

ECONOMICS
OF
MUNICIPAL REFUSE

by

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A THESIS

submitted to

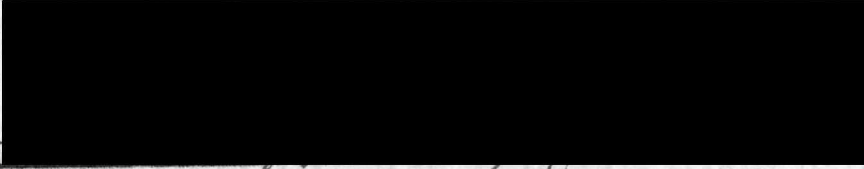
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ECONOMICS
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Wherever people congregate the problems of community life have quickly developed. Some of these have been recognized and accepted as community problems and the remedies have been promptly supplied. (It is universally accepted that the development of safe water supplies and excreta disposal have done much to reduce certain kinds of disease. Health authorities recognize certain other diseases, possibly not as spectacular in character, but as truly communal in nature which need control and which need the community approach which water supply and excreta disposal have received.

Vegetable and other organic material are generally subject to decay and in the process give rise to objectionable odors. On medical evidence the courts have held that odors do not create disease and therefore are not specific public health problems, but public health workers are agreed that disease does originate in filth and decaying matter through an intermediary acting strictly as a carrier or as a host. In such a classification an animal, an insect, a mollusk, or some other form of animal life is recognized as playing a part in the disease picture.

Some of these causes of public health hazards such as the mosquito in malaria, yellow fever and sleeping sickness and the louse in typhus fever, are recognized in certain localities but there is no wide spread interest in demanding or developing a community protection from them.

One of these disease creating problems involving decaying organic matter, carriers and host, is present today. Household refuse, and particularly garbage, is the most common source of decaying organic material in a community.

About the home, the restaurant, grocery store, tavern, and other places where food is handled, stored, processed, served, or sold, there is a constant accumulation of what is generally termed garbage. To this can be added the metal, glass, and paper containers in which the food is shipped or packed, which along with the ashes and other solid material, called refuse. This garbage and refuse presents a very definite problem at the property. Aesthetically, it is unsightly, and very apt to be odoriferous. It attracts flies and promotes fly breeding which increases the possibilities of the spread of disease. It attracts rodents and insects and these too are the vectors of numerous diseases. Containers that will hold water become sources of mosquito breeding. The refuse further contributes to the fire hazard. To eliminate these condi-

tions requires regular removal from the premises. Failure to remove only adds to the unclean, insanitary, dangerous condition; breeds contempt for cleanliness and indirectly increases the cost of numerous services already rendered by other agencies.

Flies, rodents, and insects have been definitely proven to be the carriers of disease, although the mode of transmission of the disease may be quite different in each case. Flies have long been known as the mechanical vector of typhoid fever, paratyphoid fever, and dysentery. They may also be proven to be of epidemiological importance in several virus diseases, including poliomyelitis. Rats are known sources of such infections as jaundice, typhoid fever and trichinosis. In addition the rodents caused property damage estimated to be about \$13 per person during 1948. (7, p.995)

When it comes to the disposal of this material numerous problems arise which have a specific health significance. When disposal is accomplished by dumping, there is only created a greater area of attraction to flies, rodents and insects for feeding and breeding. This makes possible the infestation of the rats with trichinosis from the raw pork scraps in the garbage. This even makes it possible for dogs, cats, and other carnivorous animals

with cannibalistic instincts to become infected with this disease; and if hogs are permitted to feed on the garbage, we have immediately opened the field to the infection of pork for human consumption. The importance of trichinosis is a public health problem that cannot be ignored. Although seldom seen in epidemic proportions, a large number of the population is known to be infected. This also adds, from an economic standpoint, to the increased infection rate of cholera among the hogs, to say nothing of making it possible for infection of the mole, the ground squirrel, and the fox, which are all known to be hosts to trichinosis. (18, p.15) If incineration is resorted to there is the problem of preventing odor, both in handling the garbage prior to burning and during burning. In the past, numerous incinerators have been abandoned because they were permitted to deteriorate into "garbage cookers" and intensified odor producers.

Why then is so little municipal attention given to this important necessity of community life and welfare? The reasons for this may be as follows: (1) Fear of increasing taxes. (2) Lack of general demand. (3) The fact that no serious loss of life or epidemics have been attributed to this source of infection. (4) The simplicity of the coal stove or trash burner in the home.

With the changing times, however, the question of

method of elimination of these filthy spots and the responsibility for control, is becoming more acute. If polio is proven to be a disease of sanitation, and it is rapidly appearing that way, the spectacular aspect may even be right around the corner.

The recognition on the part of municipal officials of a new service requirement and new responsibility is needed. The removal of the wastes of the community is an obligation. Not only the garbage, but the refuse as well, must be removed regularly from the individual premises to maintain clean and sanitary conditions. The removal of garbage alone is not enough and the desire to make the service self-supporting requires careful planning. It is essentially a scavenger service from which, in certain cases, some minor return may be obtained, but otherwise is an expense item. It is a service which must be available to all the people of the community to be effective. It can never be effective when it is left to the individual home owner or occupant to subscribe for the service. That only encourages the promiscuous throwing of garbage and refuse in highway ditches, and vacant lots. The ideal collection and disposal service should be one that is available to everyone and the ideal legislation when necessary would make it unlawful to fail to use the service. Ordinances have been passed (6) to make

it unlawful to burn any wet garbage or other substances which create foul or obnoxious odors within the city limits.

Every municipality has a service department in some form or other rendering services now. It is no long step to add another activity or expand an existing activity to that department. The cleaning of streets and alleys, the removal of trash in the spring clean up, the leaves in the fall and the snow in the winter, the collecting of trash from the cans on street corners, are already practices in many cities and are part of a municipal refuse collection service. The definition of refuse disposal need only to be expanded in content and frequency and the goal will be obtained.

Throughout this report the term "refuse" is used to designate both garbage and other non-liquid waste products.

REFUSE COLLECTION

Refuse must be collected before it can be disposed of by any method. The collection and removal of municipal refuse has not been given the attention that this public function deserves. Only within relatively recent years have municipal officials been willing to admit that refuse disposal is a technical management problem worthy of their attention and study. The problem should be analyzed in terms of sound administrative management with the consideration given to the public health aspects of government.

Necessity for Refuse Removal.

People living in towns and cities continuously produce large quantities of waste materials which ordinarily cannot be disposed of safely, effectively or economically by themselves. Garbage results from processing, marketing, storing and preparing food; rubbish of all kinds accumulates through normal processes of living; and ashes are produced wherever coal, coke, or wood is burned. Such materials cannot be left to accumulate on individual properties without menacing public health, creating fire hazards, causing nuisances, and generally detracting from community appearance.

Complete removal of all refuse depends upon the size

and density of the population of the community. Small communities where businesses are not numerous and the houses far apart may need but little organized collections. Even in such places garbage should be removed frequently and regularly because it decomposes rapidly, produces foul odors, and it also provides breeding places for flies.

Responsibility for Refuse Collection.

To safeguard public health and to prevent nuisances, municipal governments must accept the responsibility for regulating the handling, storage, and hauling of refuse. Some communities prefer to leave the operation to private enterprise and to depend upon normal competition to keep the cost of the service at a reasonable level. In still other communities a private enterprise purchases a franchise to remove the refuse and the municipal government officials enforce the sanitation standards. In some instances the city itself may elect to do the collecting with municipal owned equipment.

Cooperation of Householders.

The effectiveness and cost of operation of a collection system depends to a great extent on the cooperation of the householders in providing proper containers, preparing and storing the refuse in accordance with regulations and placing the material for collection regularly.

Effect of Disposal Methods.

Careful consideration should be given to the means of disposal which will permit the lowest cost of collection. The separation of refuse by the householders and the classes of refuse collected together are fixed by the disposal method. The size and kind of equipment depends upon the nature of the refuse collected and the length of haul to the disposal site.

Seasonal and Daily Variations.

The amount of refuse produced varies considerably with the seasons of the year. The quantity of garbage produced is greatest in the summer months when fresh fruits and vegetables are plentiful, and smallest in the winter months. Yard refuse is most plentiful in the spring and fall, although some must be collected throughout the summer, and ashes, are normally produced only in the cold months.

In addition to seasonal variation, the quantity of refuse will also vary from day to day. When the Sunday collection is omitted large amounts of garbage accumulates which must be collected on Monday. The quantity of garbage then decreases toward the middle of the week and then starts increasing again toward the end of the week.

(5, p.2-4,8)

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Refuse Collection Equipment.

Equipment is usually selected for reasons of economy, sanitation and appearance. The bodies may be open or enclosed and may have dump, fixed, removable, or can carrier beds. There may be mechanical elevating or compressing devices.

Numerous factors (14, p.443) such as loading height, unloading devices, covers, turning radius, watertightness, divided bodies, end gates, and safety devices may influence the over-all economy as well as effectiveness of the equipment. Furthermore, it may be desirable to select vehicles that can be used on other municipal work as well.

Sometimes it becomes uneconomical to transport the refuse to the disposal site in the collection vehicles. In this case transfer stations must be operated.

These numerous factors will be discussed separately further on in the report.

Financing Refuse Collections.

Municipal collection services are normally financed from general tax revenues, but in late years many communities have been unable to provide the kind of service wanted by the citizen from the amounts available from this source. Some cities have adopted the service charge plan under which the householders and other refuse producers are

charged fees in proportion to the amount and kind of service given. In some cases separate taxes or even special assessments have been used for financing refuse collections.

Public Relations.

Citizens are people. If their property is damaged, their senses offended, or their pride insulted by an act of a public agency or employee, they are apt to condemn the whole program of the offending agency. But when their rights and feelings are respected by public servants, they will most often react sympathetically to efforts to improve the service.

The adequacy of the collection system is judged from the service rendered and the equipment and personnel seen on the streets. Fortunately, manufacturers of collection vehicles have recognized the importance of sightliness and utility, so that suitable collection vehicles for any requirements are obtainable.

