulk storage container of circular type has a capacity of 1¼ cube yard while the capacity of the elliptical type is 1 cube yard. These bulk storage containers are being widely used in commercial promises, schools and wherever there would be a need normally for a number of standard size bins. This saves space and greatly improves the standard of refuse storage. The bulk container helps faster loading and is reported to reduce fatigue on the part of the men carrying out the bulk.

1.9.2 The bulk storage containers in America are completely enclosed and are made of heavy gauge steel to eliminate fire hazard of rubbish. They are relatively fly and rodent proof when properly used and kept in good condition. To prevent fly breeding they must be thoroughly cleaned each time the contents are removed. Where containers are emptied in collection trucks at the storage site, adequate cleaning presents a problem.

1.9.3 The containers may be square or rectangular. They may be provided with flat bases with gins, support legs or wheels together with channel, angle bar, trunmious or other fitments for lifting. This brings in the question of the suitability of container lifting vehicles.

1.10 Collection responsibility:

1.10.1 In our country, the responsibility for collection vests in the municipal authority as mentioned earlier. In U.S.A. the work is often got done through private enterprise, particularly for commercial refuse. In Europe, the collection is the responsibility in majority of cases of the local authority with the technical and even financial assistance from the Central Government. The financing for this service is predominantly out of general tax revenues. In France, the municipal sanitation services from 1959 are being subsidised by the Federal Government upto 35 percent of cost of the collection equipment and disposal facilities used. In Germany and Scandanavian countries, a direct charge is levied on the householder in

proportion to the size (amount and distance) of service rendered. It is not advisable to give this work by contract as the contractor may fail to carry out the work and the breakdown in the service will affect public health.

1.10.2 In Stockholm (Sweden) any one can collect refuse. About thirty contractors are working in the city. House owners can let out their refuse, removal to the lowest bidder, the Board of Health has a certain degree of supervision over the execution of the collection.

1.11 Collection characteristics:

1.11.1 The prevailing practice is for combined collection without any segregation at the source, in most of the countries, as is the case in India. In England and Scotland, paper picked up from the house, is dropped into separate compartment of the truck or into a special unit trailing behind. Subsequently, this paper is processed and baled in special salvaging plants.

1.12 Location of the household dust bin:

1.12.1 The site selected for the individual dust bin or the container in the house or on the premises

should not only be convenient to the tenants, but it should be easily accessible to the collection crews so that no time is lost by the dustman at the time of collection. It is therefore desirable that while planning for a building or apartment houses, a site for the dustbin or the container should be set aside which fulfills the above requirements. It is suggested that this should be made compulsory by law while submitting building plans for the approval of the local authority.

1.12.2 For example, the British standard code of practice C.P.306 (1960) lays down that the following factors should be taken into consideration while preparing working drawings for an estate or a building.

(a) Method of storage and collection relative to layout and the type of buildings.

(b) Approach roads for refuse collection.

(c) Storage capacity relative to volume and frequency of collection.

(d) Responsibility for cleaning of receptacles.

1.13 Chute system:

1.13.1 Another method of storage and collection employed in tall buildings is the 'Chute system'. This method is adopted for tall buildings both abroad and in one or two cities in the countries. In Bombay, the chute is built of stone-ware pipes 12" to 15" in diameter with accessible hopper inlets so designed as to prevent dust emission. The chute is fitted in an external and freely ventilated position with adequate means of access for cleaning. It is ventilated at its top and bottom. The chute discharges the refuse directly into a container for removal from the premises without causing nuisance. It is fitted with an opening bottom to enable sweeping out and spraying with disinfectant.

1.13.2 In apartment houses of Europe vertical metal chutes are incorporated in the permanent building construction. The chute is of tight and clogless construction. Light gauge corrosion resistant metal is used in the construction of the chute. It has a cross-sectional area of 3 to 4 sft. It is free from bends and constriction.

1.13.3 The question of velocity reached by a heavy item such as a bottle when dropped from one of the upper storeys into the chute and impinging on the base of an empty bin in the chute chamber, has to be taken into account. Provision of a pad at an angle in the chute itself may take care of such a situation.

1.13.4 A cylindrical form of chute is to be preferred as it is simple to construct. It consists essentially of no more than a base disc and a flat sheet rolled to form the vertical wall. The rectangular container is rather costlier and has also the disadvantage that there may be a tendency for pockets of refuse to be retained in the corners of the receptacle inspite of the efforts made in the design to obviate this by the use of a radius, as far as possible, at the joints.

1.13.5 A solution has been found in the use of refuse turn-table enabling a full bin to be readily removed from the mouth of the chute and an empty one to be put into its place.

1.13.6 The hopper in the chute system should be of the self-closing type. One of the difficulties appears to be the prevention of nuisance from spillage when the refuse is carelessly handled. The largest size of hopper is about 14" clear of the framing with a formed extension of the hopper, when opened, of about 12 inches.

1.13.7 The London County Council's round-about system requires only one chute of 1'-3" to 1'-6" dia. instead of several chutes. Under this system, blockages, if they occur, are limited in height to one storey as hoppers are provided at each floor. The round-about unit consists of a filled concrete type base on to which is bolted a central bearing carrying a welded steel frame work. The unit revolves on the bearing and it could be turned by one man. The supporting legs are adaptable for all types of containers which are carried on the unit at the normal height above floor level. A standard lifting trolley is used in the normal way. This leaves the floor of the chamber completely free for easy cleaning around the central concrete base. The maximum

free space required is 11'-0" and 9'-4" dia. for each type respectively. The overall height of the unit is 6'-3". The chute outlet pipe can be positioned over any of the containers but preferably is kept over one of the containers near the entrance.

1.13.8 The disadvantages of the chute are the possibility of its getting clogged if not looked after properly, fire and odour hazards and insect harbourage. Where this system is adopted, the responsibility of the caretaker must be defined to ensure proper control. It is desirable to provide on alternate floors, a rectangular opening about 2'-6" x 2' covered by a metal plate, screwed down by lock nuts to facilitate cleaning. This would enable the maintenance staff to brush and lime the chute periodically.

1.13.9 No chute should be permitted unless final removal of the refuse discharged therefrom is coordinated in advance with the municipal cleaning service as special equipment is necessary for removal.

1.13.10 Where chute cannot be used in tall buildings each family usually keeps an individual

container or bin which is emptied daily into a larger or bulk storage container placed in the yard.

1.13.11 Refuse chutes are still in use in tall buildings in England but not in most cases with a good heart. They get soon fouled when wet refuse, such as kitchen waste, is emptied down them. Opening a hopper on a fouled chute is not a pleasant operation. The present practice seems to be to use the sink waste grinder units for disposal of wet refuse and the chute for dry refuse. Chutes, even when used for dry refuse get continuously blocked by cardboard cartons. To make the chutes universally acceptable for the disposal of refuse from tall buildings some serious thinking to make them fool proof is necessary.

1.13.12 The Garchey system described in para 3.57 may have something to offer to tall buildings. It is understood that the patentees of this system have carried out considerable research and are now satisfied that with the new sink receiver unit, they have developed, branch lengths upto 30 ft. may be made self-cleansing. Further experiments have shown no difficulties from the drop of refuse in the stack.

1.14 Bin trolleys:

1.14.1 Rubber wheeled trolleys are in use abroad for lifting and carrying heavy & bulk storage bins with the object of making a difficult job of lifting less unpleasant. This reduces the efforts required by the dustmen to lift and unload the heavy bins. The rapid development that is taking place in the use of new materials like paper and plasters would go a long way in solving this problem.

1.15 Proper maintenance of refuse bins:

1.15.1 The responsibility of the householder does not end with the emptying of the container by the refuse collection crew. Post collection maintenance is equally important to control fly and rodent nuisance. Where curb collection is practised, the householder should return the containers from the curbs to the normal.

1.16 Type of collection:

1.16.1 The type of collection is determined largely by the method of disposal. Combined collection of mixed refuse is the most practical and economical method and is suited where disposal is by sanitary landfills or incineration.

1.17 Point of collection:

1.17.1 Alley or kerb collection is probably the most economical because it reduces the pick up time from each premise. It is reported that in American cities, the point of pick up are various combinations of kerb, alley front house line and rear house line, or front or rear house line exclusively.

1.17.2 Yard collection is also in use in U.S.A. and Europe. In this type of service the collector enters the premise and collects the refuse from the normal storage location. This is done in several ways, the collectors may carry the containers to the truck and then leave them on the kerb or may return them or he may have a tub or burlap square into which he empties the refuse from several houses before returning to the collection vehicle. Yard collection is more convenient to the occupant of the premise but is obviously more time consuming and expensive.

1.17.3 Different types of services for collection in use may be briefly summarised as follows:

(1) Residents carry bin to kerb; collection crew empties bin; residents return bin.

(2) Set out crew carries bin to kerb and returns it after emptying by collection crew.

(3) Set out crew carries bin to kerb and return it after emptying by collection crew.

(4) Larger collection crew travels with the vehicle, carries out empties and carries back the bin.

(5) Bins remain at storage place. Dustman empties bins into specially designed, light weight container which he carries on his back. Such a container can take refuse from one to three standard bins.

(6) Bin exchange system whereby the full bin is collected and replaced by a clean empty bin.

1.17.4 The service of the type mentioned under (1) above is in use in Bombay in some wards of the City. A bell is rung when the vehicle enters the street and the house holder brings his bin or container which is emptied by the collection crew into the vehicles. Type service mentioned in (2) is also in use in some parts of Bombay.

1.17.5 In some European cities the house holder keep the bin or container at the kerb sufficiently in advance of the time fixed for collection and the crew empties the bin into the vehicle and keeps it at the kerb which in turn is removed by the resident to the household. The disadvantage of this system is that the bins are likely to be disturbed by dogs if the bin remains at the kerb for a long time. It is also possible that some people may disturb the contents of the bin or container to salvage some useful material for being removed.

1.17.6 Kerb side collections are used on a larger scale in England, while in Scotland, the practice is divided equally between kerb and backyard collection.

1.17.7 Type of service under (6) is expensive and cannot be adopted by local authorities having medium revenue, though this type of service is very sanitary as the dust bin or the container is cleaned before it is used again for the storage of refuse.

1.17.8 A major number of towns in India collect the refuse from the public or communal bins or containers which cannot be kept in a sanitary condition due to the habits of the people.

1.17.9 The house to house collection system being costlier is not likely to be introduced in India in the near future. Besides, existing type of housing in India is not considered suitable for economical collection by this system.

1.18 Collection and haul:

1.18.1 The collection must be carefully planned with the aid of the city's map on which the city's roads with their hourly traffic density, their gradients,

residential zone occupancy, location of large restaurants, hotels and other refuse producing business and industrial concerns, along with the location of communal bins and depot or transfer stations and the disposal site or sites are correctly marked.

1.18.2 After studying the map the routes for the collection vehicles should be fixed. Heavy traffic roads and business streets should be avoided as far as possible by collection vehicles except when picking up and the picking up should be done as far as possible at the time when the traffic volume is the lowest. Where practicable the collection vehicles should avoid steep up grades loading or travelling full and the collection should be in the direction of the disposal point.

1.18.3 In foreign countries it is usual to collect refuse from residential areas during the day and from the down-town business districts at night to avoid heavy day time traffic. Larger cities more frequently than smaller communities practise night time collection in business districts.

1.18.4 In Bombay, refuse collection is done in two shifts each of 8 hours begining at 6.30 a.m. and ending at 10 p.m. No night collection is done except when necessitated by breakdowns or other abnormal conditions.

1.19 Summary of suggestions

1.19.1 Whether bins placed in the houses should be standardised? Their weight and the material of which they are made should be light, non-rusting. The material should also be fire resisting. Paper sacks are being used in foreign countries to reduce the weight and the collection effort on the part of the dustman. The bins should be provided with hinged lids. Whether the bins should be provided by the local authority by charging fixed rent? This will depend upon the financial resources of the local authority and that of the municipal tax payers.

1.19.2 House to house collection, which is costlier may not be within the means of small & medium size municipalities but such a service could be introduced in larger municipalities in stages as it is more sanitary but costly.

1.19.3 If house to house collection is introduced whether it should be of the kerb collection or back yard collection type. The latter costs more. For the introduction of such a service the houses from which collection is made must be suitable as to facilitate easy removal of the household dustbin from the house to the kerb.

If back yard collection is practised, the site of the dust bin in the yard must be easily accessible to the refuse collector.

1.19.4 Communal or public dust bins will continue to be used in almost all the Cities and towns. Their location and design demand considerable serious thinking. The design should be such that it creates no insanitary conditions in its vicinity. It should also not be accessible to vagrants and stray animals.

1.19.5 Special sites for communal or public dust bins must be created in suitable positions in the built up areas of the town because with the increase in traffic it should not be desirable to continue them in their present positions on the streets. Their number should be sufficient to prevent householders piling the refuse on streets.

1.19.6 It may be advisable for the municipality to insert a byelaw in the building-byelaws that while submitting building plans to the municipality for approval of site or sites, the household dust bin or bins should be shown on the plans.

1.19.7 In preparing development plans for the undeveloped areas of the town or city, sites for communal dust bins should be earmarked in advance.

1.19.8 The provision of good, clean, unobstrusive and accessible storage on the premises is a great asset.

1.19.9 Samples of refuse from a few Cities should be regularly analysed to determine their composition and weight after evolving a standard method for the sampling and analysing of refuse.

1.19.10 A correct assessment should also be made of the quantity of refuse production per capita per year.

Table - 1

Breakdown of physical components percent by weight.

Component	EUROPE		U.S.A.					
	Berlin (1953-58)	Six towns in England and Scotland (1954-55)	Chandler Ariz 1953		Philadelphia Pa 1957		Chicago (III) 1956-58	
Dust under 5/16"	40.84	37.22	Fines in pulverised mixture	11.0	Ashes dirt	16.40	Ashes	18.7
Cinders under 3/4"	0.83	13.99	Garbage	21.8	Garbage	5.00	Garbage	4.8
Cinders over 3/4"	1.00	12.01	Grass, leaves	1.3			Grass	9.6
Putrescible matter	23.16	6.43	Paper	42.7	Paper	54.4	Paper	56.5
Paper, Card board	12.97	12.02	Tin cans	8.7				
Metal containers	4.22	3.83	Other Metals	1.1	Metal	8.4	Metal	7.9
Other metals	1.34	1.05	Rags	1.9	Rags	2.6		
Textiles, rags etc.	1.76	1.28	Glass	7.5	Glass	8.5	Glass	6.2
Bottles and jars	2.17	3.29	Wood	2.3	Wood	2.4		
Broken glass	3.34	1.68	Rubber	0.7	Rubber	0.9		
Bones	0.84	0.32	Plastics	0.4	Plastics	0.2		
Combustible debris	0.95	2.39	Leather	0.3	Leather	0.6		
Incombustible debris	6.58	4.48	Stone & ceramic	0.3	Ceramic	0.6		

Table - 2

Country	Density (lbs. per cubic yard)		Potential salvables percent by weight		Putrescibles (percent by weight)		Combustibles (percent by weight)		Total moisture (percent by weight)	Calorific value of combined refuse (B.T.U. per lb.)	
	Range	Median	Range	Median	Range	Median	Range	Median	Range	Range	Median
U.S.A.	200-700	350	50-65	60	10-30	15	67-76	70	18	2700-5300	4000
England	215-760	550	25-40	30	4-18	6	26-62	46	20	-	3500
France	-	-	-	-	-	-	60-70	65	35	1500-3700	2800
Germany	490-780	560	-	50	-	24	-	42	-	-	-
Scotland	300-375	500	20-30	25	2-7	4	47-59	50	-	-	3500
Sweeden	240-360	330	-	50	-	10	-	50	30	-	4300

Note: - The substantial difference in the properties enumerated in the above tables may be accounted for by the following.

(1) In European markets much of the salvables like paper, rags and similar light weight material is separated from the refuse at the household as it fetches a good return.

(2) A large proportion of combustible refuse is burnt in fire places for domestic heating.

(3) 'On-the-site' destruction is practised where the household has to pay for collection and disposal costs on the basis of amounts collected.

(4) In England, generally the municipal forces pick up the salvables, usually paper, in the course of their regular collection service for being dumped into a separate compartment of the truck used for collection.

2. REFUSE COLLECTION VEHICLES

2.1 Basic requirements

2.1.1 For collection and transport of refuse a large load capacity is the first requirement to reduce the number of journeys to the place of disposal. The vehicle must be capable of maintaining a good average speed, to keep travelling time to the minimum. There should be sufficient crew accommodation for the men travelling with the vehicle, so that they do not have to hang on in positions, which are or may appear dangerous. The vehicle must also be designed to permit speedy and trouble-free discharge at the tip as delays mean time and money.

2.1.2 Thus, the three main points forming the basis of the design of a refuse collection vehicle are loading, transport and discharge. All the three requirements can not be had in one vehicle. Consequently, a compromise has to be made in selecting the vehicles for refuse collection service.

2.1.3 There are a number of vehicles offered in the foreign market for which a claim is made by each manufacturer of the vehicle that his vehicle is most suited for refuse collection work and its transport to the point of destination both from the point of economy and efficiency.

2.1.4 India has to depend upon foreign markets for the purchase of refuse collection vehicles, because,

so far, manufacturers of automobiles in India have not devoted any attention to manufacture a vehicle suitable for refuse collection work. The vehicles in use at present in Indian towns are of different types and makes. It must be noted that the type of vehicle used affects the character of refuse delivered at the point of disposal Bombay has ten different types of vehicles in use while Calcutta has 13.

2.1.5 The types of vehicles generally used comprise:

(1) Self-contained vehicle with fixed specific purpose body or with detachable body or container carrying equipment.

(2) Tractor or mechanical horse with inter-changeable trailers.

(3) Tractor combined with animal drawn trailers.

(4) Motor chassis with inter-changeable animal drawn containers.

2.1.6 Some of the models in use have become obsolete and great difficulty is experienced in getting spare parts for the same. This results in putting the vehicle off the road. Even in the case of current models, it is not easy to get spare parts due to the shortage of foreign exchange.

2.1.7 Most of the Indian Cities are short of refuse collection vehicles. Sufficient number of vehicles must be at the disposal of the municipalities with a good stand-by fleet for rendering collection service

regularly and at scheduled time. Besides, very few municipalities stock spare parts and they have therefore to wait for a long time to get the spare parts to put the vehicle on the road.

2.1.8 Further, the vehicles in use are not looked after properly. There is no preventive maintenance. Even in Bombay, where a large fleet is employed for refuse collection work, proper arrangements do not exist for garaging and for carrying out regular repairs to the vehicles quickly and in time. This results in reducing the life of the vehicles, causing breakdowns in the service and increasing the cost.

2.1.9 It is not possible to evolve one standard model for a refuse collection vehicle. If this could be done collection costs would be considerably reduced. It would also save stocking of a large number of spare parts of different types and would help to ease and simplify the maintenance problem. A suitable model for an ideal refuse collection vehicle is not likely to be evolved even in distant future.

2.2. Petrol & diesel driven vehicles

2.2.1 Most of the refuse collection vehicles in use in the country are petrol driven. Cities like Bombay and Calcutta have a few diesel driven vehicles. The petrol driven vehicles are cheaper in capital cost than the diesel driven but are costlier in fuel expenditure. Besides, the diesel orgine has a larger life between overhauls.

2.2.2 In addition to petrol and diesel driven vehicles, animal drawn vehicles are in use. They are preferred on economical grounds to cover short distances ranging between 3/4 to 1½ miles. They are also useful for negotiating short bends and entering narrow alleys and lanes.

2.2.3 In the United States, diesel engines for refuse collection vehicles are preferred as they are considered more suitable for 'stop & go' service.

2.2.4 In France, 52 percent of refuse collection vehicles are diesel driven, 34 percent electrically driven and 14 percent petrol driven.

2.2.5 Electric battery power is used for running refuse collection vehicles in Europe. It is gradually losing its place in favour of petrol & diesel oil driven vehicles. Petrol is costlier in Europe as compared to diesel oil and electric power.

2.3 Improvements made from time to time in the Design of refuse collection vehicles:

2.3.1 Some of the improvements in the design of the vehicle are for the purpose of ensuring quick loading and unloading without creating nuisance. The height of the loading has been lowered by reducing the chassis and fitting smaller diameter wheels. Small wheels are a great disadvantage when the vehicles have to operate on tips, but this drawback has been overcome by using twin rear wheels fitted with pneumatic tyres. The lowering of the loading unit tended to decrease the carrying

capacity of the vehicle but this difficulty was got over by introducing rear loading, moving floor, back step or platform and compaction.

2.3.2 Continuous efforts are being made by the manufacturers of the vehicles to make the vehicle more adaptable to modern conditions especially from the point of strength and cost of maintenance. More attention is being directed to improve transmission gearing, reduction of engine and body vibration, independent springing, group lubrication, direction indicators and other accessories. In making these improvements, the initial cost of the vehicle is kept to the forefront.

2.4 Classification of vehicles according to loading position:

2.4.1 Refuse collection vehicles are often classified according to their loading positions e.g. side loader, end loader, front loader and top loader. Side loader is preferred in our country as it is low in initial cost and is easy to maintain.

2.4.2 It appears that the end loader is getting popular abroad. This vehicle in its simplest form is a van or a barrier type loading body. It may also include a moving floor, forward lifting and compression type vehicles.

2.4.3 Moving floors, though they act as a large capacity transporters are losing ground in favour of packer type vehicles which take large loads.

2.4.4 Considerable developments have taken place in recent years in the compression type vehicles and this vehicle is getting popular in many countries.

2.4.5 The refuse vehicles including trailers in Bombay number about 275 - 22 moving floors, 12 banton carriers, 31 scamell horses, 2G.M.Gs, 12 low loaders, 7 jeeps. Out of this, about 225 vehicles are roadworthy.

2.5 Improvements in the materials used in the manufacture of the vehicles:

2.5.1 The materials used in the manufacture of the vehicles are also being improved. In European countries, the vehicles are made of suitable corrosion resistant alluminium alloys or reinforced fibre glass. These vehicles present smooth and readily cleanable surfaces and do not require costly painting. The change from steel to alluminium helps to reduce the dead weight and assures a maximum ratio of pay load to unladen weight.

2.5.2 The following table by Mr. P.S. Oppemheim, Dy. Managing Director of South African Company specialising in the development and sale of refuse collection vehicles will illustrate the great advantages in economies likely to be effected by the use of alluminium bodies.

Diesel chassis heavy duty 5 to 6 ton body
Capacity 10-12 cube yard with 900 x 20 tyres

Type of body	Weight of chassis & cab.	Weight of body	Tare weight	Approx. gross vehicle weight	Actual pay load.	Rated pay load to Tare weight
	lb.	lb.	lb.	lb.		
A. All steel dome top-side loader.	6400	4400	10500	22000	8000	1:1.3
B. Alluminium body with compression mechanism - 12-18 cube yards.	6400	5000	11500	22000	10600	1:1.09

8 Ton diesel chassis

(a) Normal body capacity 15 cu yards
(b) Normal body capacity 16 cu yards

a) Big box body rear door loading	10000	5900	15900	29000	12000	1:1.3
b) Alluminium body with compression mechanism 25.16 cube yards.	9520	5400	14920	29000	14000*	1:1.09

*In practice this figure has reached 16000 lbs. and more.

The use of alluminium bodies increases the economy of body components of transport considerably. No painting is required. The body life is reported to be in excess of the chassis life.

2.5.3 These vehicles have fully enclosed bodies and are equipped with inner loading and compaction mechanisms. The compaction mechanism is of four different types. One type is suitable for either mechanical or manual loading. In another type individual containers are

raised mechanically by a cable or hydraulic lift so as to discharge the contents into the body either through a large canopied opening or a dust bin shutter system. In the third type, the container is lifted at the rear of the vehicle either manually or mechanically and dumped into a circular rotating end hopper or bucket wheel equipped with internal radial hinged blades, which lift the refuse to a top chute and then into the body. The fourth type is similar to type (3), except that the body of the drum is fixed and is separated from the rotating end hopper.

2.5.4 When refuse is compacted in a compaction vehicle it becomes denser and can be more easily handled by bull dozers, chain buckets and a conveyor.

2.5.5 Compression devices have been developed to deal with the decreasing density of refuse. These devices are installed in the rear hoppers of the vehicle. They are mainly confined to the hydraulically operated pressure plate, located inside the rear loading hopper, which moves continuously backwards and forwards along the inclined floor of the hopper, feeding refuse into the enclosed body and compressing it as the body fills. In some cases, a secondary operation provides for crushing the refuse prior to compressions. In another design, continuous and compression loading is achieved by means of a mechanically driven feed screw about 18" diameter, fitted into the rear

loading hopper, which also provides some degree of crushing and tearing prior to compression.

2.6 Dustless system of collection:

2.6.1 While refuse from the premises is being emptied from the bins into the collection vehicle, some portion of refuse falls on the street and creates nuisance. Similarly, while the bin is being emptied, some noise is created which is objected to by many citizens. This has led to the development of dustless loading system in foreign countries.

2.6.2 Where dustless system of collection has been introduced, it is reported that it results in the avoidance of nuisance due to dust dissemination on house holders premises. The dustless loading feature of the vehicle results in much more hygienic conditions on the streets in the neighbourhood of the vehicle. The system results in better and cleaner operating conditions for the dustmen & loaders - an important consideration, these days. One would have thought that the operating cost of such a system would be very high but it is reported that the costs are necessarily a little higher but not unduly so.

2.6.3 While the householder is mainly concerned with conditions on his own premises, the general public using the streets can be equally inconvenienced by dust arising from the operation of tipping the dust bin or skip into the vehicle or from the action of

wind on the contents of the vehicle.

2.6.4 Various systems of dustless loading are in operation in England and the Continent. We have not yet reached the stage but as we get more and more advanced and nuisance-conscious, a day will come when the common man will demand a dustless loading system from his local authority.

2.6.5 The system of dustless collection comprises the use of hinge-lidded dustbins, provided by the authority, in conjunction with a mechanically operated shutter device, fitted to the rear of the collection vehicle. The bins are provided with special attachments, which enable them to be fitted to the specially designed shutter and the bin is emptied with little manual effort and almost without any dust emission. The system operates almost as a totally enclosed method of transfering refuse from the bin into the vehicle. Refuse is transferred into the body of the vehicle by one of the various compressing devices.

2.6.6 A description of two systems of dustless loading is given below:-

Shefflex system (in use at Sheffield, England)

The body of the shefflex vehicle is provided with a rear door for discharging the load. It is hinged at the top and covers the whole of the rear aperture, extending to within approximately 1 ft 3 inches of floor level. On the outer space of the door,

tracks or guides are fitted in which the bin cradle is caused to move up a drum, and a movable shutter is incorporated in the rear door, this being of sufficient dimensions to pass bins or articles of unorthodox size and shape.

2.6.7 Mounted on top of the body at the rear is the 'dustless shutter'. It is designed to receive the bin and to form a dust seal while the refuse is transferred from bin to body. The shutter and sealing flat act automatically with the operation of the lifting or tilting mechanism, together with the trimmer for compacting the load and ensuring a well fitted body. Also mounted on the top of the body is the mechanism for operating the bin-lifting and load-trimming device. These comprise, an hydraulic double acting ram secured to the moving cross heads or sheaves fitted with bushes, which slide on tubular guides or bearers. Each sheave has two pulleys grooved to take 1/4 inch wire rope. Two fixtures fitted with two pulleys are also provided. The sliding cross heads move along tubular shafts which are secured at each end by fixed pillars to channel section bearers, and these, in turn, are bolted to the roof bearers and supports. The principle employed is similar to that used in ordinary type pulley blocks, except that here, the process is reversed, power being applied to the moving sheave and not to the hand or light duty rope. The action of the ram

when operated is to increase and decrease the distance between the centres of the fixed and moving sheaves (i.e. hauling in and paying out the rope ends as the block moves to and fro), and since the ends are taken over a pulley mounted on top of the shutter and down to the cradle, the action causes the cradle to rise and fall.

2.6.8 The bin cradle is constructed in heavy steel sections to withstand the heavy duty imposed. It is mounted and fitted with four solid rubber wheels with steel bushings. When the control value is operated, the ram moves the sliding sheaves (one on either side of the shutter) along the tubular guides, hauling in the rope ends and causing the cradle to rise. When the cradle reaches the swing plate on the shutter, the continued pull on the ropes makes the swing plate cradle and bin to tilt or rotate, the seal plate opens by gravity and refuse enters the body. Operation of the control valve reverses the procedure, the cradle moves back, the seal plate closes sealing off the body, and the bin returns to its loading position. The operation takes approximately ten seconds.

2.6.9 In the 'NOBRA' system of dustless storage and collection of refuse, a number of patented devices have made it extremely efficient & economical. The bins are emptied into a closed vehicle, equipped

with a specially designed loading shutter to which the bin is attached during its clearance. While the bin is being tipped, its lid is automatically opened inside this shutter, thus allowing the refuse to slide down into the vehicle. No refuse is visible either in the bin or vehicle during the emptying and the lid and its hinges are not subjected to any strain whatever, during the operation.

2.6.10 For greater convenience in traffic, the dustbins are emptied into the containers from the rear. The bins are brought out on rubber wheeled trolleys and are then hooked on to the emptier which elevates the bins; they are emptied into the container and lowered again without any dust being caused. The whole process can easily be performed by one man, whereas two men often used to be required for this formerly laborious operation. The container is tipped by means of hydraulic tipping gear powered from the gear box. The tail door opens automatically at the same time as the container is tipped backwards. The tipping gear is operated from the rear of the dust cart by means of a lever handle and is automatically disengaged at the top and bottom limits of this operation. The opening of the tail door as well as the actual tipping can thus be closely supervised by the man operating the lever. The tail door is hermetically closed with strong fasteners which are adjustable to allow for wear, and

are operated by one hand lever. This is conveniently placed so that, it is easy to open and close the tail door.

2.6.11. One of the objections against introduction of dustless collection system seems to lie with the cost of new bins. Special model vehicles have therefore been constructed capable of emptying many different kinds and sizes of dust bins, in a simple way, independently of whether they are of round, square or other form.

2.6.12 In addition to NOBRA a number of vehicles for dust-less collection have been developed. In England, where Clean Air Act is being enforced, it is reported that the cost of introducing dustless refuse collection is negligible when matched against the cost of introducing a smokeless zone over a comparable area.

2.6.13 One system known as Hermetic dustless collection system has been developed in European countries. In this system a fully enclosed truck, mechanically loaded through intermittently operating shutters is used. The truck is provided with an integrally mounted rear-end mechanism which lifts uniformly sized, specially designed containers to the shutter opening and tilts the refuse into the body. The emptied container is returned to the pavement with its lid enclosed. The enclosed container, with dustless, litter-free loading and the fully enclosed truck assure optimum sanitation in the entire collection - operation of storing, loading and transporting the refuse.

2.6.14 The two essential components of this system are:

(1) uniformly sized, rugged containers with hinged lids, and

(2) a combination lifting, tilting and shutter mechanism on the tail gate.