REFUSE MATERIALS

Refuse is of highly heterogenous nature and the names given to its various components differ considerably from community to community. It is not uncommon for a city to use one of the terms, "garbage", "rubbish", or "refuse" to mean all the materials it has decided to accept for collection. In some sections of the country the word "trash" is used to mean miscellaneous household debris other than garbage and ashes; in other sections "rubbish" is the term used to designate such material.

This situation leads to numerous uncertainties and at times actual error in the interpretation of the literature of the field. This is especially true in connection with court decisions and popular articles concerning refuse collections. (16, p.457; 17, p.640)

The following table (p.13) by the Committee on Refuse Collection and Disposal, American Public Works Association, 1941, gives the classification of refuse materials.
(1, p.17)

CLASSIFICATION OF REFUSE MATERIALS					
Refuse	CLASS	DESCRIPTION		ORIGIN	DISPOSITION
	Garbage	Wastes from the preparation of cooking, and consumption of food. Market refuse, waste from the handling, storage, and sale of produce.		From homes, hotels, stores, institutions, markets, etc.	Municipal responsibility for collection and disposal
	Rubbish	Combustible Rubbish	Paper, cartons, boxes, tree and yard trimmings, wood and excelsior, bedding		
		Non-Combustible Rubbish	Metals, tin cans, glass and crockery, dirt, other mineral refuse		
	Ashes	Residue from fires used for cooking and for heating buildings.			
	Street Refuse	Street sweepings, dirt, leaves, content of litter receptacles		From streets, side-walks, alleys, vacant lots, etc.	
	Dead Animals	Small animals: Cats, dogs, etc. Large animals: Horses, cows, etc.			
	Abandoned Automobiles				
	Industrial Refuse	Solid waste resulting from industrial processes and manufacturing operations, scraps, cinders, etc.		From factories, power plants, etc.	Private responsibility for disposal

PREPARATION OF REFUSE FOR COLLECTION

Until refuse is collected, responsibility for its disposal cannot pass to the municipal forces; up to that time the householder is in sole charge. The manner in which it is stored, prepared, and presented for collection is an important factor in determining the effectiveness and efficiency of the collection operation. At one extreme, the refuse may be carefully separated by classes; the garbage carefully drained, wrapped, tied, and placed neatly in watertight covered can; the rubbish placed in covered receptacles or carefully bundled and put beside the containers; and the ashes kept in covered cans. At the other extreme, all refuse may be dumped without discrimination in a heap in a back yard or alley. Consequently, it has become the responsibility of city governments to regulate and define local requirements, specifying proper practices for separating, handling, and storing refuse, and placing it for collection.

From the public health standpoint, putrescible refuse must be stored so that rats, flies, and other disease-bearing animals or insects cannot have access to it and so that liquids cannot leak from the containers. For the preventing of nuisances, refuse of all kinds must be stored so that it cannot be scattered by the wind, by dogs, or by

other animals; so that disagreeable odors are not created; and so that accumulations are not unsightly.

Regulations for the Preparation of Refuse.

Every city has specific regulations governing the householders responsibilities in the handling of refuse and the preparation of it for collection, regardless of whether the material is picked up by city forces, contractors, or private collectors. Often these regulations are prescribed by ordinance, sometimes in great detail. In other places, much of the formal control of practices is left to the municipal officials who have supervision of the collection work or who have charge of the collection operations.

In most cases, the ordinance provisions are written in rather technical language and are usually not clear to the average citizens. (16, p.457; 17, p.640) In some of these cases printed instructions, giving in more or less detail a practical interpretation of the ordinance, are available for the individual.

Effect of Disposal Methods on Separation.

The following table (p.16) by the committee on Refuse Collection and Disposal, American Public Works Association, 1941, shows the influence of disposal methods on separation of refuse. (1, p.67; 13, p.11)

INFLUENCE OF DISPOSAL METHODS ON SEPARATION OF REFUSE		
METHOD OF DISPOSAL OR UTILIZATION	MATERIALS SUITABLE FOR DISPOSAL	USUAL PREPARATION AND COLLECTION PRACTICE
Hog feeding	Garbage	Should not be wrapped. In some instances small amounts of combustible rubbish permissible with the garbage.
Incineration	Combustible Materials	Garbage should be drained and wrapped. Combustible rubbish should be kept dry. Sometimes combustible rubbish collected separately. Sometimes all classes of refuse collected together, when proportion relatively small.
Grinding	Garbage	Preferably should not be wrapped. In some instances small amounts of paper with the garbage are not objectionable. Other materials, such as metals and glass, removed.
Open Burning	Combustible Materials	Usually limited to bulky rubbish, such as tree branches, boxes, and burnable materials.
Open Dumping	Non- putrescible materials	Sometimes rubbish and ashes together. Sometimes ashes and noncombustible together. Sometimes all refuse, if dump is isolated.
Sanitary fill	All refuse	All classes of refuse collected together.
Cover materials	Ashes & dirt	All other refuse collected together.
Reduction	Garbage	Should not be wrapped.
Recovery and sale	Materials of value	All classes of refuse collected together. Sometimes garbage collected separately and disposed as above; rubbish and ashes together. Specified materials separated.

FACTORS AFFECTING THE COST OF REFUSE COLLECTION

Conditions and practices in the field of refuse collection vary from place to place and no two cities present exactly the same situation.

The following factors (18, p.91 - 3) may affect the cost of refuse collection: (1) Climate and geographical differences; (2) Frequency of collections; (3) Place from which the refuse is collected; (4) Length of haul; (5) Population density; (6) Kind of service demanded by citizens; (7) Methods and operating practices; (8) Wage rates of collectors and drivers; and (9) Character of administration and supervision.

Effects of Climate and Geographical Differences.

Prevailing climatic conditions influence considerably the amount of certain class of refuse produced, and in some cases the collection operation itself. (5, p.2-4, 8)

The amount of ashes produced in a community is closely related to the prevailing winter temperature. In some parts of the country ashes exceed all other types of refuse during the cold months. The introduction of gas and oil for heating purposes, however, is gradually tending to reduce the amount of ashes produced.

Where rainfall and humidity are high substantial variations in the amounts of yard rubbish and garden refuse is

noticable. In the warmer climates it may be necessary to have more frequent collections of garbage because of rapid putrefaction that takes place.

The influence of topography on refuse collection may control the selection of equipment, the layout of routes, and even the points from which refuse is collected.

Frequency of Collections.

The frequency of refuse collections influences the cost considerably because of the increase in the amount of material collected. If frequent collections are made there is usually no need for householders to burn refuse or to dispose of it privately.

The frequency of refuse collections may be governed by the following factors to a very great extent:

1. The normal time for the accumulation of the amount of refuse than can be placed in a container of reasonable size.
2. The length of the fly-breeding cycle.
3. The time it takes fresh garbage to putrefy and to give off foul odors, under average conditions of storage.

Location of Refuse Containers.

The location of the refuse container at the time of collection is an important factor in determining not only

the cost of operation but also the nature of the collection service itself. In some cities the refuse is picked up from the back doors, back porches, and even from the basements, and carried by the collectors to the vehicles for loading. In other cities, the householders are required to place the containers out at a convenient spot for the collectors to empty.

Length of Haul.

Under normal conditions, the shorter the haul the easier are the planning and supervision of refuse collection operations, and the lower is the cost of the service. Long hauls require more and frequently larger equipment, and occasionally the refuse must be transferred from the collection vehicles to others for transport to the disposal points.

Variation in Wage Rates.

Normally the expense for labor is from 60 to 75 per cent of the total cost of refuse collection.

Methods and Operating Practices.

The refuse collection system must be carefully coordinated with the system of disposal. Sometimes disposal methods can be selected so that the most economical and effective collection practices can be employed. This will be governed considerably by the available sites for disposal.

REFUSE COLLECTION EQUIPMENT

Numerous types and sizes of refuse collection vehicles have been developed to meet the requirements of individual municipalities. The needs of cities are not all uniform. Varying local situations influence the selection of vehicles. Then, too, some communities demand, and are willing to pay for, better looking and more sanitary conditions.

In recent years many motor vehicles have been designed especially for refuse collection. Much of the development has come from the municipal refuse collection agencies because the type of equipment wanted was not available on the open market.

Vehicles, in addition to being properly designed as to size and strength, must be sanitary, reliable, easy to load and unload, and safe for the workmen. Frequently some efficiency is sacrificed in order to provide more elaborate or showy vehicles for the effect on public opinion and citizen support. (14, p.444)

Size and Capacity of Vehicles.

One of the most important factors in equipment design is the proper relation between the volumetric capacity of the body and the weight-hauling capacity of its chassis. Smaller size trucks are generally used for refuse collections. Large trucks are frequently used where the hauling

distances are quite long and loading speed relatively high.

Loading Height of Vehicles.

Loading height of refuse collection vehicles is one of the critical features of their design. The loading height depends considerably upon the weight of the individual receptacles to be handled. It is usually considered that the shoulder height (about five feet) is the maximum lifting height. Width of the bodies is limited to eight feet by most state laws; height of the truck bed from the ground is fixed by the chassis design; and the length of the body is limited by law in some cases or by practical design and in others by narrow alleys with sharp turns. This leaves only the height of the sides of the bodies without unlimited dimensions. As a result, many bodies have high sides which make it harder for loading of the refuse.

On the latter equipment power-loading devices have been devised which furnishes a low loading height although the bodies extends well above the point of loading. This is also utilized on the compaction type vehicles.

Unloading Devices.

The collection vehicles must be capable of rapid unloading so that the minimum amount of time will be lost at the disposal sites or transfer stations. Gravity dump bodies are frequently used. Hand shoveling and power-

machinery, such as a large shovel, is used in some cases. Many of the newer collecting vehicles are equipped with devices for unloading as well as loading.

Covers for Vehicles.

Covers of some kind are almost always required for refuse collection vehicles. Covers are used principally to improve sanitary conditions by making it more difficult for flies and other insects to have access to the refuse, and to hide the unsightly accumulation from the public view. Covers also prevent spreading of the collected refuse during transit to the disposal site and from being blown off by winds.

Turning Radius of Collection Equipment.

The turning radius of refuse collection vehicles should ordinarily be as short as practicable, so as to cause the minimum obstruction to traffic in narrow streets, and simplify maneuvering around parked cars and at corners. In some cities the necessity for making refuse collections from narrow alleys has resulted in the use of a much smaller truck than would otherwise be desirable.

Watertightness of Collection Bodies.

When the refuse material is so wet that liquid collects in the bottom of the body, special provisions must be made

to prevent its escape as it is undersirable to have refuse drip or flow onto pavements or roadways.

Devices for Safety and Comfort of Collectors.

Properly designed refuse collection vehicles have incorporated in them devices to make it easy and safe for the collectors to load the materials and to ride on the vehicles. These devices include a sheltered place for the driver and collectors, suitable steps, well located hand holds, adequate door fastenings, and ample racks or supports for tools and other equipment.

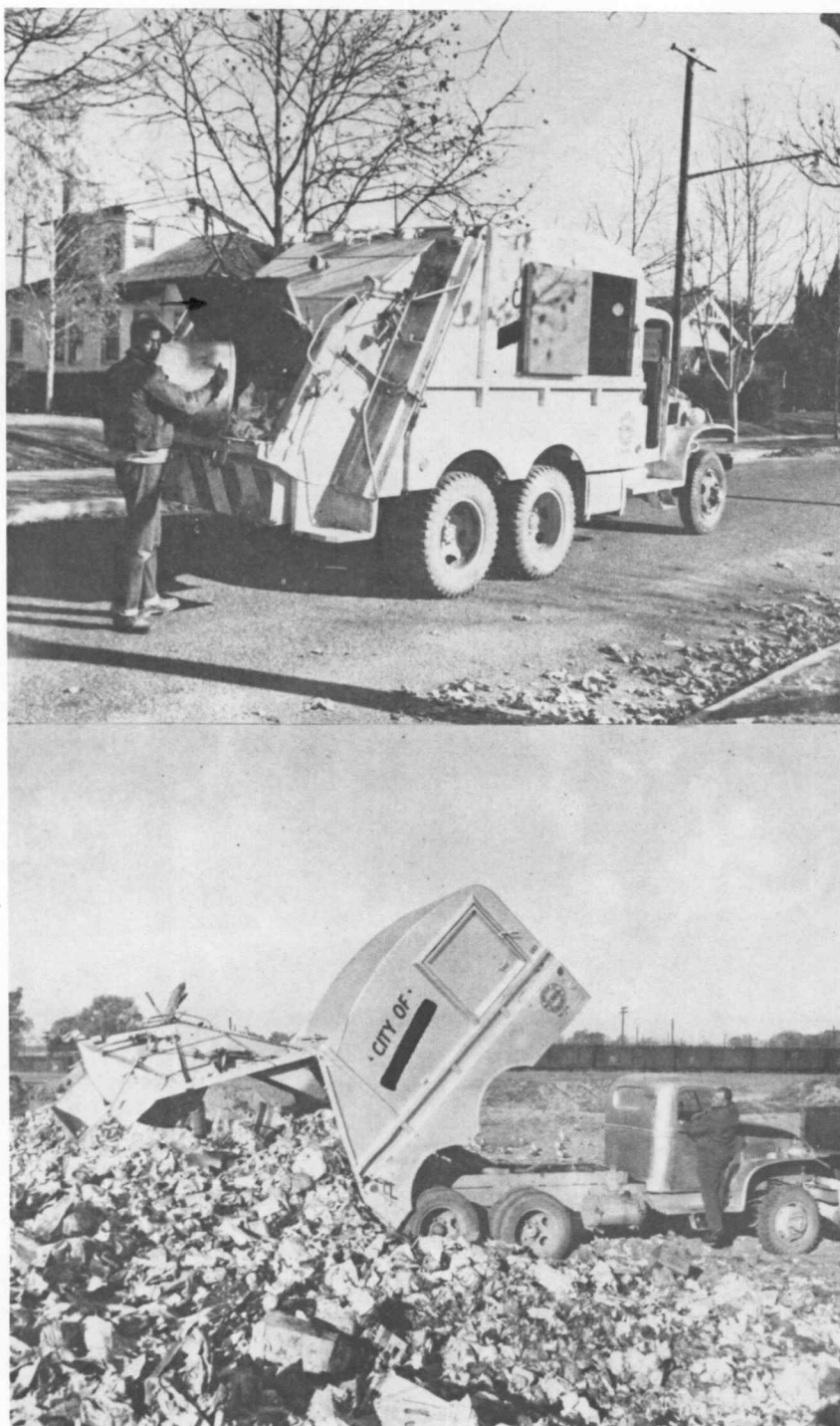
Adaptability of Collection Equipment for Other Work.

In some cases cities purchase equipment with the idea of adapting it to other uses in the municipal service. In other cases the equipment is purchased only for use in refuse collections and the bodies make it impractical to use for any other purpose.

Appearance of Vehicles.

The general appearance of refuse collection equipment is becoming more and more a factor in its selection, care, and upkeep. Many officials think that the appearance of refuse collection equipment is unconsciously taken by the average citizen as a general index of the character of the municipal government.

Numerous cities spend considerable sums on rather attractive equipment and maintenance and yet load the vehicles well above the top of the body, thus nullifying much of the pleasing appearance that has been secured. Covers may be placed over the finished load to improve the appearance.



Upper: Low-loading type body with a swinging door (arrow) pushes the refuse into the main compartment. The plunger action of this door distributes and consolidates the material. Lower: Load-packer discharging refuse at face of fill.



Tarpaulin covered body equipped with hinged sides (arrow) and open back. Refuse loaded from the rear and moved forward by hand. Refuse must be swept out by operator at the dump.



Open box equipped with a removable tarpaulin cover. Tail gate made by arrangement of refuse as it is collected. (A few boxes are placed in truck ready for the next day) Truck is equipped with hydraulic hoist for unloading.

PLANNING REFUSE COLLECTION OPERATIONS

Planning refuse collection operations consists of finding the most suitable combination of methods and equipment to meet local conditions. Local conditions influencing collection operations, the refuse collection methods available for use, and the kinds of refuse collection equipment are factors which must be considered to correlate an effective plan.

The planning of refuse collection is essentially the process of evaluating the various ways of using men and machines to find the most efficient arrangement. The actual determination of the best combination of methods and equipment involves a thorough understanding of local conditions, a knowledge of refuse collection activities, and the application of simple engineering economics. Determinations on the basis of estimates, guesses, or opinions are not satisfactory.

All policies fixed by the council, committees, or executives should be clearly stated in writing to the planning group. This will define the boundaries. Precise definitions serves to clear the air and enables the planner to see exactly what determinations he must make.

(19. p.92)

Effect of Disposal Methods on Planning.

The disposal plan depends, not on the collection systems, but on the availability of suitable sites, the market for salvageable materials, the degree of sanitation desired and similar matters. The collection system must be fitted to the requirements of the disposal processes.

The disposal method virtually dictates the kinds and number of refuse separations. Garbage should be separated from other refuse when it is disposed of by the hog-feeding or grinding processes. Likewise combustible materials should be separated from noncombustible materials for disposal by incineration or open dump burning; and putrescible materials should be separated from other refuse that is to be put in open dumps. Disposal by sanitary fill does not require any separations whatever. These requirements as to separations in turn fix many of the practices of householders in preparing refuse, influence the selection of methods, and effect the problem of determining the type of equipment most suitable for the work.

The selection of disposal methods involves the determinations of the sites for the necessary plants or dumps and also may govern important aspects of the design or selection of the collection equipment.

Selection of Methods and Equipment.

After it is known which refuse collection factors are fixed, it is possible to study the variable elements. The collection method and collection vehicles, consistent with fixed policies and existing conditions must be selected. The cheapest equipment and the cheapest arrangement of crews will not always combine to give the most economical services.

Time of Collection.

For most residential properties it is of little importance at what time during the daytime collections are made, and in general convenience of the collection agency will determine the hour. Night collections in residential areas, however, are not usually satisfactory because of the inevitable noise. Night collections in the commercial areas of most cities are favored where daytime traffic congestion will hinder the efficiency of the collections.

SPECIAL REFUSE COLLECTION PROBLEMS

Almost every community faces special or seasonal problems in connection with the regular collection or refuse. The control of human scavengers and the regulation of private hauling of refuse are mainly administrative matters. The disposal of special kinds of refuse such as market garbage and rubbish, condemned food, dead animals, and street cleaning accumulations affect particular routes or special crews rather than the regular service. Also, annual rubbish collection is sufficiently different from normal routine operations to justify special treatment.

(13, p.234)

Control of Scavengers.

Scavengers cause some particularly irritating problems in connection with the collection of municipal refuse. As results of their operation, the contents of refuse containers are scattered over streets, and alleys, cans and covers are damaged or lost, and the collection officials and employees may be unjustly blamed for unsanitary conditions.

Scavengers are usually very poor or unemployed persons who pick over the refuse to salvage articles and materials that can be sold to junk dealers, or to glean food or supplies that can be used in their homes. They operate with-

out instruction or permission of the householders, and collect merely select parts of the refuse.

Ordinarily scavengers will not trespass on private premises, but once the refuse is placed in the alleys or streets they feel free to explore it and take any part of it. Often they learn the routes of the collection vehicles and on collection days they precede the regular collection crews.

Under their police powers cities have the right to prohibit scavengers from operating. It is unusual, however, to find such prohibitions rigidly enforced except in cities that charge fees for refuse collection service or that sell the refuse materials.

Various corrective measures have been adopted. Some communities have changed the point of collection from the curbs and alleys to back doors. Others have tried to enforce the ordinances prohibiting such practices. Several cities have allowed scavengers to work at the disposal sites only. Still others have established licensing procedures.

Private Hauling of Refuse.

Commercial and industrial establishments not given municipal service frequently haul their refuse to disposal points instead of employing private collectors. This

practice may create a nuisance on the municipal streets, increasing street cleaning costs, unless special precautions are taken by the establishments.

Satisfactory control of refuse hauling involves both the approval of the equipment proposed for use and the insistence on proper loading and handling practices. Better results are secured from a more positive plan of regulation under which any individual or corporation desiring to haul refuse over city streets must first secure a permit issued under definite conditions which stipulates acceptable methods and practices. (6)

Market Refuse Collection.