2.6.15 The bins used vary from 2 to 5 cubic feet capacity but four cubic feet capacity is most popular. Dimensions must be exact to fit with the correspondingly sized shutter device. Lifting of 2 Cft. container is done manually. Lifting of heavier containers weighing when fully loaded from 100 to 150 lbs. is done mechanically. The loaded bins are either rolled, in the case of kerb side pick up or brought to the truck by a special two wheeled cart. The crew places the loaded container on to a pair of lifting cleats which raise and tip the contents into the body of the truck. An interlocked system opens and closes the shutter opening simultaneously with the opening and closing of the container lid. In addition, a spraying mechanism is provided in some vehicles to squirt a disinfectant into the container before lowering it back to the street. The total cost of such a truck with all the above described appurtenances ranges from 13,000 to 17,000 dollars depending upon the size and type of chassis used. The total annual repair cost is reported to range from 2800 to 3800 dollars.

2.6.16 This system requires from two to six loaders depending upon whether the containers are at the kerb or in the backyard. The time taken for the whole operation is about 10 seconds. Loading rates for back-yard and kerb collection are reported as 1200 to 1400 lbs. per day. The use of such costly equipment for refuse collection evinces the interest of the European countries in maintaining a high level hygienic collection system.

2.7 Essential requirements for a satisfactory refuse collection vehicle:

2.7.1 A satisfactory refuse collecting vehicle should meet, as far as possible, the following requirements:

(1) Strength - sufficient to withstand driving on good and bad road surfaces and capable of bearing the strain of frequent stopping and starting.

(2) Power - strong enough to haul the load under varying conditions but economical in performance.

(3) Speed - easy to allow variations in speed when required.

(4) Steering - capable of easy operation at low speeds in conjunction with an efficient braking system.

(5) Cooling system - adequate both in respect of capacity and circulation to suit the large amount of gear work entailed in house to house collection.

(6) Clutch - totally enclosed for tipping work to prevent damage by articles thrown up by the wheel.

(7) Tipping gear connection, exhaust pipe, silencer etc. fitted in such a manner as to be clear of obstruction.

2.8 Capacities of collection vehicles:-

2.8.1 The capacity of vehicles used in the country vary from 4 to 6 tons. Smaller capacity vehicles of 1½ to 2 tons capacity are also in use. There is a trend in foreign countries to increase the capacity of vehicles to convert them into bulk transporters.

2.8.2 The following table gives information in regard to the capacities of collection vehicles in use in some foreign countries.

Country	Population served per truck		Truck capacity cu.yds.		Types of collection body per cent			Average age years	Average purchase cost dollars	Capital cost dollars per 1000 population per year
	Range	Median	Range	Ave.	non-compaction	Compaction	dust less			
U.S.A.	3000-5000	3700	10-24	16	25	75	0	5	10,5000	350
England	4300-7400	5200	10-30	15	55	40	5	5	6,500	250
France	4600-6400	5500	13-26	18	15	75	10	15	-	-
Germany	11000-18000	13000	12-17	16	-	-	100	12	14,000	-
Scotland	5200-7200	6000	7-25	18	65	25	10	5	8,000	260
Sweden	3800-6100	5000	40-45	40	-	-	100	10	12,000	260
Switzerland.	---	7400	10-24	20	20	-	80	11	-	310

2.9 Cost of refuse collection and transport:-

2.9.1 The cost is dependent upon the design of collection routes and such major variables as frequencies, points of and density of pick up, size, design and

number of household containers, type and size of collection truck, wages and productivity of collection crews. It is reported from abroad that the cost of backyard collection is higher by 120 to 190 percent of the kerb-side collection. It is also reported that mechanical loading trucks effect from 12 to 15 per cent manpower savings.

2.9.2 The attached table No.3 giving collection performances and costs in some countries, abroad, will be helpful in comparing the cost incurred by large Municipalities in this country on this service.

2.9.3 As there is no convenient yardstick by which the standard of service may be measured, costs alone may some times be misleading. A good service may be more expensive than is necessary or on the other hand a system operated at small cost may be relatively dear if the standard of service is low.

2.9.4 At Liverpool (England), the costs below were calculated on the basis of an average of 200 miles a week for each vehicle (excluding insurance).

Wages	34 19 percent
Depreciation	17.31 "
Maintenance	16.89 "
Fuel	12.60 "
Interest	5.60 "
Tyres	4.89 "
Licence	3.86 "
Overheads	2.56 "
Rent & rates	1.54 "
Lubricants	0.56 "
	100.00

2.9.5 It will be noted that the wage bill is the highest. The only way to reduce 'wage bill' is to get

the work done as quickly as possible a with as few men as possible.

2.9.6 The cost incurred on this service as reported by some Municipalities in India is indicated below:-

	Population	Area in sq.miles	Annual cost rupees
Madurai (Madras State)	426975	8.56	11,283
Varanasi (U.P.)	573588	28.5	1,600
Ambala (Punjab)	78000	3½	284400
Baroda (Gujarat)	306000	10½	228000
Ernakulam (Kerala)	181683	11.25	163232
Trivandrum (Kerala)	322000	30.60	2.53 p head p day.
Sholapur (Maharashtra)	337547	2	495353
Lucknow (U.P.)	600000	42	8.63 p head p day.
New Delhi Municipal Committee.	225000	-	1,50,000
Bombay	4200000		1,200000

Correct records of costing are not maintained by most of the Municipalities.

2.10 Transfer depots or stations:

2.10.1 Where length of haul is great, it sometimes proves economical to provide transfer depots or stations at convenient points. Refuse from the surrounding areas is brought to the depot and transferred therefrom in big vehicles to the point or points of destination.

2.10.2 In Bombay when bullock carts were in use, there were three transfer depots from where the refuse was taken to Mahalakshmi siding for being conveyed by rail to the landfill at Deonar or to a fill in the low lying areas adjacent to the city limits. Since the abolition of bullock carts, these transfer depots have been done away with. A critical economic study should be made before decision is taken to introduce transfer depots as a part of the refuse collection service.

2.10.3 With transfer depots maximum capacity collecting vehicles must be used. There is the difficulty of 'tipping' such large size bodies. To avoid the difficulty two or three non-tipping types of bulk haulage vehicles, based on 8 wheel chassis have been evolved.

2.10.4 One of them is the moving floor type and the other one is the ' Telescopic type'. The body of the latter vehicle is made in sections. The sections are made to move over each other, by means of hydraulic rams, forcing the contents of the body out at the rear.

2.10.5 In the Dempster-Dumpster bulk transporter, compression is achieved by means of a loader plate at the forward end, actuated by a multistage hydraulic ram. This ensures compaction of refuse in the body. The refuse is discharged by opening rear doors and extending the ram to its limits, thereby utilizing the full length stroke of the compression plate.

2.10.6 At Preston (England) four bulk transport vehicles of 'Octopus' make, diesel driven 8 wheeler equipment, each of 49 cube yard capacity have been reported to be operating for the past year with great success. They are provided with moving floor bodies. incorporating compression mechanism which enables increased quantity of refuse being loaded in the vehicl Each vehicle has been painted, under-coated and furnish with special 'Nitolux' preservative paint which gives a smart appearance to the vehicle & offers long standing protection despite the particular nature of duties which the vehicles have to carry out. The additional cost of the paint per vehicle is reported to be 100 shillings only.

2.10.7 It should be noted that Preston's refuse collection is not confined to waste paper, cinders, packaging and household scraps. No fewer than 650 old beds, nearly 120 derelict bed sheets, over 500 discarded mattresses, more than 50 unwanted perambulator and 700 odd cast-out chairs were picked up during one year.

2.11 Preventive maintenance:

2.11.1 Regular washing, cleaning, lubrication and 'preventive' inspection and maintenance are of importanc to minimise loss of working time. The vehicles must be serviced on time and not on mileage basis. Cleansing work by its very nature involves continuous starting and stopping, creating heavy demands on the

clutch, transmission and tyres. It is therefore important that vehicles should not only be designed for this type of work to reduce loss of working time but they should also be maintained in a top condition.

2.11.2 Vehicles should also be kept in good paint work condition in order to encourage greater care on the part of the driver and the team.

2.11.3 Spare parts of the vehicles should be stocked in advance to enable a vehicle being put on road in the shortest possible time.

2.11.4 There should be adequate number of standby vehicles for being used in break-downs. This will help in not dislocating the service which otherwise is bound to occur.

2.11.5 A typical maintenance schedule is set out below which can be modified to meet individual cases and specialised vehicles:

1. Drivers daily check - Radiator water level, engine oil level, visual check on tyres, removal of flints or stones, check pressures, hydraulic fluid level, horns, wipers and indicators; report any visible leaks.

2. Weekly check - Wash & grease - check battery level, dynamo & out out.

3. Monthly check - All round greasing, clean filters, check steering, brakes,

wheel nuts, petrol plugs, points, leads; for diesel engine, check injectors.

4. Three monthly check - Adjust - brakes
" - plug gaps
" - points
" - fan belt
Check - fluid levels, rear axle, dynamo & starter brushes, hose connections, taffets cylinder head & manifold bolts & pedestal travel.
Lubricate - door hinge, body pivots, change engine oil, tighten bolts.
Take road test.

It should be borne in mind that the true value of the vehicle lies largely in the hands of the driver. The life of a complicated vehicle is precarious in the hands of an incompetent mechanic driver. Right type of personnel must be selected for driving refuse collection vehicles.

2.11.6 Considering all the above mentioned points, it can be seen that a proper type of refuse vehicle plays an important part to ensure efficient, and regular

refuse collection and removal services. If a proper type of standardized vehicle is obtained, it will also prove economical both from the point of initial and maintenance costs.

2.11.7 The standardisation of a refuse vehicle will depend on the conditions existing in a town or city and also the economic position of the local body. It will therefore be necessary to group such towns or cities having common conditions for finalizing and introducing a standardized type of refuse vehicle.

2.11.8 To achieve this, a Committee of experts and experienced personnel on all India basis will have to be formed to go into details of all the aspects of this subject and finalize the standardization of the refuse vehicle.

2.12 Summary of suggestions.

2.12.1 In any system of refuse collection, collection vehicles are the most important factor. Hence standardisation of two or three types of vehicles to suit refuse collection work is necessary.

Suitable vehicles for refuse collection are not being manufactured in the country. Their manufacture in the country should be encouraged.

2.12.2 A Committee of experts should be appointed to prepare standard specifications for refuse collection vehicles.

2.12.3 The question of changing the body of the vehicle from mild steel to alluminium should also be considered by the expert Committee as such a vehicle may prove economical in the long run.

2.12.4 It is desirable to make suitable arrangements for garaging, repairing and cleaning of the vehicles in due time.

2.12.5 Preventive maintenance should be insisted upon to increase the life of the vehicles and to ensure regular service.

2.12.6 It may be necessary to give a subsidy or loan to the local authorities for purchase of vehicles as many local authorities are not in a position to purchase them with the means at their disposal.

2.12.7 As the life of the vehicle depends upon its driver, competent mechanic drivers should be engaged for this service. It is worthwhile to consider the grant of some sort of incentive bonus to the drivers who keep their vehicles on the road in a tip top conditions.

TABLE - 3

Collection performances and costs

Country	Truck crew loaders & drivers		Truck loads per day.		Pay load tons per truck		*Truck miles per load		Maximum hours per ton		Cost difference per ton.		
	Range	median	Range	median	Range	median	Range	median	Range	median	Range	median oc	Dollars per capita per y
U.S.A.	2-4	3	6-3	2.3	20-45	2.75	10-30	2.0	2.4-6.2	3.2	4.00-0.25	16.0	5.0
England	3-7	4	2-5	3.5	1.5-4.4	2.20	0.6-3.2	1.5	1.9-12.0	3.2	-	4.50	1.65
France	3-5	3	1-2	1.5	-	-	2.5-4.5	3.0	-	-	-	-	-
Germany	3-7	6	2-3	2.5	-	5.5	-	-	13.2-9.0	2.2	6.15-6.5	6.25	-
Scotland	-	3	-	2.0	2.5	4	1.0-7.0	2.5	1.8-3.0	2.4	-	-	-
Swedon	-	3	-	2.0	-	2	-	4.5	-	4.4	-	13.50	3.50
Switzerland	-	3	-	1.9	-	2.7	-	8.8	-	-	-	-	-

* Does not include travel to disposal points. This varies from 4 to 100 round trip miles with a median of about six miles.

oc All costs included, except amortization, for collecting combined refuse.

Notes:- Truck operating costs per route mile, including fuel, oil, tyres, materials, repairs, overhead and amortization are 28% for U.S.A. and 35 percent for Germany.

3. METHODS OF REFUSE DISPOSAL (Sanitary landfill, incineration and composting)

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3.1 Disposal is normally the final operation in the handling of refuse. Although performed last, in the organisation of an integrated refuse handling system, it must be planned first, since it has an important influence on both storage and collection. There is a close relation between the three parts of the Public cleansing service, handling, storage, collection and disposal. Inadequacies in one of these integrated activities can produce problems in the rest of the system.

3.2 As pointed out earlier, the disposal of refuse is the most neglected phase of the total refuse handling system in most of the cities in the country and also abroad.

3.3. Several methods of refuse disposal are being widely used in the various parts of the world. Most prominent of them are sanitary landfill, incineration and composting. They are described in detail hereafter.

3.4 Dumping in water was practised in the past, on a large scale by coastal cities but this practice has since been abandoned, as it was found that the discharged refuse was being floated back to the shore when the tides were unfavourable, resulting in creating nuisance and thereby endangering public health. The method has almost been abandoned even by coastal towns.

Some towns and cities, located along streams and rivers, have established open dumps along their banks as is being done in Delhi at Badli dump. This method causes stream pollution by liquid refuse leached from the refuse or by solid waste refuse washed downstream by floods.

3.5 Open dumps:

3.5.1 Open refuse dumps are a menace to the health of the residents of the nearby areas. They are used because they are cheap and need no planning. They harbour flies and rats and produce a considerable number of mosquitoes. They emanate objectionable smoke and odours. The vermins are capable of carrying disease to man.

3.5.2 Every local authority should avoid disposal of refuse by open dumps on grounds of public health and adopt other sanitary methods of disposal, suited to local conditions without much strain on its financial resources.

3.5.3 Cost considerations are allowed in many instances to override the more important aspects relating directly to public health and this circumstance accounts without question for many examples of tipping (open dumps) paying no regard either to health or amenity standards.

3.6 Controlled tipping or sanitary landfill.

3.6.1 This method goes under the name of 'controlled tipping' in British Isles and by the name of 'sanitary landfill' in European countries and the United States. Sanitary landfill, as defined by the Committee on sanitary land fill practice of the Sanitary Engineering Division of the American Society of Civil Engineers, is

"a method of disposing refuse on land without creating nuisance or hazards to public health or safety by utilising the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume and cover it with a layer of earth at the conclusion of each day's operations or at such more frequent intervals as may be necessary".

3.6.2 It is satisfactory and economical sanitary method of garbage and rubbish disposal for any community (large and small) where sufficient suitable land is available and the length of haul to the tip reasonable. Its operation however must be properly controlled.

3.6.3 Before adopting this method, long range planning with regard to the ultimate use of the reclaimed land such as parks, playgrounds, parking plots or other community facilities is essential. In selecting the area or areas for reclaimation by this method, ease of operation, their location and size should also be taken into consideration.

3.6.4 Personnel used for this type of work should be trained. This method of disposal cannot also prove economical and efficient unless suitable mechanical equipment for excavating the 'cover' material, for placing the refuse and for its thorough compaction and spreading, and also for compacting the cover is provided.

3.6.5 This method of disposal is carried out in four steps:

(1) depositing the refuse in a planned, controlled manner;

(2) spreading and compacting it in thin layers to reduce the volume;

(3) covering the material with a layer of earth; and

(4) compacting the earth cover.

3.6.6 The British Ministry of Health have issued instructions as to how ' controlled tipping' should be practised by the local authorities. Similarly, several European and American cities have framed ordinances to ensure its satisfactory, efficient and effective performance. One such ordinance is reproduced in Appendix I.