Probably more refuse is produced in public market areas than in any other kind of municipal district. Large amounts of spoiled or unsalable fruits and vegetables, banana stalks, vegetable tops, husks, pods, poultry waste, and similar organic materials are discarded daily and will cause serious aesthetic and public health problems unless the material is properly handled and removed. In addition, a large volume of combustible refuse such as crates, cartons, boxes, and miscellaneous wrapping and packing materials accumulates.

Handling of Condemned Food.

Food or produce that has been condemned by local, state, or federal health officials still belongs to the wholesaler, jobber, shipper, or merchant who is usually held responsible for its disposal. The materials condemned must, under most health ordinances, be promptly removed by the owner and destroyed in a manner approved by the health officer.

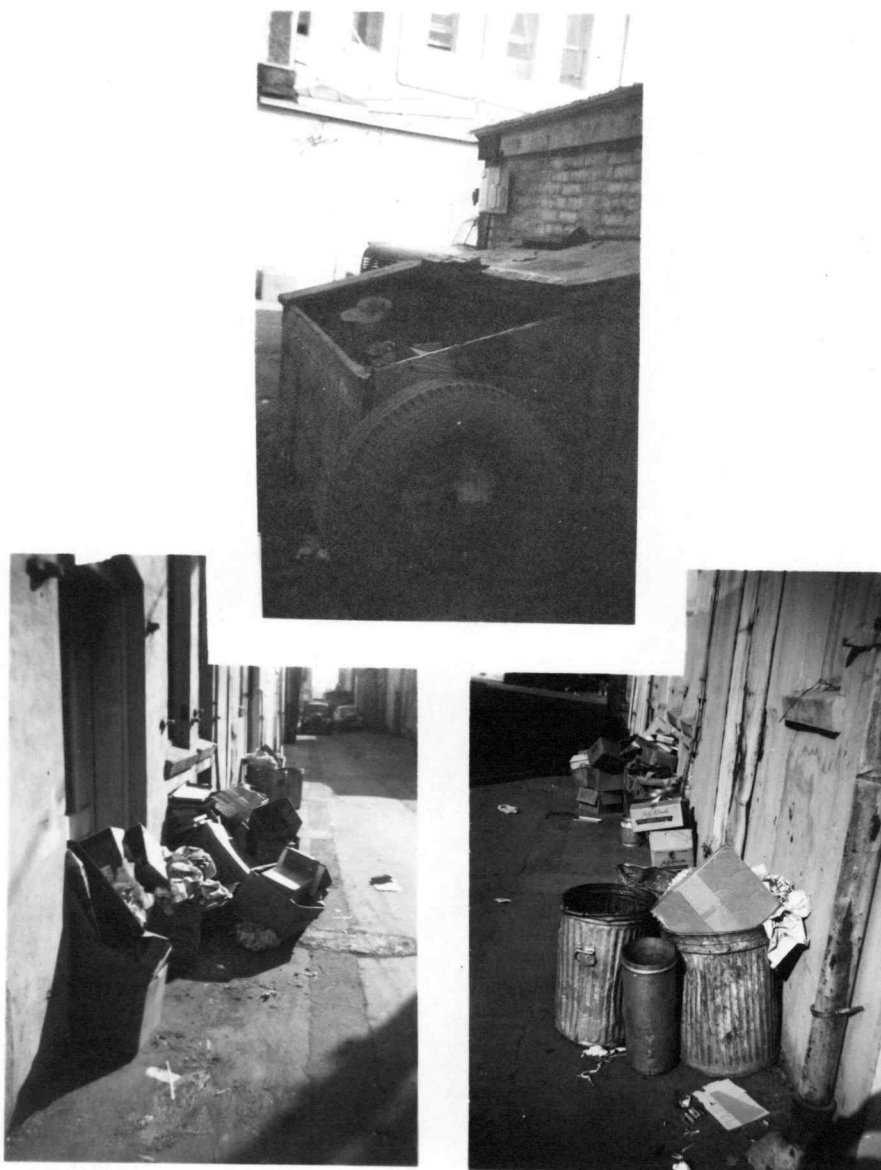
Collection of Dead Animals.

The collection of dead animals is usually considered separate from the municipal refuse collection agency because of the emergency nature of such services. Public demand for immediate removal of animal carcasses is so great, particularly in densely populated areas, that most cities have established emergency collection services to insure prompt removal.

Some cities have arrangements with rendering companies to have all of the large carcasses collected by the rendering company while the city collects the carcasses of smaller animals. Other cities collect both large and small carcasses and in turn sell them to the rendering company thus compensating for the costs involved to the city.

Annual or Semi-Annual Refuse Collection.

Many cities collect at public expense only garbage, or garbage with combustible refuse, expecting householders or property owners to remove the other refuse themselves or will employ licensed private collectors to dispose of it. Under this system some people will allow large quantities of ashes and trash to accumulate in alleys, backyards, and basements with the result that portions of the cities become littered and disorderly in appearance, and fire hazards are created.



Upper: A refuse box used by a business house. Although the refuse is confined to the box it is a big job for the refuse collectors to empty.

Lower: Refuse stacked behind business places. Some have garbage cans, without lids, but fail to utilize them effectively while others fill discarded boxes.

MUNICIPAL, CONTRACT, OR PRIVATE COLLECTION OF REFUSE

Whether municipal refuse shall be collected by city forces, by contractors, or by private collectors is a problem that arises at least once in every community and in some places recurs rather frequently. When the issue is raised it is usually because of dissatisfaction with the existing collection services, because of demand for increased service, or because of agitation to reduce the cost of the operations.

Municipal Collections.

Municipal collection involves the performance of the removal operations by city employees and equipment under the supervision and direction of a regular municipal department or official. Municipalities are motivated to operate their own collection system by the desire to protect public health, prevent unsanitary conditions, and to improve community appearance. Because of their direct responsibility to the people, they provide numerous extra services and exercise greater care in handling and loading of refuse than is expected from contractors or private collectors.

Under municipal operation, it is much easier for city officials to respond to demands of citizens for improved community appearance. Efforts can be made to reduce the

amount of littering by citizens and by collection forces, and in many places the equipment may be better supervised.

Advantages and Disadvantages.

Advantages of municipal operation are: (1) Profits do not have to be earned. (2) Sanitation and the protection of public health are primary aims. (3) There is greater probability of obtaining qualified employees. (4) Actual operating costs are less than those of contractors or private collectors. (5) Management and policies are continuous over a long period. (6) Greater flexibility in operations can be secured. (7) Continuous records over a long period of time are invaluable. (8) Citizens cooperate more readily and more effectively.

Disadvantages of municipal operation are: (1) Demoralizing when the operations are directed by political machines for the benefits of party workers. (2) Many city councils and officials favor cheapness instead of economy in administration. (3) The tendency to provide unreasonable extravagant service to complainers beyond that wanted by the majority of citizens. (4) The failure of municipalities to provide adequate retirement plans for their employees.

Contract Collection.

Contract collection consists of the engagement by cities of privately organized companies under formal agreements and definite specifications to do the work of collecting and hauling municipal refuse, for which contractors are paid from general public revenues. Usually the contracts are awarded on a competitive basis to the lowest responsible bidder, and contractors must furnish suitable performance bonds.

Refuse collection contracts must be of sufficient duration to make it feasible for contractors to purchase and amortize equipment and facilities necessary to provide effective and economical service. Five years is considered a reasonable time over which outlays for vehicles can be amortized.

Advantages and Disadvantages.

Advantages of contract operation are: (1) Comparative freedom from political influence in the management and operation of the services. (2) Costs of collection are low. (3) The necessity of comprehensive statement of the precise duties to be performed and the responsibilities to be assumed prevents the development of extravagant services.

Disadvantages of contract operation are: (1) Grant-

ing of contracts in reward for political support.

(2) Tendency to sacrifice sanitation to profits. (3) Contractors are generally reluctant to answer complaints promptly. (4) Operations must be continuously inspected by competent city officials and employees. (5) Limited duration of contracts makes it necessary to absorb amortization costs in a short period. (6) Contractors when losing will cut corners wherever an opportunity develops.

Private Collection.

Private collection involves the collection by individuals or companies of refuse materials from private properties in return for payment in accordance with the kind and extent of work done. Private collectors usually operate under city licenses or franchises.

Advantages and Disadvantages.

Advantages of private collection are: (1) Private collection businesses are often somewhat further removed from political control. (2) Costs are paid by householders and property owners. (3) Each householder or property owner may obtain any kind of service for which he is willing to pay. (4) Costs are charged on the basis of the benefits received.

Disadvantages of private collection are: (1) Cost

to citizens is ordinarily much higher. (2) Unrestricted competition among collectors. (3) Political favorites may be able to secure a license in some cities. (4) Private collectors subordinate both sanitation and community appearance to profits. (5) Municipal control is very difficult. (6) Sparsely settled communities must pay higher rates. (7) Poor people cannot afford to pay for private collection services and may dump their refuse in the country.

FINANCING REFUSE COLLECTION OPERATIONS

Cities must face the difficult and often perplexing duty of providing the funds necessary to conduct the kind of refuse collection services wanted by their citizens, and the equally puzzling problem of distributing the burden as equitably as possible. The principal methods of financing this function are general property taxation, separate property taxation, service charges or fees, can rentals, and special assessments.

General Revenue Financing.

A great majority of cities finance municipal refuse collection operations by making regular appropriations from general revenues obtained largely from general property taxes.

Advantages and Disadvantages.

The advantages of general revenue financing are:

(1) Complete refuse collection service benefits the whole community. (2) The cost of the collection operations is distributed more nearly on a ability-to-pay basis. (3) All residential properties receive collection service. (4) Special bills do not have to be issued or paid.

The disadvantages of general revenue financing are:

(1) Many cities are not able to provide sufficient funds

to carry out a reasonable minimum program of refuse collection. (2) It is not practical to provide complete collection from commercial properties at public expense.

(3) If a large number of properties are exempt from general taxation many citizens will get free service and others will have to bear undue burden. (4) The assessed value of a property may have no relation to the amount of refuse collected from that property.

Revenues from Separate Ad Valorem Taxes.

A few cities raise part or all of the funds needed for providing municipal refuse collection and disposal service by levying separate ad valorem taxes, usually on the same base as the general property taxes. All of the advantages and disadvantages cited for general revenue financing apply also to separate taxes on property.

Service Charge Plan.

Service charges are periodical charges by municipal governments to householders and other producers of refuse based on the measured, estimated, or presumed amount of waste material that is removed. These charges are established as nearly as practicable according to the amount and kind of service rendered and benefit derived by individuals and business.

Advantages and Disadvantages.

The advantage of the service charge plan are:

(1) Additional municipal revenue can be raised. (2) General property taxes may be reduced. (3) Complete municipal service becomes available to all properties at reasonable cost. (4) Adequate funds can be obtained to conduct system properly. (5) All citizens and all properties are treated on an equitable and impartial basis.

The disadvantages of the service charge plan are:

(1) Refuse service charges levied according to the benefit received are highly regressive. (2) Actual benefits accrue more to the community than to the individuals. (3) Administrative costs of billing and collection are high. (4) Citizens will probably register numerous complaints over the rates charged. (5) Poor families refuse to purchase refuse service. (6) Cost of sanitary inspections increase.

Miscellaneous Revenues.

Cities obtain revenue to help finance their removal services by selling collection privileges, by granting licenses to private collectors, and by selling salvaged materials. These receipts are usually quite small, but in some instances they may be sufficient to help provide better service to the citizens.

PUBLIC RELATIONS

Because refuse removal forces are in constant contact with the citizens, they are in an excellent position to carry out the public relations policy of the local government. Citizens understand the difficulties confronted by the collection forces and cooperate to improve the service.

A program of public relations encompasses the policies of the municipal governments; it depends on the competence and efficiency of the administration; and it is furthered and developed by the education of the public. Public relations includes everything done by the government.

The chief executives of the city and the members of the city council foster the municipal activities they believe the people want. The scope and extent of refuse ordinances are determined by temper and attitude of the public.

When citizens recognize the problem faced by refuse collection agencies, adequate funds are more likely to be appropriated. Failure to win the support of the people may result in drastic curtailment of the service.

The importance of personal contacts between citizens and employees is perhaps nowhere greater than in the refuse collection service. It is here that the city, or the policies of the city, make their impressions on most citizens.

Because in the eyes of the citizens every public employee represents the city, what an employee does is of vital importance to good public relations.

Effective and economical operation of the refuse collection system is one of the best ways to gain the good will and approval of the citizens. Careful training of employees in the proper ways of doing their work will eliminate many complaints and will promote better public relations.

Citizens usually associate the collection of refuse with the idea of uncleanness. The idea of cleanliness must first be instilled into the habits and thoughts of the refuse collection personnel. The cleanliness principle should also apply to the refuse collection equipment.

Force is seldom used to secure the cooperation of citizens in complying with the municipal ordinances and regulations. Householders will not conform unless they are convinced that the demands are reasonable and desirable.

WARRANT BOND

METHODS OF FINAL DISPOSAL

The term "refuse disposal" includes the final disposition, utilization or destruction of the refuse materials after their collection and delivery to the disposal site. Several methods are in common use in different countries, and even in the same country under different conditions. To be satisfactory to a community, the disposal must answer two requirements: It must be sanitary; and it must be economical.

The demand for a satisfactory final disposal may be progressive, for it generally becomes more and more important and urgent with the growth of a community. In a very small town, simple methods suffice for a number of years. In large communities, more complex and costly works are necessary.

One purpose of refuse disposal is to provide a definite place to which all the waste materials can be brought, and thereby prevent a promiscuous dumping on or near places where it might become objectionable. At such works the materials must be treated so as to control the organic decomposition, to prevent objectionable odors, to recover any valuable parts and to reduce the final residue to the smallest quantity and the least offensive condition.

Within the last several decades, changes in the scale

of living have brought about a number of changes which affect the disposal problem. There has been an increase in the amount of refuse produced per capita, largely due to an increased amount of rubbish. The volume of refuse to be disposed of has increased in greater proportion than the weight, and the moisture content has decreased. There has also been a general raising of the standards of sanitation. This trend has been to some extent affected by war conditions with an increase in use of fresh vegetables and with salvage of paper, but it is believed that these conditions are only temporary. These changes have tended to render obsolete or unacceptable some methods of disposal which had been in general use.

Several methods are available for such disposal, their preference depending on local conditions and the character of the materials. Most of them have been tried and developed to a satisfactory degree of efficiency and economy.

GARBAGE DISPOSAL BY FEEDING TO HOGS

The hog feeding method of garbage disposal is probably more common than any other in the United States, yet there is comparatively little general information written on this subject. At farms and isolated country houses it has been an old and common custom to dispose of the garbage by feeding it to the hogs and chickens, and farmers have found it profitable to collect it from near-by towns. Garbage is fed to them raw or is first cooked or warmed, and sometimes it is enriched with supplemental feeds. This method of garbage disposal existed quite extensively during the 1920's in the United States and is still used to a large extent on the Pacific Coast. More sanitary methods are now available for the disposal of garbage, but they are being slowly adopted by the hog-feeding communities that show a profitable business out of garbage feeding to hogs. During 1917, owing to war conditions, the United States Food Administration commended its use as a food-producing and waste-conservation measure. With the increased study, of the sources and cause, of trichinosis in man this practice is now being frowned upon.

Site.

The distance of the hog farm from the municipality depends upon local conditions. In some instances it may become necessary to haul the garbage several miles. One large city in California hauls its garbage fifty miles to the hog farm by railroad cars.

Operations may be conducted so that the hogs may be fed on concrete feed floors part of the year and during the summer months, garbage may be dumped directly on the ground. In the latter case the feed lots may be plowed under at intervals throughout the season and the soil allowed to rest before feeding operations are resumed. This practice assists in reducing odors and complaints from neighboring residents. Lime may also be spread on the feed lots to keep the ground sweet.

Concrete feed floors soon deteriorate from the acid in the garbage thus requiring repairs approximately every three years. Life of the feed floor has been increased by adding Silicate of Soda to the surface of fresh concrete. Other operators prefer the feed floor surface to be constructed of vitrified brick with asphalt filler.

Garbage Requirements.

The chief requirements in feeding garbage to hogs are, to keep it fresh as possible, so as to preserve the

food value, and free of sharp objects, to safeguard and maintain the health of the animals. Both of these requirements call for special sanitary care in the house treatment, collection service, transportation system and the farm. As the highest food value depends on cleanliness and freshness, so do these in turn depend on the source of the garbage, the care taken in the separation, and the frequency of the collections.

Garbage that is to be fed to the hogs should not contain any noticeable portions of ashes, glass or other refuse. Tin cans are objectionable because they cut the hogs mouths. A continuing program of public education is necessary to eliminate placing of foreign materials in the garbage.

Diseases of Hogs.

Hogs are subject to several different diseases such as, cholera, pneumonia, influenza, foot and mouth disease, and trichinosis which is the most important. (12, p.873)

Dr. Wright states, "American municipalities either directly or indirectly are probably the largest feeders of raw garbage to swine and would therefore appear to be chiefly responsible for the dissemination of trichinosis. Many hogs maintained on municipal garbage are slaughtered locally and many cities are thus contributing indirectly to the ill health of their own citizens." (25; 18, p.78)

Efforts to prevent the spread of trichinosis in man

have resulted in an amendment to the United States Interstate Quarantine Regulations stipulating that no garbage may be shipped interstate for hog-feeding unless first cooked for thirty minutes at 212° F. In Canada, where the number of cases of trichinosis is one-twelfth as great as it is in the United States, the law stipulates that before garbage may be fed to hogs it must be either cooked, held at 5° F for 20 days, or at 0° F for 72 hours to render the meat scraps free of parasites. (24, p.19)

The state of Oregon requires that all offal or fresh animal products shall be thoroughly cooked before being fed to swine. (15; 18, p.111) This applies to all farms licensed to conduct the business of feeding garbage to hogs. Another law stipulates that all buildings connected with such a practice should be of sanitary construction.

Advantages and Disadvantages.

The advantages may be summarized as follows: (1) The annual cost is low, compared with some other methods, and often a profit can be returned to the city. (2) Garbage fed to hogs must be reasonably fresh, and therefore must be collected frequently.

The disadvantages are as follows: (1) The danger of losing hogs by disease and by sharp cutting objects in the garbage is always present. Should many of the hogs

die, the regular method of garbage disposal would be seriously crippled. (2) In some localities the comparatively large farm area required is not available. (3) The practice of allowing a large number of farmers to collect garbage in a city, for feeding to hogs, makes supervision difficult. (4) Consumption of insufficiently cooked pork from such hogs is believed to be the chief source of human trichinosis. (12, p. 873-886)

Summary.

Hog feeding as a method of garbage disposal is rather general but present day trends indicate a desire to change to other systems for health and sanitary reasons. This method requires constant supervision and regulation to meet the minimum public health standards. Some cities are realizing a profit from this method of disposal but if they are required to cook the garbage, the cost of operation may approach that of other methods. When this method is used, however, different disposal methods must be found for the other types of refuse.



Additional revenue obtained from the sale of waste paper and cardboard containers which are sold to a paper company for re-processing. Waste paper is collected from the business district in burlap blankets. Here a truck delivers its load in a hopper from which it goes by conveyor belt to a paper baling machine inside the building to the left.

THE REFUSE DUMP-OPEN DUMP

The refuse dump, which has been considered as a low cost disposal, is now recognized as costly and, in an increasing number of communities, not to be considered at all. This type of refuse disposal never could be defended from the sanitary standpoint as it only amounts to the concentration of a nuisance.

Some kinds of refuse material will probably always be disposed of on "dumps." Present dumps, in many places are objectionable, and improvements in their management are desirable. As often practiced, the refuse is taken to waste land or low land and deposited over it promiscuously. Picking over such dumps is often practiced, and sometimes left entirely to scavengers. The presence of refuse having some small value for picking over, increases the desire of some poor people to scavenge the material deposited there.

Site.

Areas available for dumping near the source of the refuse should be carefully considered, because the distance to them effects the cost of collection and the selection of the method of final disposal. If such areas are scarce, they should be reserved only for materials

which may be deposited there without objection, as otherwise an unnecessary addition to the cost of hauling will result. If other methods of disposal are provided for garbage and other organic materials, the available sites will last longer for the more desired materials, and a much better appearance will be maintained.