3.7 Preliminary considerations:

3.7.1 The first consideration is the suitability of the site selected for land disposal. It is governed largely by the proximity to the source of refuse and by such factors as the availability of suitable land having adequate acrage, access roads etc. The suitability and availability of 'cover' material are also important. Some exploratory work by way of geological investigation is necessary to find out the suitability and adequacy of the 'cover' material. These considerations usually determine whether or not the sanitary land fill method can be used economically.

3.8 Land requirements & length of land:

3.8.1 According to experience gained in foreign countries it is estimated that one acre of new land will

be needed, every year for 10,000 population. This figure may vary from 3/4 to 1½ acres depending upon local conditions, such as methods of operation, ratio of industry to houses and the type of refuse collected. A city may some times find it convenient to fill in relatively small low areas in its various sections, moving from one to the other over a period of years before beginning operations on a larger tract.

3.8.2 According to Mr. J.L. Vincens, consultant for Calcutta Metropolitan Planning Organisation, the land requirements in India, based on refuse production of 450 lbs per capita per year would approximately be 2½ to 3 acres for 100,000 population per year for a fill of 10 ft.

3.8.3 As regards length of haul, it is reported that, a round trip of from 15 to 30 miles is the maximum distance of haul for a land fill project. The capacities of collection vehicles is another factor which needs consideration. A town using 15 cubic yards compactor type trucks might find a 20 mile round trip excessive but by using a 20 cubic yard vehicle, a round trip of 20 miles might be economically feasible. Other factors which may require reckoning in determining the economical length of haul are the possibility of using transfer stations, condition of the road surfaces and the density of traffic.

3.9 Cover material:

3.9.1 The selected 'cover' material should be capable of being compacted and provide a tight seal which should not crack excessively when dry and it should be relatively free from putrescible materials and large objects. It is the nature of the soil that dictates the type of equipment required for excavating, hauling and compacting. Sandy soil is to be preferred as it can provide a tight cover within the least expense. With other types of soil, additional work for excavation compaction and maintenance of cover is involved.

3.10 Principal rules to be observed during operation:

1) Refuse must be deposited in uniform layers upto about 8 ft. deep with ordinary equipment. With heavier earth moving and compaction equipment and careful compaction of each layer, the depth of deposit may be increased to 20 ft.

2) The layers must be properly packed.

3) Each layer must be covered in its exposed surface with 6" to 9" of suitable covering material.

4) No refuse should be left exposed for longer than is necessary to ensure continuance of tipping (tipping face only).

5) The tipping area should be adequately screened.

6) The final level of the fill should provide de a 0.5 percent to 1 percent slope to allow for adequate drainage. Steeper slopes should be avoided as they encourage erosion. In case, the finished slope has a boundry and/or side slope, it should be as gradual as

possible to prevent erosion. These slopes should be sealed properly and covered with straw to minimise erosion until vegetation becomes established.

7) The face of the working fill should be kept as narrow as is consistent with proper operation of trucks and equipment.

8) Control of wind-blown paper should be adequately maintained.

Note:

When the solid compact mass of refuse is adequately sealed with inert material on all exposed surfaces it secures (a) controlled biological decomposition by the retention of heat, gases and moisture; (b) prevention of fires either deliberate or spontaneous; (c) elimination of the breeding of insects, flies and vermin and (d) a neat and clean appearance of the site and its surroundings.

3.11 Compaction:

3.11.1 While consolidating the refuse, greatest care has to be exercised. Where earth moving plant or refuse vehicles are used for consolidation, the sloping longitudinal faces cannot be thoroughly compacted. With a special plant for compaction, it is possible to traverse these sloping faces and ensure proper compaction. Special compaction plant is rarely used with the usual grade slope of 45°. Where excavations are made for the reception of refuse, the solid walls provide lateral support and ensure uniform consolidation.

The method of excavation has the advantage in as much as it provides adequate covering material.

3.11.2 In some cases, 'refuse reception lagoons' are created by providing artificial bunds of inert material. This method is costly as it requires heavier equipment.

3.11.3 While compacting the refuse, excessive and uneven settlement should be avoided. Such settlement is dangerous from the point of health as it permits the ingress and egress of insects and rodents.

3.11.4 Compaction should be initiated by spreading the refuse evenly in shallow layers not exceeding a depth of 2 ft. of compacted material rather than placing the material in a single deep lift. Further compaction is provided by the repeated travel of landfill equipment over the layer and in some cases by the use of special compacting equipment. It is not unusual to provide for additional compaction by routing collection trucks so that they travel repeatedly over the finished portion of the fill.

3.11.5 Construction of a 'fill' in well compacted lifts of not more than 8 ft. each, minimises settlement, surface cracking and release of odours. Depths more than 8 ft. may not be economical.

3.11.6 Final cover: The final cover should be of a suitable material compacted to a minimum thickness of 2 ft. over the entire surface of each portion of the final lift, not later than one week following the placement of refuse within that portion.

3.12 Mechanical Equipment used:

3.12.1 Controlled tipping or sanitary land fill can only be operated efficiently and economically with suitable mechanical equipment for excavating the cover material, for placing & compacting the refuse, covering it with earth and for finally cleansing the tip.

3.12.2 The mechanical equipment used includes:

1. Crawler tractor with blade or shovel type attachment.

2. Bull dozer, dragline combinations - These are needed for large operations or for operating in swampy and marshy land. The drag line is equipped with 3/4 - 1½ cub-yard bucket.

3. Carry-all scrapers and bull dozers for large operations or where earth must be moved to a considerable distance.

4. Bull-dozer and truck to haul cover material plus loading equipment at the source of cover material.

3.12.3 A high standard of equipment maintenance is essential. The machine should be taken off duty on full-day-per-week for servicing. One hour each day should be allowed for minor jobs such as cleaning rags and plastics from the tracks which can cause damage, if not removed frequently. Two smaller machines should

be preferred as this will enable one machine being used in the event of a breakdown.

3.13 Arrangements for weighing the refuse delivered at the fill:

3.13.1 To measure incoming refuse to the disposal site weighing machines should be provided. Weighing will provide reliable data as regards quantity initially dealt with at the site, will also give indication of the quantity to be dealt with in future. Weighing will also provide basis for cost analysis.

3.14 Prevention of contamination of subsoil and ground waters.

3.14.1 Refuse should not be tipped into pits containing water as it would result in causing serious nuisance arising from odours given off by the decomposition of organic matter contained in the refuse. Experience abroad has revealed that even filling a dry pit is a potential of heavy contamination of the subsoil and ground water by the percolation of rain water through a pit.

3.15 High standards of operation essential:

3.15.1 For effective operation of a land fill, high standards must be set from the very commencement. Planning of sanitary land fill should be a part of a complete programme of refuse handling. As mentioned earlier, a trained personnel is necessary for satisfactory performance. Inspection for and control of insects and rodents should be carried on until fills are stabilised.

3.15.2 All collections of surface water resulting from land fill operations should be drained, filled or treated with effective chemicals to prevent mosquito production and alley disagreeable odours.

3.15.3 After operations are completed a maintenance programme should continue until the fill has become stabilised. This should include prompt repairs of cracks, depressions and erosion of the surface and side slopes.

3.15.4 Seeding of finished surfaces, as soon as possible, is highly desirable as a good strand of grass will decrease erosion, improve appearance and decrease surace cracking.

3.16 Rate of decomposition:

3.16.1 The rate of decomposition of refuse in a land fill generally precludes reuse of the land for many years. Cases are reported where decomposition of refuse has been observed after a period of 10 to 15 years. Moisture content in the fill area and local temperatures are important factors in the rate of docomposition.

3.16.2 The following are the advantages and disadvantages of the sanitary landfill:-

Advantages	Disadvantages
(a) Cheap in intial cost and operation.	(a) Suitable land at reasonable cost within economical hauling distance may not be available.
(b) Flexibility - It can accommodate increase in the population.	(b) Possibility of surface cracking and uneven settlement due to improper construction.
(c) Submarginal land can be reclaimed for future use thereby benefitting the community.	(c) Maintenance after completion for getting over settlement which is of the order of 10 to 15 percent.
(d) Elimination of unsightliness, health hazard and nuisances caused by open dumps.	(d) Possibility of contamination of subsoil and underground water by seepage.
(e) Ease of being brought into operation quickly.	(e) Requirement of relatively large areas of land.
(f) Several sites can be filled in simultaneously at a relatively small additional cost.	(f) Non-availability of suitable cover material in sufficient quantities.

3.16.3 Information regarding operation cost of land fills in some foreign countries is given below.

	Operating cost per ton disposed.				Mode of transportation to land fill percent		
	Dollars (a)		Man days		Truck	Marine Transfer	
	Range	Median	Range	Median	(b)	(c)	(d)
U.S.A.	(0.50 - 1.50 (2.0		0.02 - 0.04 0.65		85	2	13
Europe	0.20 - 1.00 1.50		0.04 - 0.05 0.10		64	1	35

(a) All costs included except land acquisition.

(b) Direct haulage by the collection truck to land fill.

(c) Transfer by barge and fill on tidal lands.

(d) Direct haulage to transfer station and transport to landfill by large trailers on rail.

3.16.4 Sanitary landfill appears to be a suitable solution for the problem of refuse disposal in our country. The land requirements are not high and its adoption will eliminate unsightliness, health hazard & nuisance caused by open dumps. Where lands are very costly or not available within a reasonable distance of haul, other sanitary methods of disposal may have to be considered. The land cost should not be the only criterion because after the land is filled, it appreciates in value and can be sold at a much higher rate.

3.16.5 Large cities like Bombay, Calcutta and Delhi should adopt this method immediately in lieu of open dumps if circumstances are favourable for its adoption.

3.16.6 The following table indicates how the sanitary land fills after completion are being utilised in the U.S.A. and Europe:

Country	Parks	Farming	Construction	Misc. A
U.S.A.	85	N	10	5
Europe	90	10	N	N

A. Airports, parking fields, fair grounds.

3.16.7 The economic factor of sanitary land fill may not continue at a future date when necessity of bulk transport arrangements for tipping the refuse is created due to non-availability of suitable & sufficient land within a reasonable hauling distance, as the haulage will add substantially to the level of disposal costs. Finding land of suitable size and situation is not a simple matter.

3.17 Incineration

3.17.1 No municipal incinerators are built in our country for the disposal of refuse. Calcutta had installed an incinerator a few years ago, but it did not work satisfactorily and had to be closed down. Incineration, no doubt, offers a satisfactory means of refuse disposal in big towns and cities where sites for sanitary fill are not available and due to the expansion of the town or city

on the outskirts, the length of haul to the sanitary fill becomes uneconomical for the transport and collection vehicles.

3.17.2 The design of the incinerator has been considerably improved in recent years, and the modern incinerator can be located in the midst of a residential area without causing odour or dust nuisance.

3.17.3 Incineration reduces the bulk of refuse and the residue of incineration is an inocuous material which can be safely used for filling low-lying land or for road construction.

3.17.4 Today, 35 percent of the refuse in the United States is disposed of by incineration; this percentage varies from 12 to 85 in the several European countries, with a median of about 40 percent for Western Europe.

3.17.5 The methods and degrees of applying incineration can be classified under the following four major basic systems:

(1) Separation and incineration: Under this syste m refuse is brought to a central depot, where the saleable components are separated, dust is screened out for disposal at a sanitary land fill and only the tailings are burnt at the adjoining incinerator. This system is most extensively used in England and Scotland and to a negligible extent elsewhere.

(2) Steam and power generation: Under this system, the incinerator plant effects nearly complete burning to recover optimum waste heat for utilization either for space heating or for producing electric power. This system predominates on the continent with a few applications in Britain and U.S.A.

(3) Intermediate disposal process or partial Incineration: Under this system, the incinerator is operated at high through-put rates with the major objective of reducing the volume of refuse for ultimate disposal, only the fluffy, high surface area, low density, and high ignition point materials are burnt. This system has the advantage that the cost of burning is low. It has however the disadvantage of producing a residue (which amounts upto 50 percent of the original by volume) which has a relatively high unstable putrescible content, requiring great care in its final disposal.

This system is intermediate between complete incineration and sanitary landfill as it helps to reduce the volume of refuse to be dealt with by the sanitary fill method. It is, at present, restricted to a few cities, in foreign countries, but it may prove attractive in course of time for adoption by other cities, due to the change in the character of refuse that is progressively taking place in regard to bulkiness, burnability and plastic content.

(4) Complete incineration: Under this system the refuse is thoroughly burnt to obtain a residue which is free of putrescibles. Complete burning reduces the volume to 5 to 12 percent of the original input, resulting in very low cost in its final disposal. In this system, the through-put time has obviously to be much longer than the partial incineration method. This system of incineration is very popular in the United States.

3.18 Design of incinerators.

3.18.1 All types of incinerators employ certain basic plant components. They include the primary chamber, wherein preheating and combustion takes place - a secondary chamber for combustion and expansion of gases and settling of fly ash and finally the stack, which discharges the gases to the atmosphere.

3.18.2 The initial plants for burning refuse under controlled high temperature were developed in England nearly 100 years ago. Then, they were known as "Destructors". Their design has been undergoing changes and the present design with proper operation has succeeded in reducing the atomospheric pollution that resulted from incinerator operation in the early designs.

3.19 The incineration process:

3.19.1 There are three basic stages in the incineration of refuse. The first stage is the elimination of moisture contents in the refuse. Before refuse can be burnt it must be dry. In rainy season, the refuse is wet and it

cannot be discharged directly into the incinerator before it is dried. Every incinerator plant must provide a way to eliminate moisture from raw refuse. This is usually accomplished by having the 'green' refuse placed at the back of the burning furnace or in a separate chamber and from there it is moved to the actual burning area by mechanically operated grates or by hand stocking.

3.19.2 The second stage, in the process, is the actual burning of the combustible material so as to convert it into gases and reducing it to an inert residue or ash. In some plants, a preheater is provided to raise the temperature of the forced draught, before the introduction of the refuse into the furnace. Waste heat is generally used for this purpose. The heated air, for the forced draught, helps the incinerator to operate efficiently particularly when the refuse contains excessive amount of moisture. Gas or oil burners are sometimes included to provide the heat necessary to evaporate excessive moisture or to bring temperatures more quickly to the most efficient range at the beginning of the operation. The furnances are designed to ensure temperatures of at least 1250° F.

3.19.3 The third stage, in the incineration process, is the conversion of any partially burnt or odourous gases to make them less objectionable. The gases are usually burnt in the combustion chamber, which is designed to ensure optimum velocity of gases and produce temperatures of at least 1400° F. This is the most

critical stage in incineration. To prevent air pollution it is now-a-days customary to provide additional facilities in the form of dust collectors, spray collectors, baffling, wet scrubbers and other devices.

3.20 Heat value of Municipal Refuse:

3.20.1 This varies from 4000 to 25000 B.T.U. per lb. on a dry inert free basis i.e. all materials burn to form gases.

3.20.2 Refuse samples are analysed to determine relative percentage of carbon, hydrogen and oxygen present therin. This analysis is helpful in designing the incinerator.

3.20.3 Stacks may be built of bricks or steel. Steel shalls operate within 600° to 900° F temperature range. They are provided with thermo couple electrical alarm systems so that when 600°F to 900°F temperatures are reached, they warn the operators to take steps to reduce the furnace gas temperatures.

3.20.4 The stacks are designed to discharge 100 to 200 percent of the total anticipated gases. The design gas velocities in the stacks vary from 25 to 50 feet per second.

3.21 Small versus large incinerators:

3.21.1 Experience has demonstrated abroad, that in big cities it is economical to locate smaller units close to refuse collection centres than to locate one big incinerator involving considerable length of haul.

3.21.2 In America, the cost per ton of refuse for construction and operation of an incinerator of 150 ton capacity per day is reported to be in the same range as that of a 800 ton capacity incinerator except that the cost of operation of the larger plant is a little bit less.