The careful consideration of the proper upkeep of dumps is quite important, both for sanitary and economical reasons. If there is a sufficient and regular supply of ashes, street sweepings and excavated soil a little additional organic matter may sometimes be disposed of satisfactorily in this manner; but, in this case, the materials must be adequately layered and properly spread.
(13, p.243)

Appearance.

The appearance of such dumps can usually be kept satisfactory by a moderate amount of attention. There should be sufficient labor to mix the materials, trim the edges of the dump, prevent or extinguish fires, and stop undesirable scavenging. Where possible, the completely filled portions should be covered with soil and seeded. In some exposed locations, it may be advisable to enclose the used portion of the dump with a light movable, but close, fence. This may hide the unsightly portions,

prevent dust and loose paper from blowing away, and more easily prevent undesirable scavenging.

Materials.

The kind of refuse disposed of should control the manner of maintaining such places. Street sweepings, building excavations, solid inoffensive manufacturing wastes, and ashes can be handled so that very little, if any nuisance is caused near-by property. When combustible refuse is included, fires are started, accidentally or intentionally, and may burn for months. The smoke and unconsumed volatile organic matter generally create disagreeable odors. When garbage is present, the nuisance from the smoke and vapors is still more pronounced, and besides, when exposed for several days, it putrifies and may give off very offensive odors. Flies and rats are attracted by the garbage and breed in it.

Advantages and Disadvantages.

The only advantage, if one may call it an advantage, in the open dump refuse disposal is the centralizing of the breeding place for rats and flies.

The disadvantages of the open dump refuse disposal are so numerous that most cities are realizing the necessity for finding other methods of disposal. Some of

the disadvantages are as follows: (1) The gradual urbanization of the country is making it increasingly difficult to find acceptable dumping grounds without excessive hauls. (2) Open dumps are not satisfactory to health authorities since they provide ideal breeding places for rats and other vermin. (3) Constitutes both a fire hazard and a smoke and odor nuisance. (4) Definitely decreases property values.

Summary:

Very little can be said to substantiate the use of the open dump method of refuse disposal. Although this method of disposal may have been satisfactory for our forefathers it has out grown its usefulness for the present generation. If this type of refuse disposal must be used it should be well maintained and located in an isolated position.



An open dump showing poor supervision. Arrows show the decomposing bodies of sheep. They are conveniently located for dogs and other animals to feast on and carry diseases to innocent citizens. With the approaching of warm weather this will also be a wonderful breeding place for flies



and other insects. An incinerator, to handle such bodies, is located about one-half mile from this dump and is passed by almost every vehicle carrying refuse to the dump.



These pictures show an open dump located on the shoulder of a secondary highway. True, this dump is readily accessible in all weather but, it is also unsightly to the traveling public.





Load-packer type (12 cubic yard capacity) and open body type (10 cubic yard capacity) collection vehicles shown leaving the fill area after discharging their loads.



A view of a city dump used for the disposal of noncombustible refuse.

SANITARY FILL

Sanitary fill, also known as "cut and cover" in this country, and as "controlled tipping" in England, was developed in an effort to overcome the objections to the insanitary open dump. The operation consists of dumping the refuse at the fill and then mixing with sufficient earth as it is the activity of the bacteria in the soil that breaks down the organic matter.

With the trend against the open dump, there has been some increased attention given to the "sanitary fill" method. Here again increased collection costs and permanent loss in property values must be considered to determine the true costs. The sanitary feature of this form of dumping is based on the theory that a layer of dirt at least two feet thick over the refuse will present a permanent barrier against rats and other burrowing animals, and that, in the absence of air, there is no danger of odor and combustion of the refuse. However, experience has shown that the selection of the site from the standpoint of drainage and type of soil is extremely important, so this method is not universally applicable. The refuse must be carefully compacted so as to prevent future settling and cracking of the dirt cover, and the covering must be properly done. An alternate method of disposal

must be available for use in times of heavy rains or severe cold weather. The land used will be rendered permanently unusable for buildings or crops requiring deep cultivation. It should also be borne in mind that the refuse is not destroyed so that if the covering is broken or appreciably reduced in thickness the objectionable features of an open dump will prevail.

Experience with the practice on the Pacific Coast, and elsewhere has indicated that where suitable land is available this method of refuse disposal is economical and has definite value for the reclamation of otherwise waste or useless land.

Decomposition.

Relatively little is known regarding the chemical, biological, and physical changes which take place in the material deposited in land fills. Garbage buried deeply has been uncovered many years later almost unchanged by the passage of time, while the same type of material deposited near the surface apparently is decomposed rather completely in about 30 months. However, it should be remembered that the amount of garbage contained in mixed refuse is usually less than 15 percent by weight. The experience with buried refuse will therefore not be strictly analogous to that with garbage. (11, p.93)

Various studies conducted by the United States Public Health Service (22, p.1-19) show that temperatures after placement of fill rise rapidly to between 130° and 150° F in about four days at a depth of three feet below the surface. After remaining at this point for 60 days or more, temperatures fall gradually until they become stabilized near air temperature after about ten months. Temperatures at a 14 foot depth average considerably below those at three feet in some cases. Such conditions are not well suited to rapid bacterial decomposition.

Certain gases generated in fills, such as methane and hydrogen sulfide, may constitute a possible hazard where basements or other closed spaces are constructed in fill material. Fires have occurred when the cover material is broken so that the gases and air come together.

Sites.

In selecting sites for landfills, low areas such as ravines, swamps, and abandoned borrow pits are regarded as particularly suitable topography, provided fill operations do not obstruct natural drainage courses. Earth should be available for cover materials, sand soil being most desirable. Attempts to use gumbo clay for cover have not been successful because this material is subjected to shrinkage cracks which prevent proper sealing of the

deposited materials. It is also undesirable from the standpoint of rodent control as mentioned previously.

Fills should not be made where springs exist or be so located as to obstruct natural drainage channels. If possible, sites should be chosen so that prevailing winds will carry any occasional odors away from the built-up areas.

The choice of a disposal site should be governed largely by the distance from sources of refuse and by the availability of suitable access roads and bridges. Refuse trucks should not be routed over main traffic arteries where this can be avoided.

Current practice in the operation of landfills varies with the size of the city, conditions at the site, and equipment available. In general, it is necessary to compromise between the fact that decomposition is most rapid at shallow depths and the desire to keep fill area at a minimum per cubic yard of refuse in order to reduce the amount of cover material needed. Relatively shallow layers of refuse have been found to settle more uniformly, thus providing a more level surface for the operation of trucks and minimizing the amount of regrading necessary. Fills will settle from 25 to 40 percent of their original height.

Coverings.

Unless extreme care is used in operation, rats may be attracted by small uncovered deposits of refuse and find shelter in nearby buildings or vegetation. Perhaps the most important factors in the control of rodents near fills are the original degree of compaction afforded the refuse cover, and the maintenance provided following completion of filling. Improper coverage and compaction often result in the formation of voids which provide ideal harborage for rats. Unequal settlement resulting from improper compaction may cause additional cracks and openings for rats sometime after the fill is believed completed. Clay and similar materials should not be used for cover since rat burrows are more easily constructed in it than in more sandy materials. The heaviest obtainable equipment should be used for compaction.

Although rats will ordinarily not burrow more than 12 inches, a final cover of earth 24 inches in depth is believed necessary on surface and face of fills to compensate for uneven settlement and grading. Where proper cover is provided, the use of disinfectants on landfills is not considered essential but it is practiced in some places.

Drainage.

Drainage from landfills has been shown to have a high oxygen demand and may cause pollution of water courses or of beaches when the fill is deposited near the shore of surface waters. It is possible that improper location of fills may also result in pollution of ground waters.

Settlement.

The amount and rate of settlement will depend to a large extent upon the amount of compaction provided and the depth of fill, and will probably vary greatly from place to place. A large portion of the final settlement may occur in six months to a year. Uneven settlement of the surface may be caused by the presence and improper placement of bulky refuse and failure to provide a mixed refuse. Large accumulations of tree branches should be burned before placing them in the fill. Some reports show that fills made of summer refuse will settle considerably more than winter refuse. In cold climates, excavating operations will be considerably hindered by frozen ground during the winter months. This may necessitate excavating of cover material during the summer for later use during the winter. All utility piping should be routed around the fill to protect them from contamination as well as protection from breaking during settlement. Loading of

uniformly distributed loads up to 2000 pounds per square foot has been supported on fills that are no more than two years old.

Advantages and Disadvantages.

Certain economic advantages of landfills when compared to other disposal methods are evident. Combined refuse collection is permissible and disposal sites may be located close to centers of refuse production without creation of nuisance conditions. Several disposal sites may be in use simultaneously for convenient periods of time.

The equipment required is not excessive in cost and is of general utility. Daily variations in the amount of waste affects operation to a minor extent. Appearance of the completed fill has no deleterious effect on nearby property values if properly completed.

In spite of their advantages there are certain aspects of landfills which render their use inadvisable or impossible in some cases.

Why Use Land Fill?

While the cost of the landfill method is the chief argument for its use there are other reasons why it recommends itself. Among these are the possibility of reclaiming low-lying land, and the opportunity to post-

pone the time when higher capital outlays will be required for more incinerator capacity.

The reclamation feature is of particular importance because it not only will eliminate many neighborhood eyesores and mosquito breeding areas but it will also add to the taxable value of the land. Where refuse fills are made on park department property, the program of adding recreational facilities to the city will be greatly accelerated. For fills to be made with other materials the cost of park development would be prohibitive in many places.

Summary.

In summarizing the sanitary fill method of refuse disposal the following may be concluded:

1. At least a two foot cover of satisfactory fill material should be used for the finished faces of the fill to prevent the invasion of rats.
2. Excavations in the fill may release disagreeable odors unless an oxidizing chemical is sprayed on the exposed surfaces.
3. Settlement of the fill is to be expected, therefore special caution must be taken if laying conduit inside a completed fill.
4. Seepage from fills may cause stream pollution

difficulties, and gases of decomposition may cause fires and explosion hazards will exist.