3.22 Location of the incinerator:

3.22.1 Factors which determine the site of an incinerator are (1) land costs, (2) opportunity for waste heat utilisation, meteorological conditions, topography, foundation characteristics and the environment. It is preferable to locate the incinerator or incinerators in an industrial or commercial district where heavy vehicles and some noise and odour may be tolerable.

3.23 Batch versus continuous charging:

3.23.1 In batch type charging, refuse is dumped into the primary chamber until it is filled to capacity and then is permitted to burn down and the ashes are removed. In the continuous charging method, material is fed to the furnace in small but regular amounts and ashes are removed as they are formed.

3.23.2 The method of charging depends upon the design of the incinerator, continuous charging facilities, maintenance of steady optimum temperature, minimum repair costs and production of good ash and stack effluent.

3.23.3 Types of incinerators easily adaptable to continuous charging are th rotary kiln or travelling grate. Mechanically stocked plants of the single hearth

can also be operated on continuous charging method with numerous small changes.

3.24 8 hour day - 24 hour day plant operation:

3.24.1 A 24 hour operation incinerator is cheaper to construct. It is reported that its cost is about half that of a 8-hour operation incinerator. The 8-hour operation incinerator requires three times the burning capacity of one operated over a period of 24 hours.

3.24.2 The design trend in Europe and the United States for incinerator furnaces exceeding 50 tons per day favours the continuously fed and discharged systems with mechanical stoking and zoned air control. These designs use the minimum of furnace access doors either for stoking or inspection - even going so far, as to install overall air tight sheet metal enclosures for the furnaces. This combination almost completely eliminates dust emergence from within the furnace or uncontrolled intake of excess air into the furnace.

3.24.3 The most advanced popular types of incinerator in Europe and the United States are the 'Volund' and the 'DeRoll'.

3.24.4 In the Volund system, the furnace capacities range upto 10 tons per hour. It originated 30 years ago in Denmark. The DeRoll system was developed in Switzerland, 15 years ago, and is gaining popularity. Its capacity ranges upto 200 tons per 24 hours day per furnace.

3.24.5 The DeRoll incinerator system operates as follows:- It is of the bin and crane type and is equipped with waste heat boilers. Mixed refuse (garbage and rubbish) is dropped into receiving hopper which continuously feeds onto the receiprocating step-down pre-drying grate. Preheated combustion air is blown under this grate at rates dictated by the character of the refuse and its moisture content. The desiccated refuse is then dropped with some attendant tumbling and mixing on to a combustion grate where additional pre-heated air is blown under, as required. Each of the grates is operated mechanically, partially to agitate and to advance the refuse at pre-set rates. The discharge from the combustion grate is detailed in an after burner, where, with the assistance of injected air and steam the clinker and similar materials are fully burned out. The final residue is then discharged by submerged scraper conveyor into water trough for cooling and subsequent dewatering and discharge, by a drag conveyor. This sealed discharge system controls dust emissions and maintains a continuous water seal. The combustion gases with their burden of particulates, aldeydes and noxious gases are burned out in the overlarge combustion chambers and then passed through a waste heat boiler before passing through electrostatic precipitators and high exhaust stacks. Auxiliary oil burners are used as required. Ash chutes drop the siftings and the fly ash respectively into the submerged conveyor system.

3.24.6 The modern 'Saintquen Paris incinerator' of the Volund type completed in 1958 has a capacity of 300,000 tons per year. The plant operates continuously for 24 hours per day, seven days per week, at an average rate of 826 and a maximum rate of 1300 tons per 24 hours. The lifting floor is 180' long and 62.5 ft. wide. It is fully enclosed. It can accommodate simultaneous dumping of 13 collection trucks at its 157 ft. long backing log. The collection pit has a capacity of 4400 cu- yds., and provides a storage for 48 hours of burning capacity. There are two bridge cranes (one as a stand-by) of 6.5 tons capacity each. They, with the help of 4 yard orange peel type buckets, load refuse into each of the charging hoppers at a rate of 65 tons per hour. A separate 8-ton bridge crane runs traversely over the four furnaces and helps on routine maintenance work. The refuse is fed through 6.5 ft. x 4.5 ft. charging chutes (they are equipped with hydraulically driven shear gates) into the drying furnace. The drying grate is 10 ft. long with a slope of about 25°. It is comprised of 13 stepped down pallets - 6 fixed and 7 mobile. These pallets work in a reciprocating motion at one of the four selected speeds and agitate and advance the progressively drying out material. The dried out and partially burning refuse drops about 6 ft. into the burning grate of similar design but about 13 ft.

long and with steel water jackets in the lower portion of the side walls. About 20,000 cft. of underfire air is delivered at about 2/3 psi. The mixture of evaporated steam and hot gases from the two furnaces is discharged into the combustion chamber through a bypass 22sft. in cross section. The partially burnt refuse, at the end of the combustion furnace, tumbles and progressively advances through a 26 ft. long rotary kiln tapered slightly to its end dia. of 8 feet. The hourly capacity of each furnace unit varies with the seasons and density of the refuse from 11 tons in summer to 14 tons in winter.

3.24.7 The hot exhaust gases from the combustion chamber, in passing through a 22 ton per hour water tube waste heat boiler, drop in temperature from 1850°F down to 450° F. A wet scrubber system removes the particulate matter before discharging the cleansed gases into a brick stack (chimney) - one for each two furnaces unit - 200 ft. high and tapering from a 12.5 ft. internal diameter at the base to 11 ft. internal diameter at the top. The residue, the siftings, and the fly ash are sluiced into a larger rectangular sedimentation basin. The settled out residue and fly ash are periodically lifted out by gantry cranes on to dewatering platforms and then trucked away for disposal at a landfill. The clarified decanted water is recirculated for repeated use.

3.25 Steam and power production:

3.25.1 These systems are used for utilising the generated

stream by piping all the steam or hot water to distant municipal or private uses, converting all the steam to electric power, or a combination of the two including some self use on the premises.

3.25.2 The rate of evaporation extends from 0.95 to 1.65 lbs of steam per lb. of refuse, depending upon the efficiency of the waste heat plant and the thermal values of the refuse being incinerated. The average figure is reported to be 1.40 lbs. per one lb. of refuse.

3.25.3 The power production factor has been reported to be as high as 300 KWH per ton of refuse but 150 KWH can be taken as the average. In Berne (Switzerland) from a population of 200,000 the waste heat recovery is reported to save the equivalent of 5000 tons of coal per year.

3.26 Refuse Briquettes:

3.26.1 Studies are in progress regarding admixing specially treated refuse to coal-dust fired high pressure boilers and (2) manufacturing fuel briquettes from refuse for either domestic or industrial use. City of Salford (England) reports that the calorific values of manufactured briquettes range from 8000 to 10,000 B.T.U. per lb. In actual combustion, an average heat output of 7500 B.T.U. per lb. was produced without any noticeable smoke. It is generally agreed that briquetted refuse requires supplementary heat to ignite and to promote its better combustion.

3.28 Costs:

3.27.1 The following table will give some idea of the cost of incinerators in U.S.A. and Europe:

	Combustion costs in dollar per capita		Operation costs per ton of refuse burnt.			
			Man days		Dollars	
	Range (a)	Range (b)	Range	Median	Range	Median
U.S.A.	4.25 - 100	7.5	0.10-0.31	0.13	4.5 to 8.00	5.25
Europe	6.50 - 19.00	9.00	0.08-0.29	0.12	2.15 to 3.50	3.00

a) for various designs and degrees of refinement in design.

b) for the mechanically stoked continuous type.

3.28 General remarks:

3.28.1 Incinerators may be located close to or in the centre of refuse production areas thereby minimising haul distances which in return reduce collection costs. They are flexible and can be enlarged from time to time when necessary. They reduce considerably the volume of material for ultimate disposal. The residue can be profitably used. Waste heat can be made use of for other community purposes. Some incinerators, abroad, are reported to be self-sufficient in operation costs due to the income received from the sale of steam and scrap metal. Well designed and effectively operated incinerators eliminate food for rats and breeding places for flies and they are therefore hygienic.

3.28.2 Incineration is comparable to composting in that it is a method in which reusable materials are salvaged but contrary to composting it does not follow the logical process of returning organic material to the soil. This method of disposal may have to be adopted in cities like Bombay where dpe to increase in population and development of suburban areas, the length of haul to the site of disposal would disproportionately increase making the sanitary land fill disposal more costly.

Composting

3.29 Recent development in composting:

3.29.1 The return to the soil of domestic refuse has been practised for ages. However, it is only in recent years, that wider attention is being paid to this method of refuse disposal to utilise the end product of composting for enriching the soil.

3.29.2 The technology of converting municipal refuse to 'compost' has, consequently, developed especially in the last two decades. As a result thereof, well over a hundred engineered composting plants are either operating or are under construction in various countries of the world. It is true that some technical and scientific problems have yet to be solved but there is reason to believe that their solution will be found soon.

3.29.3 This method of disposal is gaining favour and it is being successfully operated where there is an easy and ready market for the sale of its end project e.g. compost. The manurial value of the compost

is not more than farm manure but it contains 'humus' which is of great value to the soil from the point of agriculture. For this reason, this method is being advocated by the 'International group of refuse disposal' (I.G.G.R.). According to this group, composting and incineration are the two most hygienically acceptable methods of refuse disposal.

3.29.4 Considerable amount of research is in progress in Japan and other countries for improving the methods of composting not only with refuse but with night soil, and/or digested or raw sewage sludge.

3.29.5 Compost is a good soil conditioner rather than a fertilizer. In some quarters, its manurial value is exaggerated but there is no doubt that this method of disposal is hygienic and it gives a useful product whose sale can help to lower disposal costs.

3.30 Chemical characteristics of compost:

3.30.1 Dr. Goaats gives the chemical characters of average compost from refuse as lying within the following units:

Substance	Percentage by weight
Organic matter	25 to 50
Carbon	8 - 50
Nitrogen as N	0.4 - 3.5
Phospherous as P_2O_5	0.3 - 3.5
Potassium as K_2O	0.5 - 1.8
Ash	25 - 65
Calcium as Ca^O	1.5- 7.0

3.30.2 The above analysis indicates that as an organic fertiliser, compost is equal to average farm yard manure.

3.30.3 The view of the American Public Works Association is that the value of composted household refuse appears to be in mechanical improvement of the soil rather than as a fertilizer measured by chemical standards. It has been proved beyond doubt that refuse composts are stable and resistant to the effects of climate and have both an excellent moisture holding capacity and the merits of improving the texture of the soil. For these reasons, municipal compost is well able to play a part in the replacement of soil nutrients.

3.31 Broad principles in composting:

3.31.1 The broad principle common to all methods of composting is the decomposition of organic matter contained in refuse to a fairly stable humus under environmental circumstances by aerobic organisms - principally theromophilic to utilise considerable amounts of oxygen in decomposing organic matter.

3.31.2 The technique of composting covers a series of operations that may be subdivided into two distinct phases - mechanical treatment and biological treatment. The mechanical treatment phase includes sorting out, homogenization or crushing, screening and elimination of grass. The biological stablization treatment

is the main phase in the whole composting process. The final quality of the product depends on this phase both from the sanitary and agricultural point of view.

3.31.3 The duration of the composting process, is an important consideration and is not itself a factor easily resolved. The time should not be so short that an immature product results. To some extent, the problem is influenced by the use to which the resultant product is to be put and even perhaps to the season of the year at which it is to be used.

3.31.4 Screening used in the mechanical treatment is helpful in eliminating the substances that could be reduced to acceptable size during the previous treatment of homogenization of crushing.

3.31.5 Biological treatment may either follow or precede the mechanical treatment phase. The fermentation therefore can take place either in the crude refuse or in the previously crushed homogenised and screened refuse material.

3.31.6 The main factors, responsible for the transformation of previously mechanically treated refuse, are oxygen, water content, pH and the presence of nutrients.

3.31.7 While aerobic disintegration is going on, heat is developed and the temperature goes sometime beyond $70^{\circ}C$. This rise in temperature promotes the destruction of pathogenic micro organisms that may be present in the refuse.

3.31.8 Thus, the fundamental requirements of the composting process call for (1) preshedding of the heterogenous refuse to a uniform size so as to get intimate contact among its compoents, (2) wetting and stirring to maintain an optimum moisture content, (3) controlling temperatures within the mesophylic range, although thermophylic range can also be used; (4) inocculation or seeding of the digesting refuse with suitable bacterial mostly through partial recirculation of the previously digested refuse, to speed up the digestion process, (5) mixing the refuse and adding air to alleviate the inherent odours, insect and rodent problems.

3.32 Carbon Nitrogen Ratio:

3.32.1 In order that the soil on which the compost is used, should derive the greatest benefit from its application, the carbon/nitrogen ratio of the finished product should be in the range of 15:1 to 25:1. If the C/N ratio is above 25:1, there is a risk of the carbon in the compost robbing the soil of its nitrogen. On the other hand, if the C/N ratio is below 15:1, the organisms in the soil and compost may attack the carbon and release the excess nitrogen as ammonia.

3.33 Methods of composting:

3.33.1 Several types of 'composting processes' are now extant. They vary from the simple backyard type manure heaps (which require land areas of 8 to 10 acres per each 10,000 population) to the progressively

more and more modernised continuously operating enclosed type methods, now being developed by several firms.

3.33.2 These methods may be broadly classified as follows:

(a) the heap process (windrow method) in which crude or presorted refuse is stacked in heaps which are turned over at intervals until the raw refuse reaches a stage of maturity. The undesirable objects are removed during the final processing with a final screening prior to sale.

(b) Mechanical composting in closed fermenting cells of refuse which may or may not have been sorted and disintegrated in some form, and which is charged from the cells in an at least semi-matured state as far example the Dano, Jersey and Earp Thomas process. At some stage there is a removal by screening of bulky objects. Further maturing of the compost can take place in the open.

(c) Mechanical pulverisation by rasps, hammer mills or similar means followed by stack-maturing. This reduces the refuse to a fairly ground material which may or may not be subsequently compacted.

3.33.3 The manually operated 'Windrow' method has the advantage of low initial cost. Its use is limited to areas which can be given considerable isolation. It is suited for warm climates. In this method, turning of the heaps or forced air aeration has to be

ash and cinder contents in European refuse the first step is screening. For this purpose, rotary and vibrating screens are in use. The same type of screens can be used to refine compost by removing coarse particles from it. Screens for raw refuse separation are usually provided with both coarse and fine mesh or perforations.

3.35.2 The rotary drum screen is housed to prevent dissemination of dust. The drum slopes slightly from inlet to outlet end, where duel screening is provided. The section nearest the inlet is provided with fine perforators (1" to 1½"). Separate hoppers beneath each section receive the screenings and discharge them to trucks or conveyor belts below. Relatively few rotary drum screens are in use at composting plants.

3.35.3 Vibrating screens may be either single or double deck types, usually single deck screens are provided with uniform perforations throughout the length but they may have sections with two sizes of holes. A double deck unit has coarse perforations (1" to 1½") in the upper screen and finer ones (¼" to ½") in the lower. Decks are inclined downwards from the receiving end to the discharge end so that the tailings bounce along to the outlet end. In turn-deck screens, the lower deck is longer than the upper. If dust is the problem, these screens may require hoods. Vibrating screens are employed in European plants.

employed to prevent nuisance from odours and flies. The refuse must also be ground 'coarse' as too fine a grind makes the pile anerobic. Turning is usually done either every day or once in two days, during the first week, and every two or three days, thereafter, for a period of three to six weeks.

3.33.4 The remaining methods fall under two categories. In both the categories, grinding of one sort or another either before or during the process is employed. In one of the methods a batch process employing controlled digestion varying from one day to weeks is resorted to, and this is followed by another period varying from two to four weeks.

3.34 Equipment used in Mechanised composting plants:

3.34.1 A wide variety of equipment is used for processing refuse and compost. The process steps vary from none to one or more of the following: Screening, hand sorting, magnetic separation, grinding, pulverization and inertial separation. In a few plants compost is bagged.

3.34.2 The degree of processing depends on the quality of refuse, plans of salvage, particle size requirements of the composting method and quality and particle size specifications for the finished compost.

3.35 Screening:

3.35.1 Refuse processing requirements in Europe differ from those in the United States, because, the constituent quantities differ. To get rid of high

3.36 Grinding:

3.36.1 This is processed by hand sorting and magnetic separation. Two types of grinders are in use-hammer mills and rasping machines. Hammer mills are usually of the swing hammer, high speed type, with horizontal axis. More recently several makes of double rotar hammer mills have been developed in which the two opposing rotars turn at different speeds. High speed hammer mills are provided with large motors to allow for the abrasive action of refuse. This also helps to prevent frequent rebuilding or replacement of the hammers and wear plates. Grinding may be done in two stages by using a coarse grinder first and fine grinder afterwards. Individual units have a capacity of 15 tons per hour or less.

3.37 Rasping machine:

3.37.1 It is a new refuse grinder. Its use usually follows the refuse sorting and magnetic separation operation. The rasping machine is a large vertical cylinder containing eight heavy hinged arms which rotate slowly horizontally above a rasp-and sieve floor. Beneath the grinding floor is another floor over which an arm rotates to scrape the ground refuse to a discharge hole. Refuse enters above, and is discharged below the machine or belt convevors. The units are generally 16 ft. in diameter by 7 ft. in height from top to discharge floor. One unit will

grind upto 60/T/Day or 2½ to 10 tons per hour varying greatly with sieve hole size.

3.37.2 The grinding floor is made up of trapezoidal plates alternating with ¼" pins and round perforations of 5/8" to 1½" diameter. The rotating arms force the refuse over the pins and through the holes in a rasping sieving action. The pins extend part way up the periphery for added rasping action. The arms rotate in the speed range of 15-25 rpm. They are hinged so that they can swing upwards when they strike resistant material that might otherwise cause damage. Tailings are released at intervals by opening a gate from the outside, permitting the arms to push the material through the opening to a discharge chute.

3.37.3 Compared to a hammer mill the rasping machine is higher in first cost and larger in size, but its operation requires only about one-forth the power and much less maintenance. The heavy arms rarely wear excessively and the rasping plates need replacement only about once per year.

3.38 Pulverization:

3,38.1 This follows grinding in European practice in order to reduce the size of such brittle materials as glass, ceramics, cinders and coal.

3.39 Roller crusher:

3.39.1 It consists of two opposing steel rollers rotating slowly on horizontal axis. The roller is under strong spring tension towards the other roller to exert a pulverising action as the material moves towards between them. Material is fed directly above the contact point of the rollers by means of a vibrating conveyor and discharged beneath to a belt or other conveyor. Stationary scrapers remove material, that sticks to the rollers.

3.40 Inertial separation:

3.40.1 Inertial separation is employed at many European plants to improve the value and appearance of the finished compost by removing some of the heavy (inorganic) and resilient particles. This type of separation depends on ballastic or gravity separation principles to remove such materials as stones, glass, metal, cinders, ceramic, coal and rubber.

3.41 Ballastic separator:

3.41.1 It consists of a high speed horizontal rotar and a large horizontal enclosure with two or three hoppers. Impellers, normally short pieces of rail-road rails, mounted on the rotar, strike the ground material and fling it horizontally or at a slight upward angle. The flying materials assume various trajectories along the length of the stilling chamber. Dense and resilient particles have a high initial speed,

and a long trajectory; light and soft particles have a lower initial velocity and a shorter trajectory. About three-fourths of the length of the 25 foot chamber is used to retain compostable materials, the remainder non-compostables. There is some overlapping of trajectories. The long compost chamber may require screw conveyors to move the material to the discharge openings. This ballastic separator serves as a grinder as well as a classifier, acting as a hammer mill that strikes the materials only once. The impeller and some of the plates of the housing are subject to heavy wear. The former requires replacement about every week or two. A single ballastic separator may serve a plant treating 10 to 100 tons per day depending on whether it is fed ground refuse or compost.

3.42 Secator:

3.42.1 It relies on gravity separation primarily to remove the heavy and resilient particles from compost. Compost is discharged from an inclined belt conveyor or operated at a relatively high speed so that it leaves in a tragectory. It then strikes a vertical plate and falls on pulley rotating in the direction as the convevor pulley. The pulley is so placed that the organics land on or forward of the centre of rotation and are carried with the pulley while the inorganics land behind the centre of

rotation and bounce off the opposite side. Hoppers collect the classified materials. They may be adjusted to rely more on either the bounce plate or the pulley for the separation.

3.43 Cost:

3.43.1 In plants, composting combined refuse (garbage and rubbish) more than half of the cost and labour is expended in refuse separation and grinding and in compost refinement as opposed to composting.

3.44. Manual composting:

3.44.1 Manual composting is effected by stacking the refuse in heaps or windrows not more than 4'-6" - 5' high and from 6 ft. to 10 ft. wide. The danger of fly breeding exists only in the outer 4" to 6" layer, where the temperature is lower. The heaps are turned over on the 3rd, 9th and 15th days. This enables the aerobic micro-organisms to work and to sterilize the refuse by exposing it to the higher temperature within the heap and to break the life cycle of the fly. Experience shows that after 18 days, the compost will be stabilised and is no more an attraction to flies. This turning process can be effected by hand labour, bull dozer, shovel dozer, fork lift or similar types of mechanical equipment.

3.44.2 The City of Haifa (Isreal) having a population of 1,50,000 has recently constructed a Dano biostabilizer garbage composting plant with a capacity to handle

sixty tons of garbage per day. This plant handles about one third of City's refuse. It has been put up as a pilot plant for eventual expansion to deal with the whole of the City's refuse.

3.45 Popularity of the composting plants abroad:

3.45.1 Compost plants in Europe are numerous. They range in capacity from 10 to 500 tons per day. The average capacity of the plant is around 25 tons per day. The plants in England are scattered in medium and small communities. They are also in use in Southern France and Germany and in the arid areas of Italy, Thailand, Japan and Isle of Jersey. Largest size plants are to be found in the low countries, particularly in the Netherland where almost 25 percent of the annual refuse output of 1.3 million tons is composted.

3.45.2 Popularity of composting in Europe is probably due to the relatively more higher capital and amotization costs of incinerators, the progressive non-availability of suitable lands within economic hauling distance for disposal by sanitary land fills and to their general philosophy and interest in the conservation of the various components of refuse for reuse.

3.45.3 Considerable amount of research is being done in Japan in improving the methods of composting with

night soil and refuse. Cities of Japan are densely populated and lack space. Therefore, the composting plant to be built in a city must be as compact as possible and issue no obnoxious odour. Accordingly, it is necessary for plants in the city area to adopt the high rate composting process in which a mechanical digester is used. The first plant in Japan was at Kobe. Five more plants have since been built after a good deal of experimental work.

3.46 Main consideration for the adoption of 'composting' as a method of disposal:

3.46.1 The first essential consideration is the availability of market for the end product and the facilities available for its transport in case there is no demand for the final project at the point of source. In situations where the inexpensive method of 'sanitary land fill' is not a possibility and incineration of refuse is the alternative, 'composting' may become economically feasible even if the final product is sold for only a nominal price. Some studies carried out in the United States have shown that composting costs were about the same as those for incineration on a ton for ton basis even without taking into account any income from the sale of compost or salvaged materials. In 1956, in the United States, the capital costs of new incinerators averaged 3000 dollars per ton of rated capacity while operational costs including amotization ranged from 1.5 to 3 dollars per ton in the same year per ton of raw refuse handled.

3.47 Composting of refuse with night-soil in India:

3.47.1 Composting of refuse with night soil is being practised in some cities in India. Indore was the first city, in India, to adopt this system on scientific lines. Bangalore followed suit and that city has its own system of composting refuse with night soil. There are thus two known systems of composting refuse with night soil in India - the Indore process and the Bangalore process.

3.48 Indore process:

3.48.1 The basic structure used in the Indore process is a shallow, open masonry pit two to three feet deep, ten to twelve feet wide about 100 ft. long. Night soil and mixed street sweepings and domestic refuse are placed in the pit in alternative layers, each about three inches thick to a depth upto five feet. This material is placed along the length of the pit but only on half width, in order to permit subsequent turning. Daily loadings in the pit are marked by small dated stakes. When the pit is filled its entire length, another pit is used.

3.48.2 The material contains house fly eggs and adult flies on arrival at the disposal site. The fly problem, at this stage, is efficiently controlled by a single application of a 2.5 percent solution of benzene hexachloride containing 6.25 percent gammaisomer in the technical grade material. Rate of application is one imperial gallon per 1000 sft. Thereafter, composting action takes care of the fly problem. The compost is

turned in the pit every two weeks for a period of eight weeks, then stored on the ground beside the pit for another month without turning.

3.48.3 The composting action is mixed aerobic and anaerobic with the aerobic action predominating, following each turning. Including placement in the pit and final removal, this process requires six complete handlings of the compost by manual labour.

3.49 Bangalore process:

3.49.1 The first step in this process is the construction of a series of earth trenches, each 30 ft. long, 4 ft. wide and 4 ft. deep. The fresh material is placed in layers as in the 'Indore' process to a height of about 18" above ground level and then eventually covered with a six inch layer of earth. The material is not turned and digested under essentially anaerobic conditions and is complete in four to five months. Fly control is achieved by the earth cover and possibly by the heat of decomposition. In this process, two handlings only are involved. The earth trenches are reused many times with a gradual loss of cross section.

3.49.2 The average nitrogen value of the compost by this process on dry solids basis is 2% as against 1% of the Indore process. The difference is due to variations in the composition of refuse and night soil collected from different areas of the city, rather than due to the difference between the two processes.

3.48.3 In this process, attempts to increase aeration and turning of compost mass are not made as it increases the cost of the ultimate product which the Indian farmer in view of his limited resources can not afford to pay. Though the process avoids turnings altogether, it lays great emphasis on the initial C/N ratio of the compost heap and initial moisture conditions.

3.50 Progress of composting town refuse with night soil in the country:

3.50.1 The scheme of town composting constitutes an important activity of the increased agricultural production programme of the Ministry of Food and Agriculture. Grants for this purpose are given by the Ministry of Food & Agriculture and the State Government in equal proportions to the local bodies. Besides, the subsidies loans are also given to State Governments for equipping the Municipalities with necessary transport needed for production and distribution of compost manure.

3.50.2 The final allocation made by the State for the implementation of this programme in the Third Five Year Plan amounts to about Rs.230 lakhs. It is programmed under this scheme to cover about 3000 urban centres in the country to produce about five million tons of compost. The Bangalore method is being followed in making the compost.

3.50.3 It is reported from the urban communities that output of refuse is generally of the order of about ½ to ¾ lb. of refuse per capita and about ¼ lb. of night soil per head of population per day although the figures

can vary due to such facts as industrial activity, local habits of the people, dilution of night soil with ablution water. It is estimated that for a unit of 10000 population about 800 to 1000 tons of refuse and about 800 tons of night soil (one ton equals about 200 gallons) are collected on average, each year. The total compost manure that can be prepared by mixing the whole of the refuse and night soil together may be estimated at about 1000 tons per year for 10000 population.

3.50.4 It is observed that about one-third of the total compost produced in a year remains unsold or unused because the distribution of composted manure does not keep pace with production. This gap is due to (1) lack of transport facilities, (2) poor purchasing capacity of the farmer, (3) lack of sufficient propaganda and demonstrations among farmers who have still prejudice against the use of night soil compost and lastly (4) poor quality of compost. Steps are being taken to improve transport facilities; to bring down the cost oby resorting to 'no-loss no-profit' basis, and to improve the quality of the compost manure. The compost is not analysed from time to time to test its quality. Poor quality of compost is due to lack of proper attention being paid by the local authorities in making the compost which results in low percentage of nitrogen and excessive amount of inert material in the compost manure.

3.50.5 A statement showing the progress made in preparing compost from night soil and refuse in the urban areas of the country since 1944 to 1961 is given below:

Year pre-plan period	No. of urban centres	Quantity of compost produced in million tons.	Quantity distributed in tons in million.
1944-45	260	0.18	0.051
1945-46	411	0.28	0.179
1946-47	578	0.41	0.289
1947-48	566	0.48	0.380
1948-49	696	0.72	0.517
1949-50	1036	1.20	0.92
1950-51	1047	1.40	1.06
	First Five Year Plan Period		
1951-52	1539	1.62	1.20
1952-53	1692	1.75	1.39
1953-54	1813	1.83	1.71
1954-55	1926	2.01	1.68
1955-56	2251	2.12	1.79
	Second Five Year Plan Period		
1956-57	2252	2.17	1.82
1957-58	1898	2.32	2.00
1958-59	1963	2.39	2.21
1959-60	2051	2.54	2.34
1960-61	2121	2.68	2.34

3.50.6 A part of night soil in Tokyo (Japan) is also used for composting with house refuse. As only 20% of the area of Tokyo is sewered, 80% of the area requires some means of night soil disposal. It is disposed of by (1) barging into the sea, (2) by putting in digestion tanks and (3) by composting.

3.51 Composting with sewage sludge:

3.51.1 About 50% of the composting plants in Europe process partially sorted refuse with sewage sludge. Some plants use digested sludge but the majority utilise raw sludge in order to conserve the nitrates and to save the cost of building and operating sludge digestion plant. The combined treatment enriches the end-product. It has been proved that this type of treatment, if properly controlled, kills the pathogenic bacteria, speeds up decomposition through bacteriological inccculations and is helpful in reducing the sludge treatment costs. The ratio of refuse to sludge is approximately 2 to 1, using sludge that has been dewatered to about 70% moisture content. By weight, about 3 tons of this mixed refuse and dewatered sludge produce one ton of compost. Gross operating costs vary but the median is about £ 3.30 per ton of refuse treated. The gross revenues approximate 1 to 3 pounds per ton depending upon refinements used and the amount of chemical added.

3.52 On site refuse compost:

3.52.1 According to APWA, an on-site refuse composting unit should consist of a small loading bin, a grinder and a small holding unit. Home refuse, except cans, bottles and other ungrindable objects would be fed into the unit, which would grind, digest and store the resulting compost for use as needed.

3.52.2 Many families could easily use the compost in their own yard. However, any excess could be collected and used as fill material. The compost would be stable and free from the objectionable characteristics of raw refuse that must be frequently collected.

3.53 Indifference to composting in the United States:

3.53.1 Since, chemical fertiliser are relatively cheap and plentiful in the United States, less emphasis has been placed on the agricultural values of refuse and more on the simpler methods of volume reduction and stabilization. In view of this, sanitary land fill or incineration is employed for the disposal of American refuse. However, serious thought is being given to composting as there are some drawbacks in both the systems, for example, land fill operation may be difficult in bad weather, when rains turn unfared access roads to mud, freezing temperatures slow earth moving operations and high winds blow dust and paper.

3.53.2 The following table from 'Municipal composting' by Mr. H.G. Davis gives refuse disposal costs by the three methods - sanitary land fill, incineration and composting:

	Capital cost			Annual operating cost		
	Total	Per ton capacity in dollars	Per capita	Total	Per ton in	Per capita dollars
1. Mechanical composting.	522000	9080	18.16	88767	4.23	3.09
2. Windrow composting.	198100	3447	6.90	42544	2.03	1.48
3. Incineration.	241500	4200	8.40	84000	4.00	2.92
4. Sanitary land fill.	40250	700	1.40	21000	1.00	0.73

Note: The above costs are based on 57.5 tons/day serving 28750 population.

Composting may have great future in India. If composting of refuse with raw or digested sludge is practised, it will help to reduce the cost of sewage treatment plants. Experiments carried out in Bombay with composting of digested sewage sludge with town refuse gave encouraging results. It is worthwhile to carry out experiments on 'composting' by putting pilot plants in two or three towns.

3.54 Refuse Pulverising (Half way to composting)

3.54.1 One of the mechanical methods of refuse disposal which at one time was very popular in England on account of its low cost of installation is getting renewed interest.

3.54.2 Pulverization or disintegration changes only the physical character and appearance of the refuse. It does not bring about any chemical change in the composition of refuse.

3.54.3 The pulverised material is largely used for dressing heavy soils and growing good crops. This material is not suitable for application on any or every kind of land for agricultural purposes. Its application can only be profitable to lands possessing certain characteristics. This limits its usefulness and sale.

3.54.4 Three main types of pulverisers used in the past in Great Britain are 'Gannow', Jeffrey and the Refuse masticator patent by Lightning Crusher Company. Disintegration in these machines if effected by feeding the refuse by hand, after removing from it very large articles, pieces of rags etc. into a strongly built metal mill where it is subjected to a beating action by hammers of alloy steel swinging or beating against a sectional grating of suitable mesh.

3.54.5 Pulverisation reduces the bulk of refuse by about 50%. This helps to reduce the cost of transport where the haul to the site of disposal is long.

3.54.6 Of the new machines now in use for pulverising, the Volund pulverizer is one. In this pulverizer, the breakdown is achieved by knives located on a heavy diameter shaft and rotating in counter direction in the screen drum, thus, breaking up the material and forcing it through the various screens.

The drive is external to the drum and does not in any way come into contact with the refuse.

3.54.7 In France, also the 'Gondard' pulverizer has been recently developed for which cheapness and high efficiency are claimed.

3.54.8 Gondard pulveriser accepts and treats municipal refuse without any preliminary sorting. The dust carts tip their contents, which are then fed directly into the machine. It can deal with every variety of refuse, household garbage including iron mongery, bottles, tins, food processing discards, grain busks, slaughter house offal, wooden boxes and crates, street cleansings, baled newspapers, trimings from market gardens, in fact, every type of rubbish that requires disposal - even if a curb or a paving stone is included, it is claimed, it makes no difference to the Gondard machine.

3.54.9 After treatment there emerges -

(1) A flaky powdery substance, a comparatively inoffensive dry material, into which every thing is transformed except -

(2) rubber tyres and metal which are discharged from a separate spout, the metal having been compressed into small lumps.

3.54.10 The machine works as follows

The tipping area is at the top and the refuse is pushed with a small wheeled dozer into the

machine; the flaky powder emerges from the bottom and falls directly into the lorry, while the tyres and metal lumps go down a chute into a trailer. Mechanical handling by a conveyor belt can be used to feed another belt or a blower, to move the powder to a dump.

3.54.11 The product can remain on the dump for a few days, after which time, it is absolutely without smell. This flaky powder is largely composed of organic substances, which, in a very short time, gets converted into 'humus'. It can be sold as manure to farmers who can grind it smaller for their particular purposes, and it then becomes a granular substance, easy and clean to handle.

3.54.12 The heavy items can be separated and the metal sold, while the tyres can be burnt. This sorting is the only sorting in the whole process. The receipts from the metal pay for the sorting and incineration. There are no magnetic separators, no sieves or shakers.

3.54.13 It is claimed that the income from sale of the humus to farmers and market gardeners can make the Gondard destructor self-supporting. The income can cover amortisation as well as maintenance and labour. The figures for 'Gondards' already in operation fully substantiate this claim.

3.54.14 The maintenance, which in effect, is the cost of replacing the worn moving-parts, is between 6 d. and 9 d. per ton of refuse treated. The consumption of

power by the electric motor is 7 KWH. This power cost depends on the local authority concerned, but it should be at a cheap rate. The tyres, metal etc. rejected from destruction vary according to the locality and the season, but can be estimated at 2½ percent of the input, of which about half is .scrap metal.

3.54.15 The space occupied by the Gondard machine is 16 ft. by 25 ft. including the platform under which the lorry and trailer wait to receive their loads, to which must be added the area of the tipping site.

3.54.16 The 'Gondard' can be operated upto a capacity of 20 tons per hr., can deal with wet or dry rubbish, can be installed in a populated area - provided refuse is treated on arrival - and, perhaps the most important factor is that the end-product can be transported away at once if a contract can be so arranged with the purchaser.

3.54.17 It is also claimed that the rats will not touch the powder and although its chemical composition varies with the area being cleansed. It should be particularly noted that in this machine glass is ground into dust and being quite imperceptible, farmers are never hesitant in bidding for it. In some cities the absolute destruction of bottles is extremely important because of the risk of residential liquids in bottles and containers affording breeding areas for mosquitoes and other insect posts.

3.54.18 Additionally, the quick destruction of refuse into this flaky powder removes the fire risk, because it is non-inflammable at all stages after passing through the 'Gondard'.

3.55 Advantages and disadvantages of Pulverising:

3.55.1 Pulverizing provides for the treatment of refuse within relatively confined spaces and ensures reduction in bulk to the extent of 50 percent which is an advantage from the point of transport to tipping sites. It also produces an innocuous material unlikely to create nuisance. It is a first stage in 'composting it can therefore be adapted to the 'composting process' at a subsequent date.

3.55.2 It is high in maintenance cost, as the knife and hammers are required to be replaced very frequently due to the extremely heavy wear and tear of the metal constituent parts of the equipments.

3.55.3 This method of disposal was tried in Bombay in the year 1922. It failed miserably owing to the unsuitability of the refuse for crushing.

3.56 General remarks on the different methods of disposal:

3.56.1 The philosophy of refuse disposal varies from country to country. In U.S.A. it is thought that refuse

should be immediately got rid of without making any attempt to salvage any useful materials contained therein. On the other hand, in European countries, the objective of refuse disposal is to recover from the same as much useful material which can be reused. Due to this difference in philosophy, the methods of disposal vary from country to country.

3.56.2 European refuse disposal practices are therefore not generally limited to a single operation as it is the case in U.S.A. Refuse, in European countries, is generally collected as mixed refuse without separation at the point of pick up (except for some paper salvaging in England). The material is brought to a central depot and treated there by 'separation' and then taken for final disposal. The refuse is treated mechanically so that screened dust is removed usually for agricultural purposes; cinders are screened out for fuel; ferrous metals are extracted magnatically; and textiles, rubber non-ferrous metals, bottles, cutlets and even string are sorted out manually and then baled, sacked or otherwise prepared for sale. Finally, the tailings or remaining refuse are either incinerated, composted or dumped at a sanitary land fill. These operations are practised in many combinations and various degrees, depending on local conditions - the salvage market, the season of the year, and other factors. It is reported that in England for most of the last two hundred years, the dust

contractors have made refuse disposal a profitable venture as one or other of the materials in town refuse acquired a marketable value.

3.56.3 Indirect salvaging through composting, waste heat recovery or power generation or through production of fuel briquettes is also coming to the forefront in foreign countries.

3.56.4 Direct salvaging in European countries seems to be losing its former importance and position as a method of disposal. It is no longer remunerative as it was twenty years before. This change in the outlook is probably due to high labour costs, modern technology and development of various synthetics.

3.56.5 Sanitary land fill or controlled tipping is resorted to where land costs are low and the length of haul is not great. When the cost of land/or the length of haul required to reach the site approaches a certain point, which would vary with local conditions, consideration is given to other satisfactory methods of refuse disposal. The capacity of collection vehicles in use is one factor that would help to determine the length of haul that would be practical.

3.56.6 When it is found that the length of haul is great and the sites available for 'sanitary landfill' are decreasing due to the expansion of the town or city, it would be advisable to consider incineration because a well designed and efficiently operated incinerator can be located close to or near the centre of refuse production areas without creating problems of

nuisance and air pollution. Incinerators may be designed with capacities large enough for future population increases, or may be built so as to facilitate subsequent enlargement of plant capacity. The residue from incineration, which is much less than the volume of refuse treated in the incinerator (provided that all dust, ashes and inert materials are removed prior to incineration) could be used for filling low areas or for road construction. Waste heat may be used for the drying of sludge from sewage treatment plants or for Dhobighats or such other purposes. The sludge from the sewage treatment works can be burnt in the incinerator. Steam can be produced from the incinerator and utilised for generating electricity.

3.56.7 Composting has also a good future provided there is an easy market for its sale. This method can be used for composting town refuse with digested or raw sewage sludge which would result in eliminating the cost of sludge digestion tanks which is usually very high and beyond the means of a medium size local authority.

3.56.8 After all, economics form a major issue where municipal administration is concerned and in this respect, land disposal schemes may find favour over incineration. It should be remembered that disposal by land is not necessarily cheaper than incineration, as much depends upon the standard of efficiency aimed at.

If the standard of efficiency is high, 'sanitary fill' may be as expensive as efficient incineration. In many cases, cheapness has been achieved only at the expense of efficiency.

3.56.9 In England, today, local authorities are experiencing embarrasment and opposition to plans for land disposal. Present generations are not inclined to accept the inconveniences and there is a call for other methods of disposal even at an increased cost. All over the country, there are instances of adjoining authorities faced with urgent and insurmountable problems of refuse disposal. The necessity of grouping of resources to provide more economical methods of disposal is being felt. It is believed that the regrouping of authorities for the purpose of refuse disposal would provide an answer to many economic problems. It also is being realised that the possibilities of composting the organic content of refuse, with or without the additional of sewage sludge do not only provide a means of refuse disposal but they also offer a method which returns organic matter to the soil.

3.56.10 Land disposal system, as pointed out before, has all the advantages where cost is concerned and is likely to remain the method of choice for many decades to come subject only to land limitations. Incineration has the drawback that land fill space is still required for as much as 50 percent of the material. Besides, it is costlier in capital cost and maintenance.

3.56.11 Incineration differs from mechanical composting in that it offers only a negative approach, to the ultimate disposal of wastes. The economic advantage of salvage measures which it offers applies equally to composting. Beyond that stage, incineration is merely an expensive and completely unprofitable form of refuse disposal.

3.56.12 Composting represents a feasible alternative by which the disposal of refuse can be effected, provided the circumstances in individual cases lead to the conclusion that composting is justified. According to experts, the opportune time to consider composting is when it becomes necessary to modernise the existing incineration plant or build a new one. This is the time to consider the claims of both the methods dispassionately. Comparisons and evaluation should have regard to all circumstances including finance and hygiene.

3.56.13 There must be a changing approach by local authorities, coupled with a general recognition that more money must be spent to achieve a satisfactory disposal. It is common to see large sums of money being spent on sewage disposal treatment and improvement with apparent willingness, yet expenditure on refuse disposal is earnestly avoided.

3.56.14 It is believed that the future municipal refuse disposal plant will consist of three integrated items:-

(a) A composting plant to convert the organic portion of the refuse into good humus. This plant may also deal with sewage sludge.

(b) An incinerator to deal with the more combustible and bulky items of refuse which are not really suitable for composting - eg. plastic, waste paper, card board and wooden containers etc.

(c) A small tipping area to receive and consolidate incombustible debris and ash from the incinerator.

3.57 The Garchey system

3.57.1 The 'Garchey' system is a hygienic method of refuse removal from large multi-storey blocks of flats. It is in use in England and France. Its initial installation at a cost of about £ 120 per flat, plus a relatively high cost of operation mitigates against its more extensive use. However, if the capital and maintenance cost of this system is compared with the cost of collection and disposal by more conventional methods, 'Garchey' appears to be very costly. It is quite likely that as water borne sewage replaced the privy, so water-borne garbage, may in some areas, replace the garbage pail in the distant future.

3.57.2 The old Garchey system has been in use for the last thirty years on a very limited scale. It has since been improved. It is now known in Great Britain as 'Mathew Hall-Garchey system for municipal Housing'.

3.57.3 It is a centralised system for dealing with household refuse in municipal flats. This system has been in operation for many years on the continent.

3.57.4 Basically, it enables the housewife to dispose of rubbish, including tin cans, bottles etc. through the specially designed waste line of the kitchen sink. Then it is carried to an appropriate receiver fitted beneath and by the flushing action of the normal waste water, into a central collection unit. In its latest form, the unit is periodically emptied by a vaccum tanker vehicle which returns water to the main drain and compresses the remaining contents into a semi solid mass ready for easy and hygienic unloading at the municipal tips. Its slightly damp nature prevents wind disposal and assists in compacting. In its original, alternative form, the Mathew Hall Garchey system, embodies an exhauster mechanism which transmits the contents of the receiver by suction into a main holder, extracts initial water and passes into a main holder, extracts initial water and passes into the sewer; it then spin-dries the solid content which it rejects into a built-in incinerator from which only clinker, a mere fraction of the volume of the original charge, has to be removed.

3.57.5 In the operation of this system no fresh water is required. It is unnecessary for any one to touch the refuse once it has disappeared down the kitchen sink; the apparatus is capable of dealing with the refuse from more than 300 buildings. The design ensures that the blockage of the sink waste outlet is virtually impossible and that the operation of the simple disposal

mechanism. in which no moving parts are used, can be carried out by any housewife. It interfers in ho way with the normal use of the sink. The immediate flushing and removal of the refuse from the receptacle prevents any unpleasant odours.

3.57.6 Contracts for this system have been placed by the authorities responsible for housing development at Leeds, Sheffield, Birmingham and in London. The Mathew Hall Garchey system has been functioning satisfactorily since 1948 at Spa Green Housing Estate of 129 flats in Finsbury and is found to be economical.

3.57.7 Its adoption may be considered in situations where large housing estates are being developed.

3.58 Street Cleansing:

3.58.1 The standard of a city's cleanliness is usually judged by the cleanliness of its streets and hence street cleansing should also be done as effectively and efficiently as possible.

3.58.2 In Indian towns street cleansing is again done either by the health or engineering departments. In some European cities the street cleansing work is entrusted to a department which is independent of the organisation responsible for the collection, transport and disposal of refuse.

3.58.3 The aim in street cleansing should be to clean the streets at regular intervals according to the importance of a street in respect of traffic passing over it and its situation. In a manufacturing or large

industrial district more frequent attention from the point of cleansing may be necessary than to a residential district. Similarly, residential areas occupied by the poor citizens need more looking after due to lack of orderly handling of rejected material and volume of wastes.

3.58.4 The efficiency of this service depends upon the type of the surface of the street whether black topped, cemented or of ordinary macadam.

3.58.5 The discarded materials required to be removed from the streets include (1) dust blown through the air (2) sand and clay tracked on by vehicles and pedestrians or carried by rains (3) particles from the wear of pavements, vehicles and tyres (4) leaves and branches from trees and shrubbery and (5) litter and other dirt consisting of refuse discarded by the pedestrians and riders in vehicles, sweepings from foot paths and buildings, droppings from over loaded and defective truck bodies and debris from construction operations.

3.58.6 In our country, hand sweeping of streets is common. Machine sweeping as used in foreign countries has yet to be introduced. Hand sweeping is done on the length or beats system while gang system is used with machine sweeping.

3.59 Road washing is done by hand with fire hoses in big cities. Sprays working under a pressure of 40 to 50 lbs per sq.inch are employed for this purpose in

some foreign cities. Road washing washes the dust thoroughly from the street surface and removes the oily film responsible for causing slipperiness on the road surface.

3.59.1 In European cities, streets are washed and cleaned at night time between the hours of 10 P.M. to 6 A.M. Machined washers equipped with rotary rubber squeezers are needed for this purpose. The quantity of debris collected from streets in European countries is 15 to 35 cub. yards per street unit per year in contrast to American 50 to 65 cub.yards. The power brooms used in European countries are of an advanced design.

3.59.2 The cost of street cleaning in the USA is about 20% and for refuse collection and disposal 80%. Similar figures for France and England are 25 to 75% and 30 to 70% respectively.

3.59.3 Manual cleaning is practised in European countries to the extent of 75% against 25 to 50% in the United States.

3.60 Littering:

3.60.1 Littering of streets is one of the evils which has to be contended with. Litter constitutes a large part of the street dirt and it also requires a good deal of money to collect. Nothing disfigures a city more than the deposits of litter on the streets through the thoughtlessness and carelessness of the

citizens. Every city has therefore to devise ways and means by which the citizens can be prevented from throwing materials from houses on the streets.

3.60.2 This evil can be checked by enacting bye-laws making littering unlawful or by obtaining cooperation of the citizens through education and appeals to public pride Where ordinances are in existence it is difficult to enforce them especially in respect of casual dropping or throwing of rubbish, materials, paper, matches, cigarettes etc.

3.60.3 The following is an example of a typical bye-law in force in some European cities in regard to 'littering':

"No person shall sweep, throw, cast, lay or direct or suffer or permit any servant, agent or employee to sweep, throw, cast, lay, place or deposit any ashes, offal, vegetables, garbage, fruit skins, dross, cinders, shells, straw, shavings, paper dirt, filth, lawn rakings grass clippings, broken glass ware, hand bills, crokery, bottles, carcase of any animal, or rubbish of any kind whatsoever on or in any street, lane, roadway, side walk or public place in the city, except ashes, cinders, sand or saw dust which may be lightly sprinkled on slippery side walks or thorough fares as a measure of safety".

"Do not place grass cuttings, and lawn rakings loosely upon the roadway, such material must be deposited in receptacles and placed out for removal only on the

regular days for collection. Your cooperation will be appreciated".

3.60.4 Some European cities have ordinances to prevent transporting materials in leaky wagons or vessels.

3.60.5 Most of the cities in the West provide containers at convenient points into which pedestrians can discard materials. Those containers must be provided at reasonably accessible points and given proper publicity. Otherwise, the wastes would be thrown on the streets as a person is not expected to carry waste paper, cigarette butts or other wastes very far or not to store them in his pockets until a satisfactory point of disposal is found.

3.60.6 The type of containers vary from city to city. In America, they range from open wire mesh baskets to elaborate sheet metal cabinets with tilting doors. The metal cabinets have a capacity of 30 to 40 gallons.

3.60.7 In European cities, the stanchion hung litter containers are generally of five to ten gallons capacity. These are placed at best one to a block and seem to be adequate for local conditions. In the U.S.A. 40 gallons containers are placed two per block.

3.60.8 In European cities, the amounts of dirt and litter collected range two to four lbs. per sq.yard of pavement per year against seven to ten lbs of sweepings and litter.

3.60.9 The extent of success achieved in creating public opinion in favour of cleaner streets depends upon

persistence and the methods used in telling the citizens what they should do and should not do. The anti-littering compaigns do not have a lasting effect and hence do not get a good response from the citizens.

3.60.10 Education against littering of streets can best be imparted through public school activities, news paper articles and advertisements, exibits, speeches, radio talks, notices attached to water and tax bills and the like.

3.60.11 Just as 'education' is required to teach the public the habit of cleanliness, the staff engaged on cleansing work has also to be trained.

3.60.12 In one of the American cities the following instructions in the form of 'Donts' are issued to the sweepers:

(1) Don't let paper or litter of any kind remain on the street.

(2) Don't sweep across a clean place, shovel up the deposit where it lies.

(3) Don't sweep into sewer inlets or depressions in the pavements.

(4) Don't raise clouds of dust when sweeping.

(5) Don't slide in brooms along the street. Use short and long strokes strong enough to move the dirt the first time.

(6) Don't sweep against a strong wind.

(7) Don't work with traffic except when

absolutely necessary. Work against it, so you can see approaching vehicles and avoid accidents.

(8) Don't forget to report the following to the foremen. Dead animals, water leaks, clogged inlets, depressions in pavements and violations of the ordinances affecting cleaning and collection work.

(9) Don't deposit dirt anywhere but in the collection barrels.

3.59.14 The standard of cleaning of the streets in India has to be raised to a much higher level.

4. MISCELLANEOUS

4.1 Organisational set up:

4.1.1 The responsibility for the collection and disposal of municipal refuse, in a majority of Indian towns vests in the town's Health Department. In Bombay and Calcutta, this work is the responsibility of the City Engineer's Department. As this service is getting more and more modernised, engineering talent must be brought in to improve the efficiency of the service as has been done by the local authorities in practically all the foreign countries. The work of Collection and Disposal of Refuse should therefore be transferred from the Health Authorities to the Engineering Department of the Municipality, who may be assisted by a special officer. The city Engineer, in large Cities, must be assisted by an experienced & qualified Engineer. Care should be taken that the officer placed directly in charge of this service is fully qualified for the position and that the salary offered will attract the right type of man; if this is not done, improvements and economies can scarcely be hoped for. Experience in foreign countries has demonstrated that where a qualified engineer with good experience is placed incharge of the service efficiency can be improved and costs materially reduced. The officer incharge must infuse in the workers the quality of high sense of duty, observance of strict discipline and the spirit required for proper team work. The key note of keeping down the cost of the service is the right selection and maintenance of the fleet employed for refuse collection and transport work. For high efficiency, the fleet must be used to its maximum capacity.

4.1.2 Most of the municipalities in England have a 'Director of Public Cleansing' to look after refuse collection and disposal work because it has been realised by them that this work is no longer of a simple nature but has become highly mechanised requiring more engineering knowledge and skill.

4.1.3 It will not be possible for small municipalities in our country to employ a Director of Public Cleansing and some means will have to be found to make the services of a competent Engineer available to them for giving proper direction and advice from time to time. If the Government of India approves of the appointment of a Committee on all-India basis to study all aspects of refuse collection and disposal work, this Committee should also look into the question of the organisational set-up for small and large municipalities and make suitable recommendations.

4.2 Work Study:

4.2.1 Public cleansing is an interesting field for 'work study'. In Swedish Cleansing Service, all jobs capable of definition by quality and quantity and the output of a worker are subjected to the techniques of work study by local authorities 'specialists in the techniques or by the work study department of the Association of Swedish towns. Based on the results of these studies, agreements are reached with the local trade unions on rate of pay per unit of work. The

element of incentive payments has also been introduced in the Swedish Public Cleansing Service. The idea of introducing incentive payments is to increase the employees' wages to bring it on par with that of the labourers working in other industries.

4.2.2 The items for work study of refuse collection and disposal service should include the following:

(1) Improvement in the mode of operation.

(2) Improvements to existing vehicles or providing better vehicles and equipment.

(3) Standardisation, wherever possible, of types of vehicles. (There is a close cooperation, abroad, between users and manufacturers of equipment and vehicles used in public cleansing work.)

(4) Possible improvements in storage vehicles.

(5) Stepping up of the organisation with a view to better utilization of manpower.

(6) Increasing effectiveness of manpower.

4.2.3 While considering the question of improving the efficiency of the system a close study should be made of all the existing systems of collection - such as street collection, bin collection without mechanical assistance, bin collection by trolley, dustless collection special type bins, mechanical composting and bulk storage containers.

4.2.4 In making the work study, flow charts, giving process and activity charts should be compiled and used

to decide the best route for the vehicles, the team size and the most suitable vehicle to serve the team as also the correct tools with which the team should be equipped for efficient performance.

4.3 Training of personnel:

4.3.1 The International Congress on Public Cleansing has stressed the necessity of laying down the items of training for officers and supervisors engaged in public cleansing work.

4.3.2 In England, larger authorities provide elementary courses of training and arrange for occasional lectures.

4.3.3 Some training to the personnel employed in this service in India is considered necessary.

4.4 Public Relations:

4.4.1 Public cleansing is one of the avenues of municipal service in which the contact with the public is most emphatic. The efficiency of the municipal administration is reflected in the way this service is operated. If the service is fairly efficient, the rate payer feels that he is getting adequate return for the money he pays to the municipal exchequer for rendering the service. For this reason, the personnel working in this service should have good relations with the public and all possible efforts must be made by those incharge of the service to get as much public cooperation as possible. The success of the service will depend to some extent on the cooperation given by the public.

4.4.2 Public relations may be described as good will achieved on the basis of the standard of service provided. In order to create good public relations, the help of 'publicity' has also to be taken. Cinema, radio, pamphlets and such other means should be employed for giving as much wide publicity as possible.

4.4.3 In our country, the work of refuse collection and disposal is done by a special class of people. The work is considered to be degrading. The status of this service has to be improved to attract better type of men, otherwise, it may so happen that in future, with the advance in education, difficulty may be experienced in getting the requisite personnel for manning this service. It is therefore necessary to mechanise it by stages and reduce gradually the staff requirements without creating unemployment problems.

4.4.4 Contact with the employees and social mixing by superiors and other officers would be conducive in maintaining good relations between the employees and employers.

4.5 Research:

4.5.1 There is great need for research in the collection and disposal methods as well as in the administrative and relative aspects including education and training. Considerable research is being done in the foreign countries in this field.

4.5.2 The American Public Works Association, two years ago, has recommended to the U.S. Department of

Health, Education & Welfare to undertake a broad programme of basic and applied research in this field, by earmarking one half to one percent of the total annual cost of refuse collection and disposal for this purpose. The amount likely to be available for research, if the recommendation is accepted, would be about 7½ million dollars.

4.5.3 The A.P.W.A. has also suggested a list of research items. It includes:-1) reduction in the quantity of solid wastes to be disposed of, 2) new uses for existing wastes on an industry wide basis. The wastes suggested for study are organic wastes for making animal feed, antibiotics, enzymes, vitamins and bone calcium phosphates. In addition to the above, the A.P.W.A. has recommended the development of a reliable and standard sampling procedure for analysis and study. Today, the knowledge of the physical & chemical composition of refuse is meagre and more information in this regard is necessary to understand precisely the nature of wastes to be handled.

4.5.4 The National Institute of Health (U.S.A.) have sponsored a project at Purdue University for developing (1) reliable methods of refuse sampling and analysis; (2) study of the physical and chemical composition of refuse produced in a number of cities and (3) statistical analysis of the data obtained in (2), to find out how it could be applied on a nationwide basis. Many cities in the U.S.A. have already done

the work now undertaken by the Purdue University. Another recommendation of the A.P.W.A. is the starting of a continuing waste testing programme to obtain comparative data on the quality and quantity of refuse produced in representative cities in different parts of the country. For conducting this programme, the A.P.W.A. has recommended the use of a mobile testing laboratory. The survey of the quality and quantity of refuse in representative cities will be helpful in determining the changes and trends which, in turn, would serve as a continuous guide in planning refuse collection operations and designing disposal facilities.

4.5.5 Research is also being carried out in the U.S.A. on alternative methods of refuse disposal, as the spreading of urban areas have reduced the number of disposal sites available for sanitary land fill.

4.5.6 Research in this activity of the municipal service, at government level, is strongly advocated in all foreign countries. Local authorities, in most of the countries, cannot afford to spend money on research when they have not adequate funds at their disposal for operating the service in a satisfactory manner without subsidy.

4.5.7 In our country, no research in this field is in progress. No local authority thinks that research is necessary. The correct composition of refuse is not known. No standard methods of sampling and analysing have so far been developed. A mobile testing laboratory will help in getting a correct idea of the composition

of refuse (chemical & physical) produced in representative towns. The Central Public Health Engineering Research Institute should be asked to take up this work along with the study of the various methods of disposal.

Appendix I.

Refuse Landfill Standards.

Sanitary land fill location: Sanitary land fills whether operated on firm ground or soft and unstabl ground as may be found in marshes and swamps shall be planned by a properly qualified Engineer and be operated and maintained by properly trained personnel. The location or site of the land fill should be chosen with the approval of the local Board of Health.

Requirements of firm ground sanitary land fills

Sanitary land fills on firm ground shall be designed, operated and maintained in such a manner that

(a) The face of the working fill is kept as narrow as is consistent with the proper operation of trucks and equipment in order that the area of waste material exposed during the operating day is minimum.

(b) All exposed surfaces including the face of the fill are covered with atleast six inches of earth at the close of each day's operation.

(c) Refuse is compacted into layers of approximately one fourth of the original refuse volume.

(d) Bulky waste material which may furnish rat harbourage is not used for the final surface or side slopes but incorporated within the fill.

(e) The final earth covering for surface and side slopes is compacted and maintained at a depth of not less than twenty four inches.

(f) Cracks, depressions and erosion of the earth covering for surface and side slopes of fills are promptly repaired.

(g) The toe of finished fills having boundary side slopes shall terminate in a dike or ditch filled with sand or gravel or either.

(h) Surface water is properly drained, filled or treated with effective chemicals so as to prevent mosquitoes production and odours.

(i) Control over the scattering of papers and other light weight materials is effected by the use of moveable fencing or other suitable method.

(j) Dust control is effected as needed by spraying of the exposed waste material and adjacent surface.

(k) Scavengers, if permitted, are properly supervised so as not to interfere with the refuse disposal operation.

(l) Equipment adequate for digging, compacting and covering is provided as needed.

(m) Sufficient stand by equipment is readily available to prevent delay in covering due to break-downs or peak loads.

(n) Adequate water and fire fighting equipment is readily available to control any or all fires.

Requirements of soft and unstable ground sanitary land fills

Sanitary land fills in soft and unstable ground as marshes and swamps shall be designed, operated

and maintained in such manner that -

(a) The face of the working fill is kept as narrow as is consistent with the proper operation of trucks and equipment in order that the area of waste material exposed during the operating day is minimum.

(b) The maximum exposed active operating area shall not exceed an area greater than 100 ft. by 150 ft. The active operating face shall not exceed 150 ft. in width.

(1) Surface and side slopes of such land fills shall be compacted and covered on a progressive basis with earth as quickly as feasible but in no case shall it be exposed for more than one week or six working days.

(2) At the termination of the filling operation or whenever a change in direction of the filling operation occurs, the uncovered surface and face shall be compacted and covered with earth on a progressive basis within one week or six working days.

(3) The exposed active area and face of a land fill shall be reduced by one half when less than 75 truck loads of refuse are brought to the land fill each day.

(c) Refuse is spread and compacted to a uniform grade with heavy equipment in order to support operating machinery and truck movement on the active operating area.

(d))
) Same as for 'fills' on firm ground.
(e))
(f))

(g) The toe of finished fills having boundary ndary side slopes shall terminate in a dike. The ditch formed by the construction of a dike shall be designed to have an open end to permit free flow of water in any or all ditches which were installed for mosquitoes control or shall be designed to permit the effective use of mosquito control equipment.

(h) Surface water is properly drained or treated with effective channels so as to prevent mosquito production and odcurs. The operator of each land fill shall cooperate with the appropriate County Mosquito Commission to prevent and control mosquito production.

(i) Control over the scattering of paper or other light weight materials is effected by the use of moveable fenning. Fenning may not be required in marsh land where tall grass and other plant growth serve as an adequate screen to prevent scattering or movement of paper and other light weight materials.

(j),(k),(l),(m), & (n) /-- same as per firm ground fill.

Rodents and insects hazardous to public health

Rodents and insects, hazardous to public health shall not be permitted to exist on sanitary land fills.

Note - The above regulations are included in the New Jersey (U.S...) Sanitary Code for Refuse land fill standards.

Equipment recommended for the operation of sanitary land fill by the U.S.P.H. Service.

(1) Crawler tractor with blade or showel type attachment.
(2) Bull dozer, drag line combination (needed only for large operations of for operating in swamp or marsh).
(3) Carry all scrapers and bull dozers for large operations or where earth must be moved to a considerable distance.
(4) Bull dozer and truck to haul cover material plus loading equipment at the source of cover material.

Guide to approximate size of equipment for different communities:

Population served	Size of equipment
Upto 10,000	One crawler tractor with bucket of shovel capacity of about 1 cu.yd.
10,000 to 30,000	One crawler tractor with bucket or shovel capacity of about 2 cu. yards.
30,000 to 50,000	One crawler tractor with bucket or shovel capacity of about 3 cu. yards.