5. Sanitary fill should be economically attractive to a small city unable to build an incinerator, and also as a stop-gap measure for larger cities that have not completed incinerator projects.
6. If a large city has convenient areas available for the operation to take place, and develops skilled personnel, it may readily find that the sanitary fill is a permanent economical method of refuse disposal that meets public health requirements.



Working face of a sanitary fill. The right foreground (arrow) shows a couple of scavengers at work.



A two foot earth cover completes the fill operation. This sanitary fill is located near the city limits and permits a reasonably short haul.

INCINERATION

The incineration of refuse has received favorable attention during recent years. There also has been some interest in plants equipped to dry and burn sewage sludge combined with garbage and refuse. The production of electrical power from the burning of combustible refuse has contributed to lower incineration costs in some places. From the standpoint of sanitation, well-operated incinerators are the most satisfactory methods of refuse disposal.

Large changes in the population of some cities because of the war have resulted in excess amounts of waste which cannot be handled in existing incinerators. Because of the large capital investment required and possible temporary nature of the population increase, the construction of incinerator additions would be of doubtful economy regardless of the critical materials required for construction.

Many of the larger cities on the Pacific Coast have abandoned, temporarily, the use of their incinerators in favor of the sanitary fill method of refuse disposal. Still other cities that have both incinerators and sanitary fill disposal are gradually reverting back to the incinerators because of the long hauls necessitated in the sanitary

fill method of disposal and the decreasing sites suitable for fills.

Site.

The character of the development in the vicinity of the proposed site should be carefully considered. It is preferable where possible, to locate a plant in an industrial area, as things which might be found annoying in a high class residential district, would not attract any notice in a vicinity occupied by factories. However, sometimes, it is mandatory that a plant be located in a district exclusively residential and at times adjacent to a high class development. When conditions make the selection of such a site necessary, it may be done and with care in plant design and all pertinent operations, no annoyance need be endured. (8, p.394-8)

The availability of land is a major consideration when determining the proper location of an incinerator. Property already municipally owned, usually receives first attention and since cost usually must be held at a minimum, use of city property is advantageous.

Availability of an ash dumping area is desirable but this is secondary in importance to a central location. A hillside site providing different levels for delivery

of the refuse and for removal of the ashes will eliminate the need for ramps and thus reduce the first cost of the plant.

Operation.

Incineration is combustion. Combustion is an exact chemical reaction, governed by definite laws of nature, involving combination of definite weights of the combustible elements with oxygen and terminating in definite results, if the process is completed. The requirements for complete combustion are heat, air and time. (21, p.559-579)

There must be sufficient heat available to maintain a high enough temperature to ignite the materials and to release and ignite the volatiles, with ample allowance for radiation and excess air losses. If there is not sufficient heat in the refuse, the deficiency must be supplied by preheating the refuse, or by use of auxiliary fuel. There must be an ample supply of air, properly admitted to the burning solids and gases and properly mixed with the gases while they are at the proper temperature. There must be a time for the mixture of air and combustible gases to burn before they are chilled below their ignition temperatures. As the gases are in continuous motion to-

ward the chimney, the time is governed by the length of gas travel in the heated zone and by the velocity of the gases.

Combustion should be completed within the incinerator. It should not be completed in the flue connection or chimney and will never be completed in the outside air. Efficient utilization of the heat, the supplying of the air, the mixing of the gases, and time factor must be provided for in the incinerator design and must be built into the incinerator.

The refuse delivered to an incineration plant consists of all the combustible wastes the community no longer wants, with a varying admixture of incombustible wastes which the plant operator never wants. If all the combustible refuse is collected, there will normally be proper proportions of wet and dry materials, so that no auxiliary fuel will be required. A deficiency of dry refuse, and therefore, of heat, might be caused by such conditions as salvage drives on waste paper, or large sources of wet materials such as food processing plants, or restaurants catering to travelers. An excess of dry refuse might result from separate disposal of garbage, or the presence of some type of industry or commerce. Incineration can be fitted to the needs of any community.

Components of an Incineration Plant.

The basic parts of an incineration plant are a space for sorting and receiving refuse, a means for charging, a burning chamber, a grate or hearth, and ashpit, a provision for mixing air and gases, a secondary combustion and settling chamber, a damper, a flue connection, a chimney, and a space for stoking and ash handling. Incineration plants of only these basic parts are in successful operation serving the requirements, of small communities such as military establishments, resorts, and summer colonies.

The addition of a suitable shelter greatly expands the usefulness of this basic plant, and normally a building should be considered as an essential part of an incineration plant for a community. Incineration in a small plant can be as satisfactory, and as fool proof as in a large plant having every type of auxiliary equipment. Such a plant should be within the means of many small communities who have considered incineration as a luxury to be afforded only by large municipalities.

Additional Uses.

The combining of the incinerator with the sewage disposal plant furnishes another use for the incinerator.

The sludge from the disposal plant may be burned in the incinerator eliminating the need of drying beds.

The gas produced from the digestion of the sewage sludge may be utilized as auxiliary fuel for the incinerators and the waste heat used to heat the digesters as well as generating electrical power.

Advantages and Disadvantages.

Incineration has definite advantages over any other method of refuse disposal. (1) The organic matter is destroyed and the final product is an inert mineral ash which can be used as a permanent fill. (2) A properly designed incineration plant can be operated without nuisance and, therefore, can be located so that the average length of haul is reduced to a minimum. (3) Access to the plant over permanent improved roads results in low maintenance costs of vehicles and reduced vulnerability to breakdowns or delays. (4) With proper planning, disposal by incineration should result in a lower assured overall cost than by any other method, with the additional advantage of providing the highest standard of sanitation.

Among the disadvantages of disposal by incineration are: (1) The chance of escape of unconsumed offensive fumes from the chimney top if plant is not operated

correctly. (2) Requires hauling of everything to the incinerator because of the combined collection of refuse, instead of hauling some parts, as ashes, to a near-by dump or fill. (This may be regulated by City Ordinance)

Summary.

In the incineration of combustible refuse, the organic or volatile components are returned to the air as carbon dioxide and water vapor, and the inorganic components are returned to the earth as mineral ash. There is no possibility of further decomposition, or attraction to vermin, and the fire hazard is nil. With other means of refuse disposal, the cost may carry on indefinitely due to insanitation, fire hazards and loss of property values, whereas the placement of the inert residue from incineration on a dump or fill, represents the final expenditure.



Front and rear views
of incinerator build-
ings formerly used by
the Army. At present
time only one is being
fired intermittently.



Comparison of appearance between the open refuse dumps (above) and a dump composed of incinerator residue (left).

DISPOSAL OF GARBAGE WITH SEWAGE

(GARBAGE DIGESTION)

Of all the various methods of garbage disposal now in use, the method of combining it with sewage sludge in a combined sewage and garbage treatment plant is one of the newest and best. This method of disposal is now being used in several Eastern cities.

Disposal of garbage is the vital item in the disposal problem, therefore, this method warrants considerable attention. This method of disposal necessitates the separation of garbage from the rest of the refuse thus requiring two different methods of disposal. The remaining refuse may be handled quite efficiently by one of the other methods of refuse disposal.

The combined process of disposal is as natural as nature itself. Food wastes and sewage are alike, and they act alike. They are both highly organic; they both go through the same process of decay; they can both be treated in the same treatment processes in the sewage treatment plant.

The story of dual disposal begins in 1923 at Lebanon, Pennsylvania. Here the idea was originated to use the sewers for the transportation of ground garbage to a sewage treatment plant for disposal. After a short period

of experimental operation this scheme was abandoned, and for the next ten years little or nothing was heard of dual disposal. The next step was taken in 1933 when active research was under taken. Contemporary with this period of research was the adoption of garbage grinding units for the home. Adoption of the home grinding units has been on the increase until today it is the housewife's dream to have one installed in her sink. (10, p.511)

Site.

As the name, dual disposal, indicates the location of the garbage disposal facilities would have to be in conjunction with the sewage treatment plant. Until every home is equipped with a garbage grinding unit , grinders would be required at the sewage treatment plant or else at centrally located stations.

Methods of Disposal of Garbage Along with Sewage Solids.

The methods of disposal of garbage along with sewage solids may be done by any of the following methods:

1. Introduction of ground garbage into the sewerage system through the use of electric grinders built into the kitchen sinks.
2. Introduction of ground garbage into the sewerage system through the use of municipal operated

grinding stations where the garbage is ground and discharged into the sewers.

3. Introduction of ground garbage into the raw sewage at the head of the sewage treatment plant.
4. Introduction of the ground garbage directly into the sludge digestion system along with sewage solids.

Under method 1, grinding of the garbage at the kitchen sink, is the ideal solution since the garbage is discharged , finely divided , while fresh, the amount of inert material is low and collection and hauling is eliminated. Food wastes are reduced to a far more uniform character than sewage solids themselves. (9, p.1098) Consequently they flow even more readily through the public sewer systems, they cause no stoppages, and they are readily treated at the sewage treatment plant. Water for grinding is supplied from the sink top, thus providing a system free from cross connections. The cold water solidifies the grease, and the high speed grinding and aeration action homogenises the particles into a buoyant, non-congealing form.

Under method 2 there is no great economical advantage over methods 3 and 4 since the major cost of garbage disposal is in the collection. The additional haul to

the treatment plant site may be offset by the disadvantages found in the central grinding station method, which includes nuisances of noise and odor unless the stations can be isolated. This method has been used by some Eastern cities to advantage.

Under method 3 and 4 the garbage must be collected and hauled to the treatment plant. Method 3 has the advantage over method 4 in that grit material is allowed to settle out in the grit chambers before entrance into the digestion tanks of the organic matter.

Methods of Collection.

The most common system of municipal collection is by tank truck which hauls directly to the treatment plant. The trucks used should have water tight, covered bodies to prevent leakage and keep down odors. The householder is usually responsible for the furnishing and cleaning of the garbage can.

A second means of garbage collection by truck crews is the can collection system. Under this system the city owns and furnishes the household cans. When a collection is made the can with its garbage contents is picked up and carried away and a clean can is left in its place. A platform truck is best suitable for this system.

Under these two methods the garbage is hauled to the treatment plant by trucks and dumped on a sorting floor from which the garbage is passed into the grinders. The garbage cans are then placed on a can washer where they are thoroughly cleaned and stacked to be ready for the next collection. With this system the householder is not responsible for cleaning of the garbage can.

The third method of garbage collection is by the use of existing sewers which is being utilized by the owners of sink grinders. Collection is free by means of water-carriage, instead of by expensive manual collection and vehicle transportation. This undoubtedly is the best and cleanest method of handling garbage, but one that has not been generally adopted as yet on account of the high cost of the kitchen sink grinder. It is quite probable that with further education of the public as to the merits of this method and with lowered cost of the grinding units, this method will become more general. City wide installation of grinders would be an economic solution of the garbage collection system.

Special Problems.

Although it is accepted practice to remove large metal objects, large bones, glass and other inert materials before the raw garbage is ground, it is impossible to

eliminate the addition of egg shells, small bones and the like, which the grinders break up. This residue which is of a high specific gravity settles out quickly in the sewerage system and pipes when the velocity is low. In addition the "sliver-like bones" interlace themselves into a mat which, combined with other grit, completely block the system unless constant troublesome labor is provided. This is especially so in the digestion tanks.

(23, p.441-459)

Grit chambers to settle out such residue have been employed to overcome such operational problems, but this only adds additional problems. The grit removed in the grit chamber contains so much organic matter that it introduces additional problems in the disposal of the grit. To overcome this handicap the grit must be washed free of the putrescible material.

Early investigations proved that in digestion of garbage solids alone, acid conditions rapidly build up which inhibit the digestion action. (3, p.1-112) On the other hand it was found that in plants handling garbage and sewage solids together the digestion was very rapid, or even at a more rapid rate than for sewage solids alone. The gas generated by the combined digestion has been found to have a methane content of 60 to 70 percent

and greatly increased quantities of gas evolved. (2, p.871)

It is the general practice now to utilize gas from a digestion tank and many plants have been built where this gas is used for pumping sewage, compressing air or generating electricity for general plant use. The addition of garbage to such plants will, in most cases, double the amount of gas available, and in plants where a considerable amount of power is necessary, the handling of garbage will produce savings in operating costs of considerable magnitude. (4, p.48-50)

Advantages and Disadvantages.

The advantages of disposal of garbage with sewage may be summarized as follows: (1) One utility set-up will handle both municipal garbage and sewage. (2) This method is efficient and one of the most sanitary methods of disposal. (3) Some revenue may be obtained through the use of digester gas and the sale of low grade fertilizer. (4) It is in line with the trend toward the use of household grinders. (5) In some cities the collection problem is rendered less costly by carrying the garbage to the plant by means of the sewage.

The disadvantages of this method of disposal may be summarized as follows: (1) This method introduces problems in the operation of a sewage plant. (20, p.1144)

It is difficult to handle garbage in an existing plant designed for handling sewage only. (2) It requires more careful separation of garbage from the other refuse than does any of the other methods of refuse disposal.

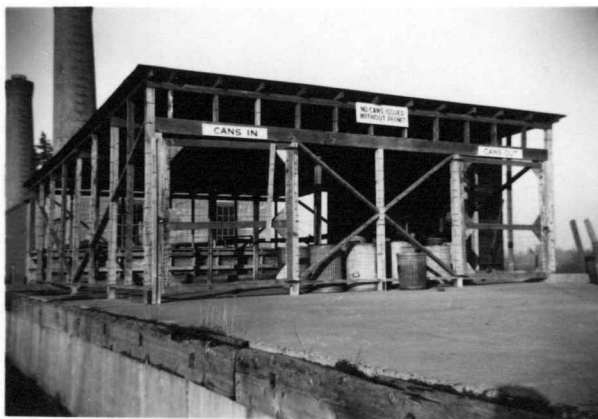
(3) Probably will require considerable education on the part of the public to obtain the proper separation of metals and other inorganic material from the garbage.

Summary.

In summing up the dual disposal problem, it appears that it is practical and economically sound to add garbage to the digester of a sewage treatment plant, where the garbage may be subjected to the beneficial effect of the microorganisms present in the sewage sludge.

Using this method of garbage disposal would eliminate a great problem in finding available sites for the disposal of municipal refuse as the offensive material would be removed. The disposal of the inorganic material left in the refuse may then be accomplished through any of the other methods of refuse disposal.

By keeping the nuisance portion, grit and foreign material, of the garbage under control and out of the plant piping system satisfactory results may be experienced by the disposal of garbage with sewage.



Can washing platform used by the Army. Mixed refuse was carried to the incinerators (left background) in the garbage cans and dumped. All empty cans were then washed and steamed before being used again.

SUMMARY AND CONCLUSIONS

Summary.

I. Organic materials

A. Collected by

1. Trucks

- a. Requires segregation of the refuse produced, by the producers, which may be governed by city ordinance.
- b. Organic matter must be kept in closed containers and protected from spreading.
- c. Collections must be frequent to prevent putrefaction.
- d. Material collected and hauled to site of final disposal by city or private crews.
- e. Cans must be washed periodically to remove the film and minute traces of organic material that may putrefy.
- f. Increases city administrative problems.

2. Water

- a. Organic material ground in kitchen sink grinders and removed immediately through the existing facilities with only minor adjustments being required.
- b. Some revision of sewers may be necessary to prevent clogging.
- c. Organic matter collected while fresh.
- d. Concentrates the disposal of sewage and garbage at a central point.
- e. Eliminates expensive labor encountered with truck collection.

ADVANCE BOND

- f. Results in an increase in the BOD load, the digester capacity, and the production of sewage gas.

B. Treatment and disposal--depends upon method of collection.

1. Burial

- a. Sufficient land area must be available within economical reach of the collection vehicles.
- b. Adjacent real estate will be decreased in value.
- c. Weather conditions may require additional methods of treatment and disposal.
- d. Administrative problems are numerous.

2. Hog-feeding

- a. Requires sorting and removing of bones and sharp objects detrimental to the health of the hogs.
- b. Loss of numerous hogs from diseases and from the presence of the above mentioned materials will cripple the practice.
- c. Garbage must be cooked before being fed to the hogs.
- d. Supplemental feeding may be required.
- e. Garbage must be fresh thus necessitating frequent collections.
- f. Requires constant supervision by sanitary authorities.
- g. Consumption of insufficiently cooked pork from such animals is said to be the chief cause of human trichinosis

3. Incineration

- a. Supplemental heat may be required for sufficient incineration of wet materials.
- b. Storage space may be necessary to permit steady stoking of the incinerators.
- c. Constant administration required to prevent forming a nuisance from odors, smoke and formation of a line of collection vehicles.
- d. Sites may be located closer to the source of the refuse.
- e. Inert ash formed may be used for permanent fill material.

4. Digestion

- a. One utility set-up to handle both municipal garbage and sewage.
- b. Combining of like materials to be digested together.
- c. Introduces additional problems in the operation of sewage treatment plant.
- d. Increases the capacity of digesters, BOD load, and gas production.
- e. Sludge dried and used as low-grade fertilizer or fill material at some isolated spots.

II. Inorganic material

A. Collection by

1. Trucks

- a. Requires segregation of the refuse at the source.
- b. Must be kept in containers or a confined space until collected.

- c. Creates fire hazards if not properly stored.
- d. Picked up and hauled to the site of final disposal.

B. Treatment and disposal

1. Open dumps

- a. Isolated land required to permit dumping and burning.
- b. Decreases adjacent real estate value.
- c. Possibility of creating a nuisance from smoke and odors.

2. Sanitary fill

- a. Sites may be located closer to the source of the refuse.
- b. Possibility of reclaiming low-lands for recreational facilities.
- c. Land thus used is made unfit for any other purposes that may require deep cultivations.
- d. Drainage from sanitary fills may contaminate water supplies.
- e. Not suitable to clay soils.

III. Combined organic and inorganic materials.

A. Collected by

1. Trucks

- a. No segregation of materials required.
- b. One method of disposal must satisfy all requirements.

B. Treatment and disposal

1. Open dumps

- a. Concentration of a tolerated nuisance.
- b. Decrease in property value of adjacent land.
- c. Fire hazards always present.
- d. Ideal habitat for rodents.

2. Sanitary fill

- a. Sites may be located closer to the source of the refuse.
- b. Possibility of reclaiming low-lands for recreational facilities.
- c. Land thus used is made unfit for any other purposes that may require deep cultivations.
- d. Drainage from sanitary fills may contaminate water supplies.
- e. Not suitable to clay soils.

3. Incineration

- a. Properly mixed refuse will not require supplemental fuels.
- b. Storage space may be necessary to permit steady stoking of the incinerators.
- c. Constant administration required to prevent forming a nuisance from odors, smoke and formation of a line of collection vehicles.
- d. Sites may be located closer to the source of the refuse.
- e. Inert ash formed may be used for permanent fill material.

Conclusions.

The main problem of refuse collection and disposal of municipal refuse is caused by the presence of organic matter in the refuse. This problem may be overcome by the adoption of the home disposal units so that the organic material will be collected and disposed along with the municipal sewage. This may become a reality when the home disposal units achieve the reliability and simplicity of the water closet. Until this goal is reached the garbage may be centrally ground at the sewage treatment plant. With this view in mind all new sewage treatment plant designs should include adequate facilities for garbage disposal with the sewage.

With the organic matter eliminated from the refuse the remaining dry inorganic matter may be easily disposed of in trash burners and the inert ash used as fill material.

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QUESTIONNAIRE ON REFUSE COLLECTION AND DISPOSAL

CITY _____ POPULATION _____

AREA SERVED _____

WHAT IS COLLECTED AND BY WHOM:

GARBAGE ALONE _____

MIXED GARBAGE AND REFUSE _____

COMBUSTIBLE REFUSE _____

NON-COMBUSTIBLE REFUSE _____

FREQUENCY AND HOURS OF COLLECTION:

RESIDENCES _____ HOURS _____

BUSINESS _____ HOURS _____

EQUIPMENT _____

BASIC MONTHLY FEES CHARGED:

RESIDENCE _____

BUSINESS HOUSES _____

METHOD OF DISPOSAL:

GARBAGE ALONE _____

MIXED GARBAGE AND REFUSE _____

COMBUSTIBLE REFUSE _____

NON-COMBUSTIBLE REFUSE _____

PERSONNEL (Crews) _____

FINANCING _____

REMARKS: