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Vector-Borne Disease Control

SANITATION in the CONTROL of INSECTS and RODENTS of PUBLIC HEALTH IMPORTANCE

SELF-STUDY

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

PUBLIC HEALTH SERVICE
Centers for Disease Control
Public Health Practice Program Office
Atlanta, Georgia 30333

SANITATION

IN THE CONTROL OF INSECTS AND RODENTS OF PUBLIC HEALTH IMPORTANCE

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INTRODUCTION

Sanitation is the most important principle in the control of flies and rodents. This concept is also of considerable importance in the control of mosquitoes, particularly in urban areas. Sanitation has been defined as "A modification of environment in such a way that a maximum of health, comfort, safety, and well-being occurs to man." Through sanitation programs, vector control workers can apply their knowledge of animal ecology to modify the environment and create conditions which reduce the populations of certain vectors and pests. The necessity for this approach to vector control has received increasing support in recent years.

Research and community demonstration programs have shown conclusively that the application of the basic principles of sanitation result in substantial reductions in the fly, rodent, and mosquito populations. In a number of communities it has been estimated that proper refuse sanitation will do 90 percent of the job in fly control and 65 percent in rat control. In most communities, good refuse sanitation, together with good general maintenance of premises, will greatly reduce the pest mosquito populations.

For years after World War II vector control programs were based primarily on the use of insecticides and rodenticides. However, in recent years the concept of integrated control has been widely adopted with less emphasis on chemical control and more on physical exclusion and sanitation. This greater emphasis on the sanitation aspects of vector control is imperative today because many of the most important species of flies and mosquitoes are becoming increasingly resistant to insecticides (*12*) and the Norway and roof rats have developed resistance to anticoagulant rodenticides in parts of Europe and the United States (*32*). In the case of rodents, reducing the capability of the environment to support a large number of rodents not only decreases this population but results in an increase in competition between those individuals remaining. This increased competition results in a lower rate of reproduction and higher mortality.

Insect and rodent infestations in homes, in businesses, and on farms result from neglect of basic responsibilities for cleanliness. Food, harborage, and water (life essentials for insects and rodents) occur frequently in and around all types of buildings wherever vermin prevail. Vermin prevalence increases rapidly as the standards of maintenance and living drop. Substandard housing and business and industrial neighborhoods produce and maintain greater and more widespread vermin populations than well kept, clean, residential and business areas. Lack of knowledge, carelessness and indifference are usually the basic reasons for the existence of such conditions.

A successful approach to resolving such problems and developing an effective program involves public education and promotion of sanitary practices by the individual and the community. Results of the 1968 National Survey of Community Solid Waste Practices by the Public Health Service (*8*) revealed that only 6 percent of some 12,000 solid waste land disposal sites included in the study were operated satisfactorily as sanitary landfills. The operations of 94 percent of these disposal sites were unacceptable and represented a disease potential, threat of pollution, and land blight. Of the approximately 300 incinerators reported in the survey, 75 percent of the facilities were inadequate. The Survey reported that over 10,000 new sanitary landfill operators would need training to operate existing disposal sites as sanitary landfills. The survey data indicated that almost $5.40 per person was budgeted for collection activities, and about $1.40 per capita for disposal activities, giving a total per capita expenditure of about $6.80 for both collection and disposal. Thus, the total amount budgeted by municipalities in the United States for both collection and disposal of refuse in 1968 was approximately $1.6 billion (*8*). In fiscal year 1972-1973, federal, state, and local governments spent approximately $1.8 billion for solid waste management programs (*15*).

Sanitation in insect and rodent control includes the three phases of refuse handling: **storage**, **collection**, and **processing** and **disposal**, together with proper premises maintenance and storage of products and material. Emphasis will be placed here on the relationships of each activity to the existing or potential insect and rodent problem.

DEFINITIONS (Adapted from (*24*))

Ashes: Residues from the burning of wood, coal, coke, or other solid combustible materials.

Garbage: Putrescible animal and vegetable wastes resulting from the handling, preparation, and consumption of foods.

Refuse: All putrescible and nonputrescible solid wastes (except body wastes). Refuse includes garbage, rubbish, ashes, street cleanings, dead animals, abandoned automobiles, and solid market and industrial wastes.

Rubbish: Nonputrescible solid wastes (except ashes). Rubbish consists of both combustible and noncombustible materials, such as paper, cardboard, tin cans, yard clippings, wood, glass, bedding, crockery, metals and similar objects.

Solid Waste: Useless, unwanted, or discarded material with insufficient liquid content to be free flowing. Includes agricultural, commercial, industrial, institutional, municipal, pesticide, and residential materials; synonymous with refuse.

Waste: Useless, unused, unwanted, or discarded materials. Waste includes gases, liquids, and solids. The gases are principally industrial fumes and smoke; the liquids consist mainly of sewage and the fluid part of industrial wastes; the solids are classed as refuse.

REFUSE STORAGE

REFUSE CHARACTERISTICS AND QUANTITIES

Each year Americans produce, consume, and throw away more and more. In 1951 it was estimated that each person produced an average of about 2 pounds of refuse every day (*50*). By 1970, the Environmental Protection Agency reported that the amount of residential and commercial solid waste actually collected had increased considerably: 3.3 pounds to as much as 5.3 pounds per person per day (*8, 39*).

Numerous factors, such as geographic location, season, social and economic characteristics of the community, types of business and industry, and type and frequency of collections, influence the amounts of refuse collected in a community. Some of these factors may also have a direct bearing on the existing or potential insect and rodent problems. The volume of garbage produced per capita is declining with the increased use of frozen packaged foods and other highly processed and prepared foods "ready for the pan or table." At the same time, there is a corresponding increase in household rubbish such as paper containers, cans, and bottles.

EFFECT ON VECTOR POPULATIONS

Like other living organisms, rats, flies, and mosquitoes must have food, harborage, water, and suitable breeding media. The inadequate or improper storage of refuse offers all of these. Improperly stored garbage provides food for rats and flies, and a breeding medium for flies. Improperly stored rubbish often offers harborage for rats and furnishes ample breeding sites for mosquitoes. Junk auto yards and junk tire yards frequently are foci from which yellow fever mosquitoes (*Aedes aegypti*) and house mosquitoes (*Culex pipiens* complex) spread out into communities. Increased urbanization, with the attendant overcrowding of the human population in many sections of cities and towns, has made the refuse handling problem more acute and the environmental factors for insects and rodents more favorable. The growing areas of substandard housing within communities (sometimes called "the ghetto") are much more important than fringe residential building as a factor in the favorable environment for insects and rodents.

Modern trends toward greater use of prepared, packaged, and frozen foods will continue to reduce the garbage content of mixed refuse. This change will be accelerated by the increased use of business and home garbage grinders and the decrease in backyard burning of refuse. But while modern food merchandising is materially aiding in the reduction of vector and nuisance populations, it does not preclude the necessity for proper storage. Regardless of the composition of refuse, in general the extent of fly and rodent infestation closely parallels the degree of carelessness and neglect attending refuse storage.

RESPONSIBILITY FOR REFUSE STORAGE

In most communities adequate refuse storage on the premises is the individual responsibility of the occupant. However, the local health department should have the authority to require sanitary refuse storage at all premises. Proper refuse storage involves more than merely providing a sufficient number of containers to hold the volume of refuse produced between collections. It also involves selection of an approved type of container, placement of containers where they will provide maximum convenience to the user, yet be readily accessible to the collection crew; the proper prestorage handling of garbage and other putrescible wastes; and the maintenance of the containers and their surroundings in a sanitary condition (*2, 3*).

The collection agency should instruct citizens as to their responsibilities in refuse storage. When these instructions are followed, general sanitary conditions will be improved and collections will be more efficient. More garbage will be adequately stored and more containers will be located at a convenient place at the proper time. One successful method of informing the public is the use of a printed card, which describes the storage practices required and gives collection schedules in different sections of the community.

Several cities supply the containers and retain ownership, charging the user a fee for service and replacement. In this manner the city is able to standardize the size and shape of the containers, thereby increasing the ease and efficiency of collections and at the same time contributing to sound fly and ratproof storage.

HOUSEHOLD HANDLING OF REFUSE

In the prestorage treatment of refuse, a number of simple yet important steps can be taken by the premises occupant which will be advantageous both to him and

the municipal department responsible for collections and disposal. These measures, together with good storage, will reduce rodent food and harborage, fly breeding, and some mosquito breeding at homes and commercial establishments.

Garbage requires more prestorage treatment than other types of refuse. The use of paper and plastic bags as liners for small containers within the home, and as liners for large garbage cans outdoors, is one of the greatest recent advances in proper refuse storage practices. The use of paper and plastic bags has numerous advantages for the householder and for the collection crews as listed below:

Advantages for the Householder in Using Paper or Plastic Bags

1. It reduces the possibility of disagreeable odors developing, either in the container or during collection and disposal.
2. It makes the garbage less accessible to flies because the bag can be closed to fly entrance.
3. Corrosion of cans is reduced, and washing is required less frequently.
4. The likelihood of can rims being damaged is greatly reduced, since the cans are more easily emptied when garbage is in paper and plastic bags.
5. If the containers are filled loosely, the contents do not freeze or stick to the inside, thus decreasing the likelihood of damage to cans during emptying.

Advantages for Collection Crews in Using Paper or Plastic Bags

1. It reduces the time required for crews to empty cans and makes the task more agreeable.
2. It facilitates burning, if disposal is by incineration.
3. It decreases spillage of waste and blowing of paper between garbage can and collection truck.

Figure 1. Refuse Can with Plastic Bag for Household Use

Figure 2. Transferring Plastic Bag with Refuse to Approved Outside Container

One recent trend is to have the householder place the paper or plastic bag at the curb (not in refuse cans) on the day of pickup. When such a system is used, there is no wasted motion of taking off the refuse can lid, no lifting the refuse can and emptying it into the bay of the truck and placing the can back on the curb, and no noise of cans being banged on the collection truck (*36*). Communities using this method must adopt and enforce strict dog leash laws.

Rubbish often comprises the major portion of accumulated wastes. Much of it is combustible, hence constitutes a real fire hazard when not disposed of promptly. Many items are bulky, such as cardboard boxes, accumulations of magazines and newspapers, garden cuttings, and tree limbs. They are difficult to handle unless proper precollection preparation is effected. Such items should be tied in bundles or otherwise reduced to a size and weight that can be handled by one man. Ordinarily, bundles should not weigh more than about 50 pounds and their length should not exceed 4 feet (this length may vary, depending on the size of the collection vehicles in use). Rubbish that has not been properly prepared often is left behind by collection crews, thus providing harborage for rats or breeding places for mosquitoes.

Shortly before collection time, the bulky rubbish, properly prepared, should be placed adjacent to refuse containers at the point of collection. In many areas, this type of refuse is collected separately on a less frequent schedule than household refuse and must be placed for collection on designated days. Other large bulky items, such as old refrigerators, stoves, hot water heaters, furniture, mattresses, may be placed at the curb for collection on designated days.

CONTAINERS

Garbage cans should be water tight, provided with a tight fitting lid, rust resistant if made of metal, structurally strong to withstand handling stress, easily filled, emptied, and cleaned, and of a size that when full can be conveniently handled by one man, and furnished with side handles or a bail. The conventional heavy duty galvanized garbage can with the recessed bottom most nearly fits these recommendations. In recent years garbage cans made of heavy plastic which is resistant to both heat and cold have proven most satisfactory. In some comparative tests, heavy duty plastic garbage cans have lasted longer than conventional galvanized metal ones. Each home or establishment should have a sufficient number of these containers to hold all the refuse that accumulated between collections. Most communities favor containers of 20- to 30-gallon capacity. For garbage, when collected separately, 5- to 12-gallon containers are frequently used. Some communities limit the combined weight of container and contents to about 65 pounds. Use of 55-gallon drums should not be permitted.

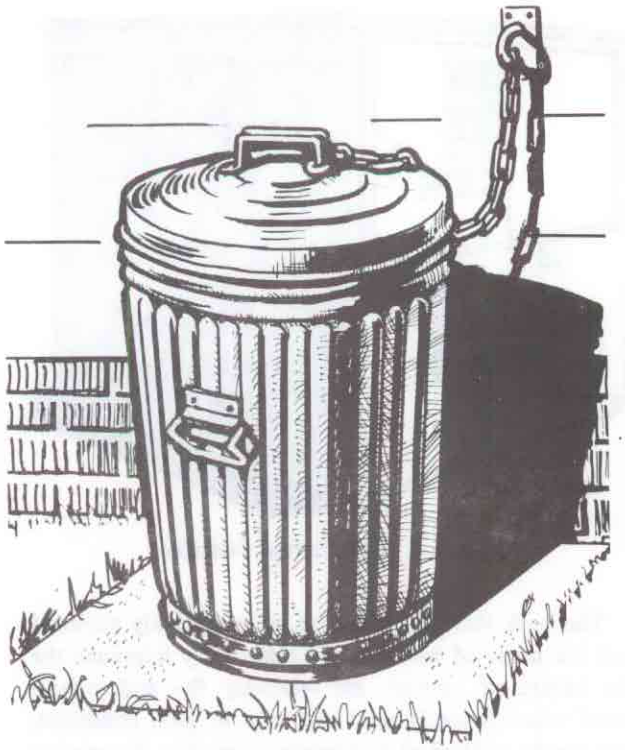


Figure 3. Galvanized Garbage Can

Sunken garbage cans have many disadvantages: (a) the pit is difficult to keep clean, (b) greater lifting effort is required of collection personnel, (c) the method is not suitable when ground water is high or rainfall is heavy, (d) maintenance cost for hinges and cover is high, (e) initial cost is high, (f) storage capacity is inadequate, and (g) frequently there are vector problems with flies, cockroaches, or rats. Sunken garbage cans have the advantage of being out of sight, impossible to overturn, and inaccessible to dogs and cats. They provide some protection from summer heat and winter freezing. Generally the disadvantages far outweigh the advantages.

Bulk Storage Containers are usually quite satisfactory at apartment buildings, housing projects, or business establishments. Commercial firms produce bulk containers of various sizes that are efficient and serviceable. Except for very large containers used commercially, practically all bulk storage containers are designed to be emptied mechanically at the storage site into compactor refuse collection vehicles capable of receiving the contents of a number of bulk storage units, as shown in Figure 13, page 13. Many bulk containers have a drain hole to permit cleaning when necessary. These drain holes, often 2 to 3 inches in diameter, should be fitted with a hardware cloth screen to prevent entry of rats and

mice, or the plug should be kept in place. Otherwise in many situations, bulk containers with open drain holes become feeding stations for rodents.

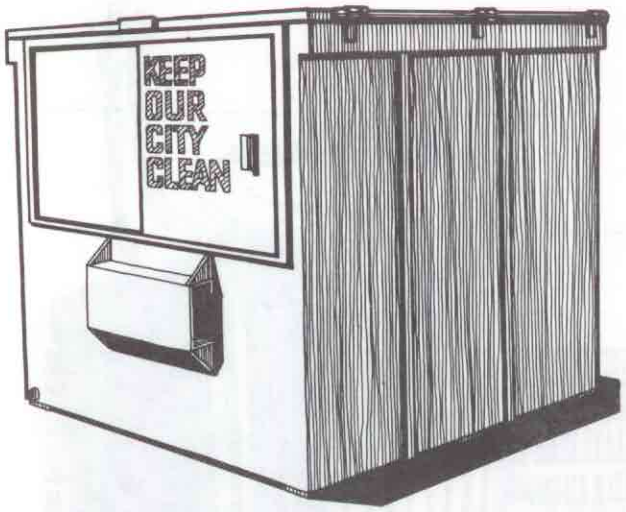


Figure 4. Bulk Refuse Container

The bulk storage containers are completely enclosed and are made of heavy gauge steel. They minimize the fire hazard of rubbish, are relatively fly- and rodent-proof when properly used and kept in good condition, and can be padlocked to prevent scavenging. To prevent fly breeding, these bulk storage units should be thoroughly cleaned each time the contents are removed. However, where containers are emptied into collection trucks at the storage site, adequate cleaning may present a problem.

Flip-top, self-closing containers are used at many parks and other outdoor areas. Many of these have a removable plastic liner which makes collection easier and reduces spillage.

Home refuse compactors can compress 20 to 30 pounds of household refuse, a week's supply for most families, into a small treated bag. In a study in Atlanta, Georgia, with nearly 400 compactors installed in homes, many of the residents reported one of the important advantages was that they did not have to make a trip to the refuse can outdoors every day (*10*). The study indicated that the average compacted bag weighed about 20 pounds. The City of Atlanta reported considerable savings at this special project. The compactors made it possible to pick up a single small bag of compacted refuse at the curb once a week as compared to collection from conventional refuse containers in backyards or alleys twice a week. In some homes, refuse compactors are used for rubbish (cans, bottles, and cartons) and garbage grinders are used to dispose of putrescible, wet garbage (thus avoiding odors in homes).

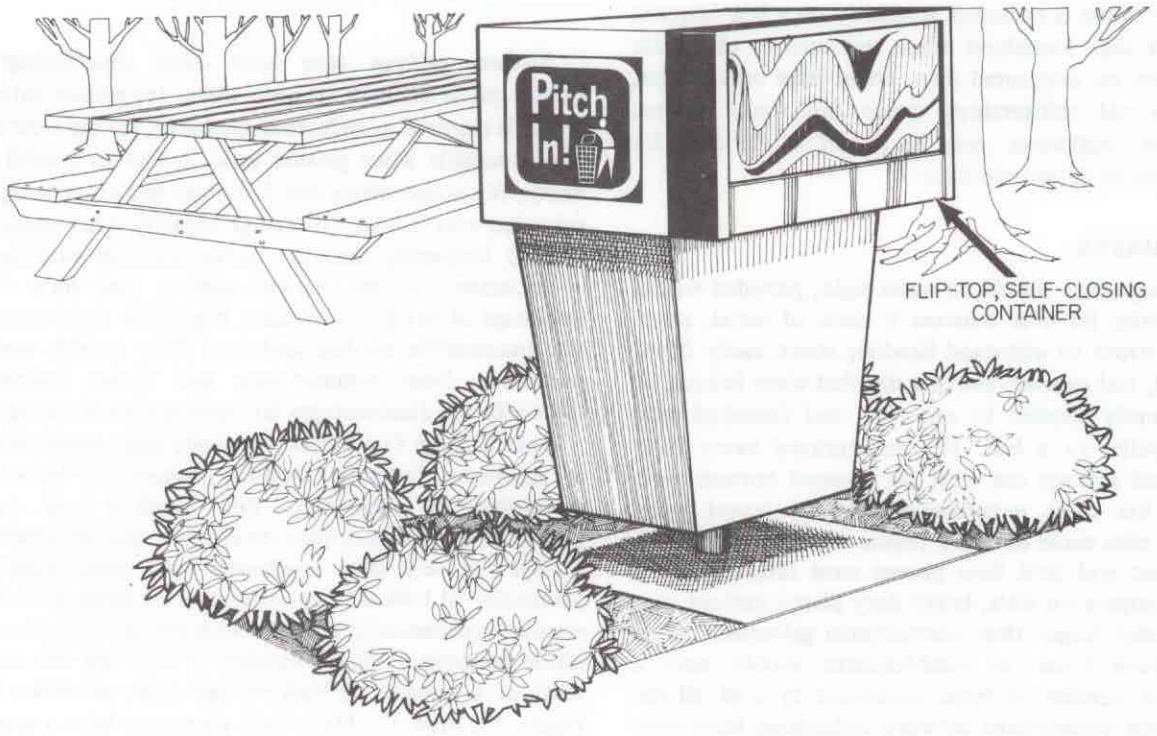


Figure 5. Flip-top, Self-closing Container for Outdoor Areas.

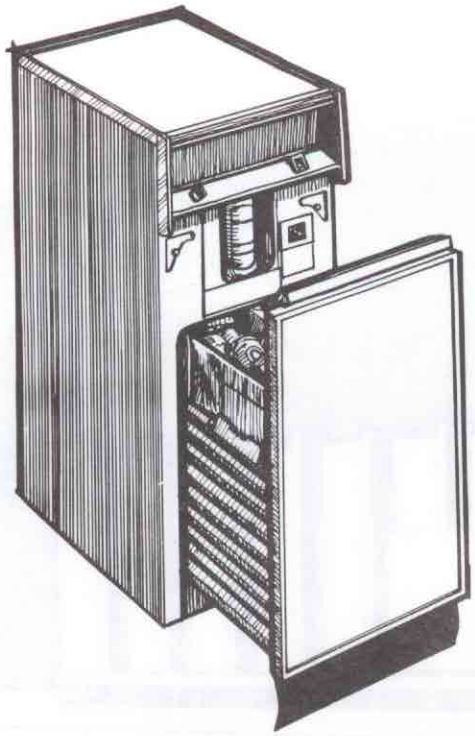


Figure 6. Home Refuse Compacter.

Rollaway containers are used in many situations for bulk storage of garbage and refuse. Some of these are relatively small and hold only a few hundred pounds, while others are larger and hold several tons. Like the bulk storage containers without wheels, rollaway containers should be made of heavy gauge steel, be leak-proof, and rodent-proof. Many rollaway containers are so located that they can be loaded conveniently from platforms or openings through building walls. They should have tight-fitting lids with automatic closing devices.

Wooden crates, baskets, and boxes are often used for bulk storage of rubbish. This practice is undesirable since garbage, or material contaminated with garbage, finds its way into these receptacles. Such misuse provides food and harborage for rats and permits fly breeding. The use of fireproof, vermin-proof containers for rubbish is recommended.

Stationary compaction equipment with bulk containers is used at many large institutions, apartment houses, food-handling establishments, and other situations where there is a large volume of refuse, much of which contains little or no garbage. The compacted material is removed periodically by special trucks.

CONTAINER RACKS AND FACILITIES

Storage on the premises can be greatly improved by providing and maintaining proper storage racks or stands for refuse containers. Sketch plans for satisfactory racks of various designs and materials can usually be obtained from local or state agencies. Types of holders that have proved adequate include: (a) a single steel post with hooks to which the refuse cans are hung by the handle or bail, and sometimes with a stirrup to support the bottom of the container, (b) a pipe rack either of threaded or welded construction, (c) steel bars such as those used in reinforcing concrete, or angle iron, welded together, and (d) single 1- or 2-can racks built of wood, of either new or scrap lumber.

All storage racks should have open "slatted" bottoms and should hold containers at least 18 inches off the ground. This elevation not only reduces corrosion of containers; it also allows room for regular cleaning underneath, eliminates rat harborage under containers, and minimizes the possibility of cans being overturned. In areas where yard collection is practiced and the owner need not carry the cans to the curb or the alley for emptying, chains attaching container lids to the racks prevent loss of lids and minimize possible damage. Painting racks improves their appearance and in some instances prolongs their life.

Concrete slabs under individual containers provide some protection but are not generally as satisfactory as racks. When these are used they should be about 4 inches thick and should have foundation toes on the outside to prevent rodents from burrowing under them. Continuous slabs of concrete adjacent to apartments and business buildings, especially if elevated to truck loading height and provided with drains, are quite satisfactory. Managers of many establishments prefer multiple-can racks, or bulk storage containers, somewhat removed from the buildings. Some restaurants, supermarkets, and other establishments use refrigerated, inside, refuse storage rooms. This practice reduces objectionable odors in the garbage storage area.

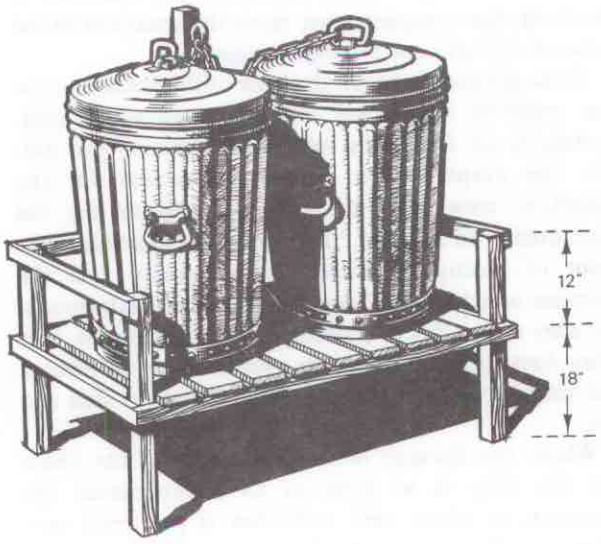


Figure 7. Garbage Can Rack and Cans

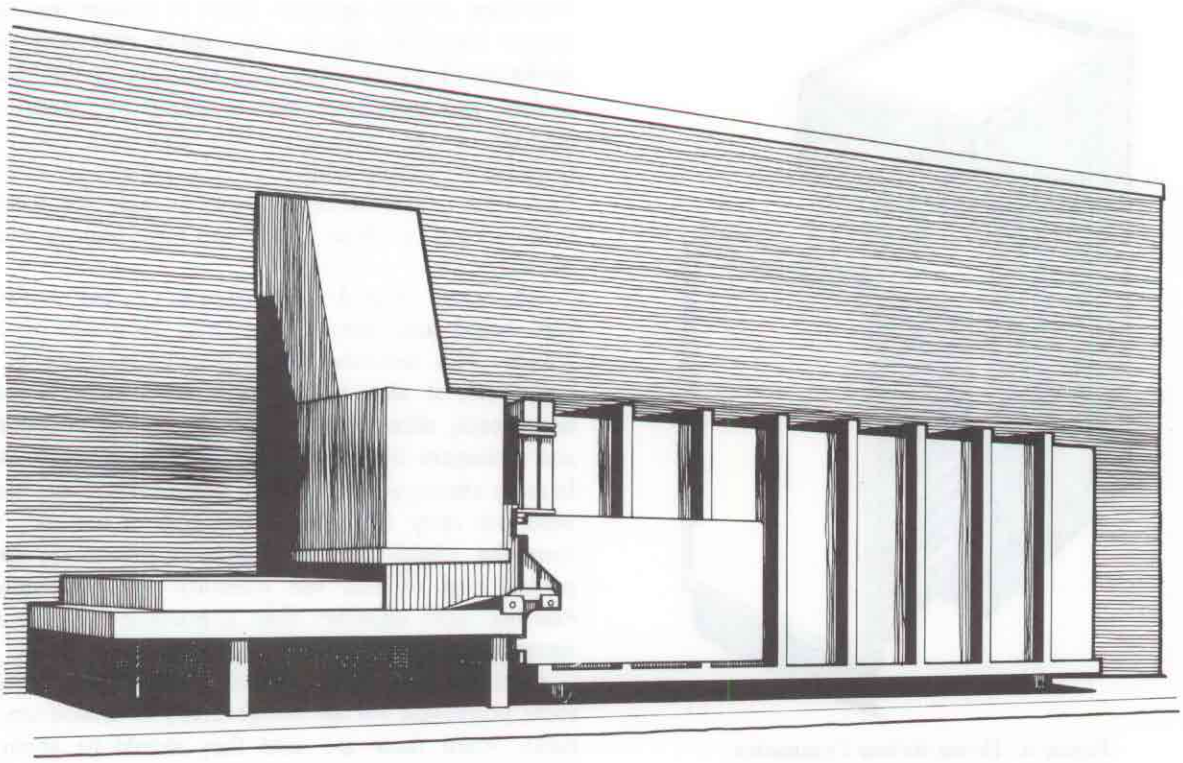


Figure 8. Stationary Compaction Equipment with Bulk Refuse Containers

LOCATION OF REFUSE STORAGE AREA

The location of refuse containers, except on the days of collection, is usually selected for the convenience of the premises occupant. Commonly, this is near a side or rear door of the home or near the rear door of the business establishment. Where the community provides yard collection, it is not necessary to change the location on collection days. Where curb or alley collection is practiced, the occupant must move the container to the point of collection on the days designated.

If the distance between the back of the house and the rear property line is not too great, and alleys exist, containers are frequently located permanently just outside the property line. This is convenient for the collection crew and not too inconvenient for the householder. In addition, this permanent location at the point of pickup eliminates the possibility that the premises occupant will forget to place the containers at the alley on the day of collection. When this occurs, as it often does, the storage facility soon becomes overloaded and garbage and rubbish are left exposed to flies and rats.

Where the distance between the back of the house and the alley is so great as to inconvenience the occupant, or where curb collection is practiced, containers usually are stored solely to suit the occupant's convenience and are moved to the point of collection on the proper day. Better maintenance of racks and containers will result when they are exposed to the scrutiny of neighbors.

PROPER MAINTENANCE OF REFUSE CONTAINERS

The responsibility of the householder does not end with the emptying of the container by the refuse collection crew. Post collection maintenance is especially important in fly and rodent control, as well as in odor control. Where curb collection is practiced, the householder should return the containers from the curb to the normal storage location as soon as possible after collections have been made. This will minimize the possibility of damage to the container and lid and will reduce the time during which flies would have access should the collectors fail to replace lids.

If plastic bags are used in the container, frequent washing may not be necessary. When any liquid or solid residue remains, it should be washed from the can, preferably into the sewer system. This is important, for extensive fly breeding occurs in accumulated garbage in the bottom and on the sides of containers. Schoof, Mail and Savage (*45*) report that garbage in containers represented 38.3 percent of the fly infested media in Phoenix, Arizona, in 1951 and 1952. If the container is washed and the washings emptied on the ground, food scraps may provide rat food and fly-breeding media, and

the liquid so saturates the ground that in time the earth itself contains sufficient nutrients to breed flies. After the can is washed, it should be inverted and allowed to dry before reuse. During insect seasons, spraying cans and racks with insecticides may be desirable. Every effort should be made, especially where large numbers of cans or bulk storage containers are used, to have the storage area hard-surfaced and sloped to a sanitary sewer drain. This procedure will allow proper disposal of waste resulting from the cleaning of the containers. Water under pressure should also be provided at these locations.

If in the process of collection, the container or the rack has been damaged, repairs or replacements should be made promptly. Rodent- and insect-proof storage does not exist where containers are materially damaged. The area around the racks should receive frequent attention to see that no refuse is allowed to remain outside the containers in which flies might breed or on which rats might feed.

SUMMARY

In any community the insanitary storage of garbage creates a major source of food for flies and rodents and a breeding medium for flies. Rubbish that is not stored properly and disposed of promptly provides harborage for rats and a breeding place for mosquitoes. It poses a fire hazard and frequently is an attractant for flies. Good refuse storage can be attained with the expenditure of reasonable effort and is just as important in the small community as in the large city.

Citizens should be encouraged to handle refuse properly. When education and information fail to stimulate satisfactory practices, local governments should enforce suitable ordinances that will require good refuse storage practices. Even the small town that plays no part in actual collection, but instead relies on householder contract arrangements, has a responsibility to regulate storage of refuse, through education of its citizens and enforcement of modern ordinances for control (*2*).

Good refuse storage in the urban community can become a reality. The whole community benefits from the reduction of vector and pest populations and the elimination of accident hazards to children playing in the area. The community also benefits through elimination of unsightly storage areas and especially through the improvement of individual and community self-respect.

REFUSE COLLECTION

IMPORTANCE OF COLLECTION

Refuse collection is an essential part of a well organized refuse handling system and has an important bearing on local vector populations. If a community has no organized collection system, conditions are often favorable for high fly and rat populations. Even where service is available, a careless collection employee may spill refuse on the premises or on the street, thus providing food for rats and flies and a breeding place for flies. Rough handling may damage the container rim so that the lid will not fit properly, thereby making the refuse accessible to flies and rats. Negligence or carelessness in this manner may also create an odor nuisance. Frequent, systematic, reliable collection service should be the goal of every community. If this is not available, capacity of storage facilities will be inadequate and makeshift containers will be used, thus making refuse more readily accessible to flies and rodents.

COLLECTION AGENCY

Careful thought must be given to providing a community with the most satisfactory collection system. A decision as to the most feasible method of disposal for refuse will have a direct bearing on the type and operation of the collection system. If the community does not accept their responsibility for providing refuse collection and disposal, the householder will find it necessary to haul and dispose of his own refuse. Usually he does this in an unsatisfactory manner, or contracts with a private hauler to make the collections. Colonna and McLaren (*19*) have studied the many alternative methods of collection. Two of the most common types are public and private collection.

Public (municipal) collection with ownership and operation of the service by a government agency, such as the department of public works, is a common practice. The advantages of public collection include:

1. Public sentiment in favor of government operation of public services
2. Less expense because of nonprofit, tax-exempt status
3. Complete coverage and legal authority to enforce regulations with regard to storage and collection, including any local innovations such as separate collection of newspaper and other usable materials for resource recovery
4. Quality service at a price.

The disadvantages of public collection include "the monopolistic nature of such operations which can result in lack of stimulus toward efficiency . . . the potential for political interference in the operation and financing of the system . . . (and the difficulty) . . . in establishing labor policies such as crew size and daily work tasks." (*19*).

Private collection has a number of advantages which include:

1. Public sentiment in favor of involving the private sector in public service
2. Flexibility to make shifts in operation which would produce labor savings and other cost reductions
3. Desire of local governments to avoid administrative details in the operation of collection systems
4. Population growth is outpacing the ability of communities to provide public services
5. Increasing numbers of qualified private contractors (*19*).

The major disadvantage of private collection is incomplete coverage if not properly managed. It is in substandard residential areas that this situation most often prevails, since many residents cannot afford, and do not want to spend the money for, private service. In the absence of municipal collection and disposal services, many residents dispose of rubbish and garbage in their back yards, alleys, and streets, thereby creating most favorable conditions for rats, flies, and mosquitoes.

In many cities, combinations of public and private collection systems are used. One of the most common types includes public collection from all residential property and private contract collection from food-handling establishments such as restaurants and hotels, large apartments, and private industries.

TYPE OF COLLECTION

The type of collection is determined largely by the method of disposal. **Separate collection** of garbage and rubbish, following segregated storage, is necessary if hog feeding of cooked garbage is the method of disposal. Since this method requires double storage and collection facilities, the trend is now toward combined collection.

Combined collection of mixed refuse is the most practical and economical method and is possible where disposal is by the sanitary landfill or by modern incinerators. Combined collection usually permits combined storage, thus preventing some abuses that often

exist where separate storage is practiced. Since garbage must be collected frequently, this combined collection allows no excuse for an accumulation of rubbish that might serve as harborage for rats or as a breeding place for mosquitoes and flies.

Many cities have two types of collection: **combined collection** of all types of mixed refuse in containers on a regular schedule; **and bulk** or **trash collection** of large items, such as old refrigerators, stoves, mattresses, large collections of yard trimmings, which are not easily handled by packer trucks, on certain designated days, or by special crews who cruise the area.

POINT OF COLLECTION

Curb or alley collection permits more rapid and efficient pickup at the edge of the street without time consumed in walking down driveways or into backyards. It permits the use of one-man collection vehicles. In many localities on the day of collection the residents bring their own garbage and refuse to the curb or alley in closed plastic bags. This practice reduces spillage and blowing of refuse during collection and loading, eliminates the lining of streets with garbage cans or carts, and the time consumed in lifting off and replacing the lids from these containers after the plastic bags are tossed into the collection vehicle.

Yard collection of refuse is practiced by a number of communities. In this type of service the collector enters the premises and collects the refuse from the normal storage location. This is done in a number of ways: the collector may carry the containers to the truck and then leave them on the curb, or may return them; or he may have a tote barrel, or tub, into which he empties the refuse from several homes before returning to the collection vehicle. In some cities, the collectors use a 2-wheeled cart to carry the tote barrel to the curb and collection vehicle. Yard collection is more convenient for the occupant of the premises but obviously is more time consuming and expensive.

Refuse collections are usually made in residential areas during the day and in the downtown business districts at night, or early in the morning, in order to avoid heavy daytime traffic. Nighttime collection in the business districts is practiced more frequently in the larger cities than in the smaller communities.

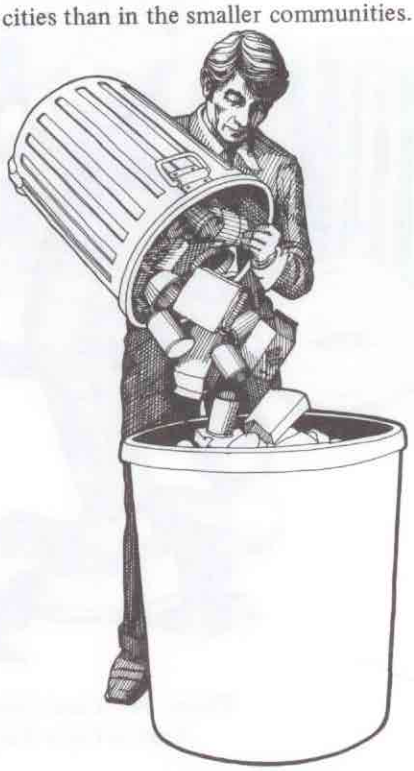


Figure 10. Yard Collection. Collector Emptying Refuse into Tote Barrel

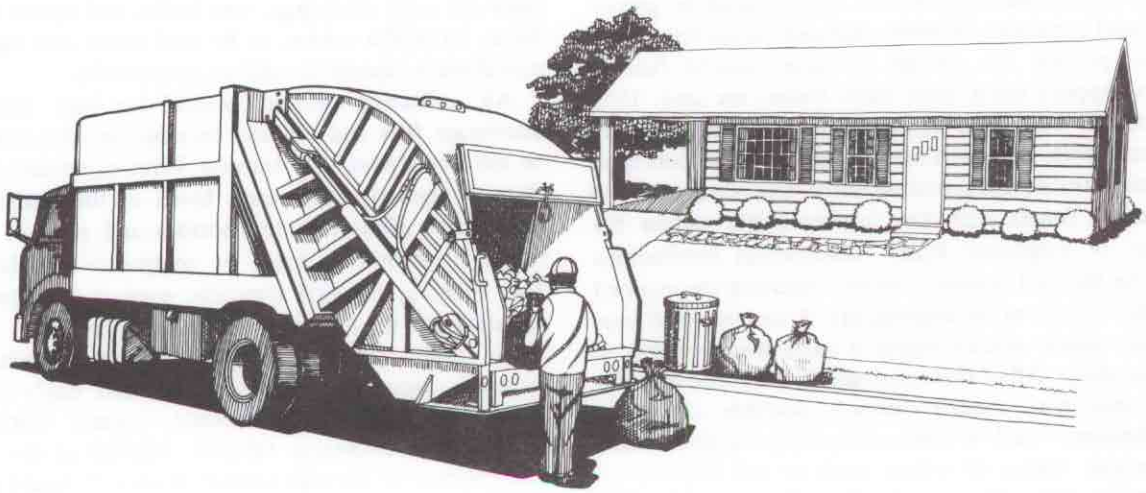


Figure 9. Curb Collection of Refuse

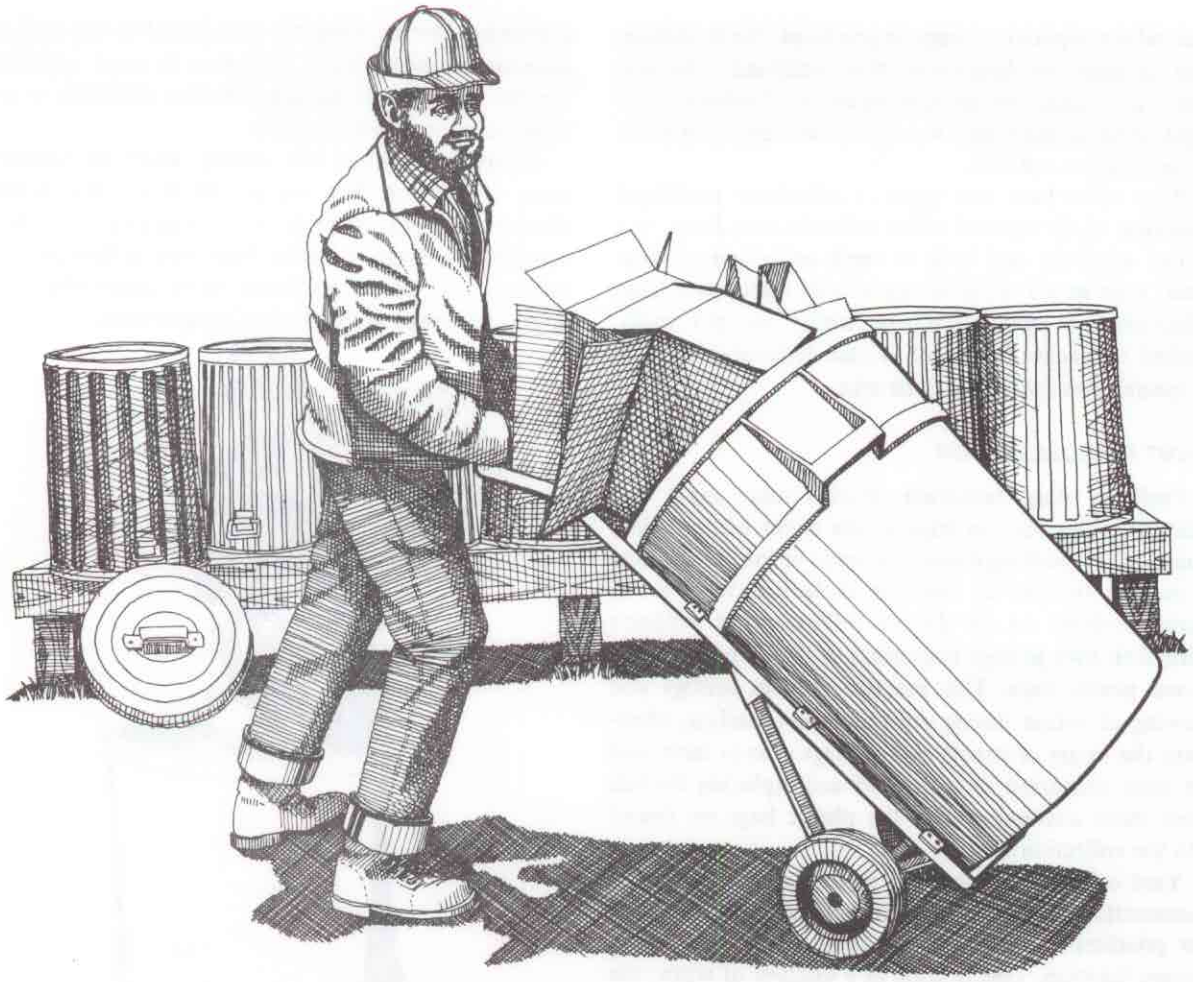


Figure 11. Yard Collection. Collector Using 2-wheeled Cart to Carry Tote Barrel to Collection Vehicle

COLLECTION EQUIPMENT

Great improvements in design and operation of refuse collection equipment have been made in recent years. These improvements have been accompanied by greatly increased capacities. Modern, enclosed, liquid-tight truck bodies prevent the spillage of loose material that so often happens when open truck bodies are used. They also reduce leakage of liquids from the vehicle onto city streets, which creates an odor nuisance and attracts flies. Enclosed trucks also minimize odors emanating from the contents. Trucks with low loading height reduce the danger of employee injury. Compacting mechanisms increase the load capacity, thereby reducing the required number of trips to the disposal site. A shorter wheel base on the vehicle chassis makes it more maneuverable in narrow alleys. All of these desirable features are incorporated into many models currently available. Capacities vary between 9 and 40 cubic yards. Open trucks are used for certain classes of refuse, such as tree limbs, yard trimmings, bed springs, and ashes. Dump trucks with power tail gates are being used increasingly for heavy noncompressible items such as discarded hot water heaters, old stoves, refrigerators, and washing machines. Trucks with chipping machines are being used increasingly for yard trimmings, tree limbs, and similar bulky items. Tarpaulin covers, to be tied down over full and partial loads, should be used on open trucks.

All collection vehicles should be kept clean to discourage flies and rats and to avoid an odor nuisance on the city streets they traverse. When equipment is not cleaned regularly, flies may breed in the sludge and grease that adheres to the bottom and sides of open trucks or within enclosed or compactor-type bodies. This adhering material may also support a limited rat population in the area where the trucks are stored.

To avoid these health and nuisance problems, thorough cleaning at the end of each day's use is recommended. When putrescible organic matter is washed from collection vehicles, disposal of the wash water should be through sanitary sewers. It should never be allowed to soak into the earth, thus creating an attractant for flies and rats and a breeding place for flies.

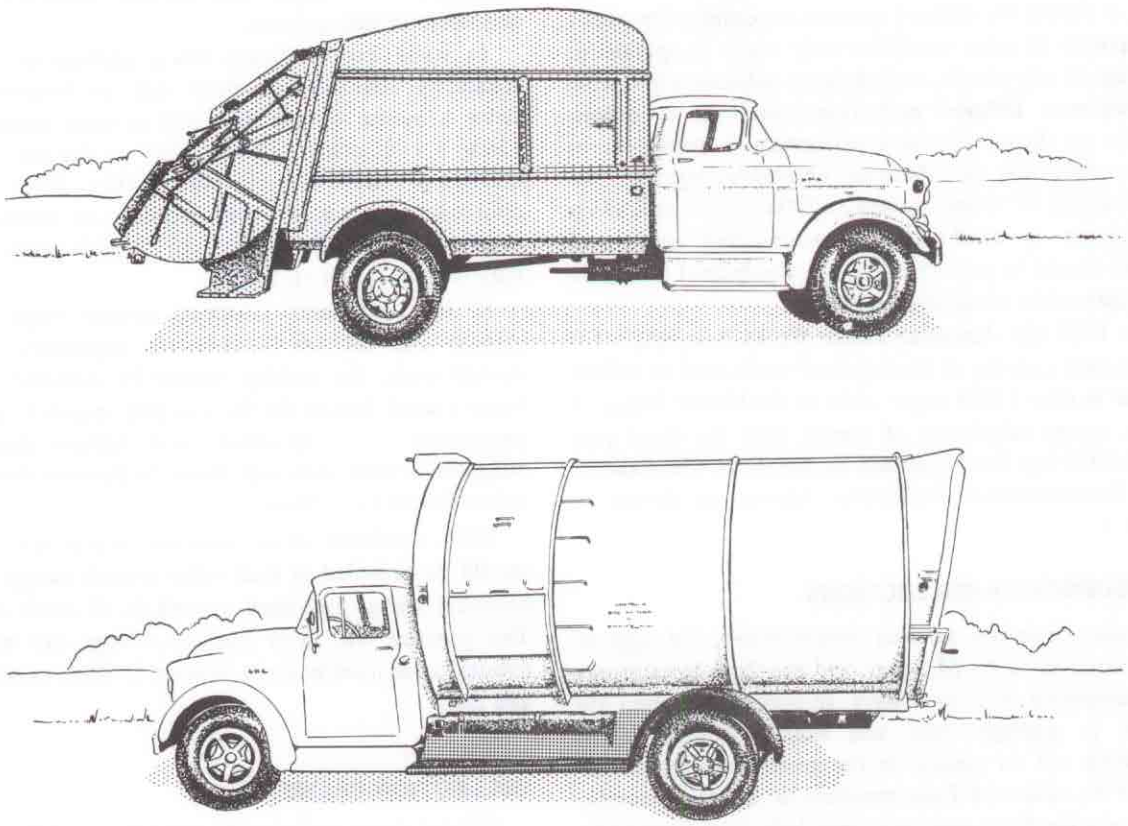


Figure 12. Refuse Collection Trucks

Figure 13. Special Truck for Collecting Refuse from Bulk Storage Containers

When collection equipment is antiquated or worn out, it should be replaced as soon as possible. Operating equipment in poor condition may result in spillage or leakage on city streets, or in delayed collection following breakdowns. Delayed collections result in conditions similar to those existing when service is infrequent or when collection is otherwise unreliable; namely, the overloading of refuse storage facilities. When collection equipment is overloaded or overworked, additional trucks should be acquired. Standby equipment should be available in the event of emergencies.

In 1964 the American Public Works Association (*2*) conducted a survey of the types of trucks used to collect refuse in over 1,000 major cities in the United States. A more recent tabulation of similar data for fiscal year 1972-1973 has been provided by Mr. E. G. Cleveland of the Environmental Protection Agency as shown in Table 1.

FREQUENCY OF COLLECTIONS

Under optimum summer temperatures, the eggs of flies hatch in 12 to 24 hours, and the three larval stages are completed in 3 to 4 days. In order to prevent fly larvae in garbage cans and bulk containers from migrating out to pupate in the ground nearby, refuse should be collected from premises at regular intervals: twice weekly from residences and daily from businesses, particularly food-handling establishments, hotels, and large apartments. If flies do gain access to garbage, it will be removed and destroyed before a new generation of flies can reach the adult stage. In addition, where garbage collection is infrequent, storage facilities are frequently overloaded and garbage becomes readily accessible to flies and rats.

In some smaller towns where garbage is collected separately, rubbish collection may be furnished only twice a month or monthly, and in some incorporated towns a semiannual "cleanup day" is the only rubbish collection offered by the municipality. When rubbish collection is infrequent and irregular, accumulations of rubbish offer rat harborage and furnish artificial containers for mosquito breeding.

If the community disposal system requires that garbage and rubbish be collected separately, in residential areas, the garbage should be collected at least twice a week during the fly breeding season to hold fly production to a minimum, and rubbish should be collected at least once each week. In business districts all refuse should be collected daily.

When combined refuse collection is practiced, service should be provided at least twice a week during the fly breeding season and once a week in all other seasons. This practice will favor sanitary storage and will contribute to an environment adverse to flies, mosquitoes, and rats.

COLLECTION CREWS

Trained crews, realizing the importance of their work, willing to handle property carefully, and able to meet the householder courteously are an asset to a collection system.

Careless crews can destroy public cooperation by damaging containers so that they are no longer accept-

TABLE 1

TYPES OF VEHICLES USED TO COLLECT REFUSE IN CITIES IN THE UNITED STATES–1972-1973
(Unpublished EPA data (*18*))

Type of Vehicle	Number of Vehicles	
	Public Agencies	Private Sector
Packer Trucks		
Front Loaders	7,000	7,700
Side and Rear Loaders	34,000	34,000
Roll-Off Tractors (For bulk containers)	unknown	6,500
Open Stake-Body Trucks	4,000	7,300
Others (Hoist type, satellite vehicles, container trains)	2,500	6,300

able for refuse storage. Owners can sometimes rightfully blame poorly trained crews for dented rims, bent and smashed lids and cans, lids completely missing, damage to can holders or racks, and spillage near containers. All these results of negligence are conducive to higher pest and vector populations. It is very difficult to induce people to buy new containers when they have experienced such service.

Crews should be well trained. Careful handling of personal property of all types should be emphasized to the crew members. Uniforms provided by some municipalities ensure the neat appearance of collectors at all times. Information concerning the collection department should be furnished to the crews so that they can answer questions asked by householders. Collection personnel represent the local government and should be careful, efficient, and courteous at all times.

Adequate pay and favorable working conditions for collection personnel will aid in recruitment of more responsible individuals, will result in better service, and will reduce absenteeism and turnover of personnel in the department responsible for collection.

One incentive used by numerous cities to attract and retain personnel is the "task system." Under this system each truck and crew has a given route to cover each day, with the number of pickups and the distance covered considered to represent a reasonable day's work. When the route has been covered, the truck and crew return to the garage. If no complaints from the route are outstanding, the crew is free to leave. If there are complaints, such as failure to collect from one or more properties, the citizens must be satisfied; but the men are paid for an 8-hour day whether they have worked 8 hours or not. When properly controlled, this system has some advantages. It discourages loitering and improves the employee's attitude in that he is pleased to be able to "get off" an hour or so early. However, without adequate controls, the system encourages haste, which frequently results in spillage, skips, and careless handling and damage to the containers.

REFUSE PROCESSING AND DISPOSAL

INTRODUCTION

Disposal is normally the final operation in the handling of refuse. Although performed last, in the organization of an integrated refuse handling system, disposal must be planned first since it has an important influence on both storage and collection.

The disposal of refuse is often the most neglected phase of the total handling system. There are many towns where storage and collection are reasonably good but whose disposal is far from sanitary. In the 1968 National Survey of Community Solid Waste Practices, only 6 percent of 12,000 sites investigated could be reasonably called "sanitary landfills." The survey data indicated that the refuse was covered each day at only 14 percent of the landfill sites and that 41 percent had no daily cover at all. Slightly more than 25 percent of the sites had an acceptable appearance. There was some form of open burning at about 75 percent of all the sites investigated (*8*). Most open dumps at the edge of a community are found to be smoky, foul-smelling, rat-infested, fly-breeding centers from which rats and flies migrate into the community. They usually have many small containers that catch and hold water providing a habitat for mosquito development. Hog farms that practice garbage feeding often prove to be malodorous and very productive sources of insects and rodents. Under these circumstances, the best storage and collection practices are nullified to a considerable extent.

Regardless of how diligently the householder or businessman attempts to control flies on his premises, he stands little chance of reducing the fly population of a community to a control level when a nearby dump or insanitary hog farm is a prolific breeding ground. Records indicate that flies may travel in appreciable numbers from 1 to 4 miles from point of origin.

The sanitary landfill is the most satisfactory method for refuse disposal. It is widely used in the United States and will be discussed in detail. Other satisfactory methods for processing, and/or reducing the volume, of refuse include:

1. Incineration
2. Composting
3. Milling
4. Grinding
5. Recycling

When these last five methods are used, some of the by-products, such as incinerator ash, often are placed in a sanitary landfill for final disposal.

Unsatisfactory methods which are gradually being eliminated, often as the result of new laws or regulations, include:

1. The open dump
2. Dumping in water
3. Hog feeding

THE SANITARY LANDFILL

Introduction

The sanitary landfill is an effective, proven method for the permanent disposal of refuse. It has been used in this country since about 1915 and has become the major method of disposal since the late 1930's (*14*).

The sanitary landfill method can be used in any community where sufficient suitable land is available. It is generally suitable for cities of 20,000 to 100,000 population because sufficient land is often available in these areas. Basically, this method of disposal consists of the following four steps:

1. Depositing the refuse in a planned, controlled manner.
2. Spreading and compacting it in thin layers to reduce its volume.
3. Covering the material with a layer of earth.
4. Compacting the earth cover.

Preliminary Considerations

Site Selection. The choice of a disposal site should be governed largely by the proximity to the source of refuse and by such factors as the availability of suitable land, access roads, and bridges. This consideration usually determines whether or not the sanitary landfill method of refuse disposal can be used economically.

1. Land must be available at reasonable cost and in sufficient acreage.
2. It must be located so that hauling distances are not too great. It may be located close to residential areas.
3. Sandy loams are the most desirable soils for landfill cover. Landfills with clay bottoms have minimal problems with leachates, or water that has percolated through the waste and extracted dissolved or suspended material. When suitability of the soil is in question, samples should be collected by borings and analyzed to determine the composition. Locations having solid rock formations close to the surface, or with large boulders, should be avoided.

4. Access roads and bridges must be capable of supporting loaded trucks. Stabilized or hard surface roads are especially important during cold or wet weather operations.
5. Fills must not be located so as to obstruct natural drainage channels.
6. Locations where springs exist should ordinarily be avoided.
7. Sanitary landfills should not be located in areas subject to flooding unless measures are taken to prevent erosion of the fill, such as protective dikes.
8. Care should be taken not to locate landfills in areas where a normal or a raised water table during rainy seasons might result in pollution of public or private water supplies, or where the presence of creviced limestoe might lead to underground pollution.

Land Requirements and Length of Haul. In estimating acreage requirements, the volume of space required depends primarily upon the character and quantity of the solid wastes, the efficiency of compaction of the wastes, the depth of the fill, and the desired life of the landfill. Sorg and Hickman (*48*) have written "using a waste generation rate of 5.3 pounds per person per day, solid waste density of 1,000 pounds per cubic yard, and one part earth cover to four parts waste, a population of 10,000 people would require 15 acre-feet of space per year." This is equivalent to approximately 2.5 acres per 10,000 population based on a 6-foot depth of compacted refuse. However, this has been found to vary depending on local conditions such as methods of operation, ratio of industry to homes and type of refuse that the city collects. A city may often find it desirable to fill in relatively small low areas in various sections of town, moving from one to the other over a period of several years before beginning operations on a larger tract.

The expense involved in acquiring a suitable tract for a landfill operation will vary greatly. Many communities have operated for years by filling otherwise useless land at the request of, or with the permission of, the land owner, at no cost to the city. The land owners were in turn benefited by the increased value of their property. Other communities have had to pay many hundreds of dollars an acre for their landfill sites.

According to studies by the University of California, on California landfill practices (*50*), a round trip of from 15 to 20 miles is apparently the maximum direct haul distance before a centrally located transfer station becomes more economical. The capacity of the collection vehicles in use would be one factor that would help determine the length of haul that would be practicable. For example, a town using 15 cubic yard compactor-type trucks might find a 20-mile round trip excessive, but if the same town used 20 cubic yard vehicles, a round trip of 20 miles might be economically feasible.

Other factors which may influence the feasible length of haul include possible use of transfer stations for refuse, traffic congestion and political problems of metropolitan areas.

Equipment. Equipment needs will be governed largely by the size of the community served and the nature of the site selected for the landfill. In some communities, the selection of equipment will be influenced by secondary considerations such as loading of earth, sand, or gravel on trucks, snow removal, and street maintenance. The following mechanical equipment combinations are available for various types of operations:

1. Tractor crawler with blade, shovel-type attachment, or front-end loader.
2. Dragline and/or tractor crawler combination.
3. Carryall scrapers and earthmovers (for large operations or where earth must be moved a considerable distance).
4. Loading equipment, tractor crawler, and trucks to haul cover material, plus loading equipment at the source of cover material.

Table 2 may be used as a guide to the approximate size of equipment needed for most communities.

For cities with populations greater than 50,000, the number and size of tractor units would be increased proportionally. In larger communities either one large landfill site or several scattered disposal areas will be used. If the first condition exists, larger more powerful equipment would be desirable. If the latter condition exists, several smaller units would probably be utilized.

Personnel. At least two men should be employed at every sanitary landfill. This procedure would make it possible for one man to render aid, or to go for help, if an accident occurred.

On larger operations, it is desirable to employ a supervisor to direct all the activities of the project. He will supervise the unloading of trucks, the excavation of soil, the spreading, compacting, and covering of refuse, and keep the records. He should also be able to operate the tractor in the absence of the regular operator.

At both large and small sanitary landfills the man in charge should be able to conduct, or direct, programs to control flies, rats, and cockroaches which may create problems, particularly in emergency situations.

For efficient operation of any sanitary landfill, a capable equipment operator is essential. If the community employs a city engineer, he may give general supervision to the project. If the community, county, or other agency responsible for the operation of the landfill has no engineer, assistance is usually available from the State or local health, environmental protection, or natural resources agency.

TABLE 2.

AVERAGE EQUIPMENT REQUIREMENTS Adapted from (*48*)

Population	Daily tonnage	No.	Equipment		
			Type	Size in lbs	Accessory*
0 to 15,000	0 to 46	1	Tractor crawler	10,000 to 30,000	Dozer blade Landfill blade Front-end loader (1- to 2-yd)
15,000 to 50,000	46 to 155	1	Tractor crawler	30,000 to 60,000	Dozer blade Landfill blade Front-end loader (2- to 4-yd) Multipurpose bucket
		*	Scraper Dragline Water truck		
50,000 to 100,000	155 to 310	1 to 2	Tractor crawler	30,000 or more	Dozer blade Landfill blade Front-end loader (2- to 5-yd) Multipurpose bucket
		*	Scraper Dragline Water truck		
100,000 or more	310 or more	2 or more	Tractor crawler	45,000 or more	Dozer blade Landfill blade Front-end loader Multipurpose bucket
		*	Scraper Dragline Steel-wheel compactor Road grader Water truck		

*Optional. Dependent on individual need.

OPERATION

The sanitary landfill involves three basic operations of spreading, compacting, and covering. Two main types are well defined: the trench method and the area method. The slope or ramp method is sometimes used, combining features of both the trench and area methods.

In some coastal areas with a high water table, sanitary landfills have been built above ground. This is essentially a modification of the area method, spreading, compacting, and covering one cell above another to build a small hill of the compacted refuse (*14*).

The trench sanitary landfill (Figure 14) is best suited for level ground or rolling terrain where the water table is not near the ground surface. A trench is cut into the ground and the excavated earth is pushed to one end to make a sloping ramp. The width and length of the ramp will depend in part on the nature of the terrain, the volume of refuse delivered daily to the site, and the number of trucks likely to be present for unloading at the same time. The minimum width of the trench and ramp should be approximately twice the width of the blade. This procedure will allow the bulldozer to move from side to side and compact all of the refuse. The slope of the ramp should not be greater than 30°.

The refuse should be deposited at the base of the ramp by the collection vehicles, spread in 12-inch layers on the ramp by the bulldozer, and compacted. This should be done many times each day to obtain best compaction, rather than attempting to spread and compact a large accumulation, many feet in depth, at one time. At the end of the day's operation, the compacted refuse on the ramp is covered with at least 6 inches of compacted earth to form a cell. The following day's refuse will be spread and compacted on the slope formed by the covering over the first day's refuse, and covered by more compacted earth. A windrow of earth built before placement of refuse alone one or both edges of that part of the slope that is above original ground level is frequently desirable. This will lessen the scattering of paper and boxes by the wind, and will help to contain the working area and facilitate covering of the side slopes. Earth placed as cover for each cell should be at least 6 inches in depth after compaction, and the cover at the final level should be 2 feet thick.

The area sanitary landfill (Figure 15) is used in flat land or rolling terrain, often where there is a high water table, and in areas where it is impossible or undesirable to obtain cover material from the base of the slope. A moving slope may be built into the area to be filled, working out from a natural bank or constructed ramp. Here the refuse will necessarily be deposited at the top of the ramp. The slope should be gradual enough to allow the bulldozer to spread and compact the refuse over its entire surface. Frequently a foundation of waste building material or other material is first placed in the low places. On this foundation, the working slope is then advanced to fill the area to the desired level. Earth for cover is obtained from nearby elevations or is brought in by truck. In some situations, cover is obtained from in front of the working slope by use of a dragline. Thus, a low area is raised as shown in Figure 15.

In Valleys and Ravines. Valleys and ravines are frequently chosen as landfill sites. When these are of considerable depth, they should be filled in layers with each layer beginning at the highest end of the raveine so that the natural drainage will not be obstructed. In some ravines, large drainage pipes may be installed to carry off excess water before the landfill is built. In others, surface diversion ditches are built, particularly near the junction of the slope and the newly constructed landfill. Earth cover for the first layer, as it moves through the length of the ravine, may often be obtained from ahead of the base of the advancing slope. However, cover for subsequent layers or "lifts" will usually be obtained from the sides of the ravine (Figure 16).

Under some circumstances it may not be desirable to extend the first layer of cells through the whole length

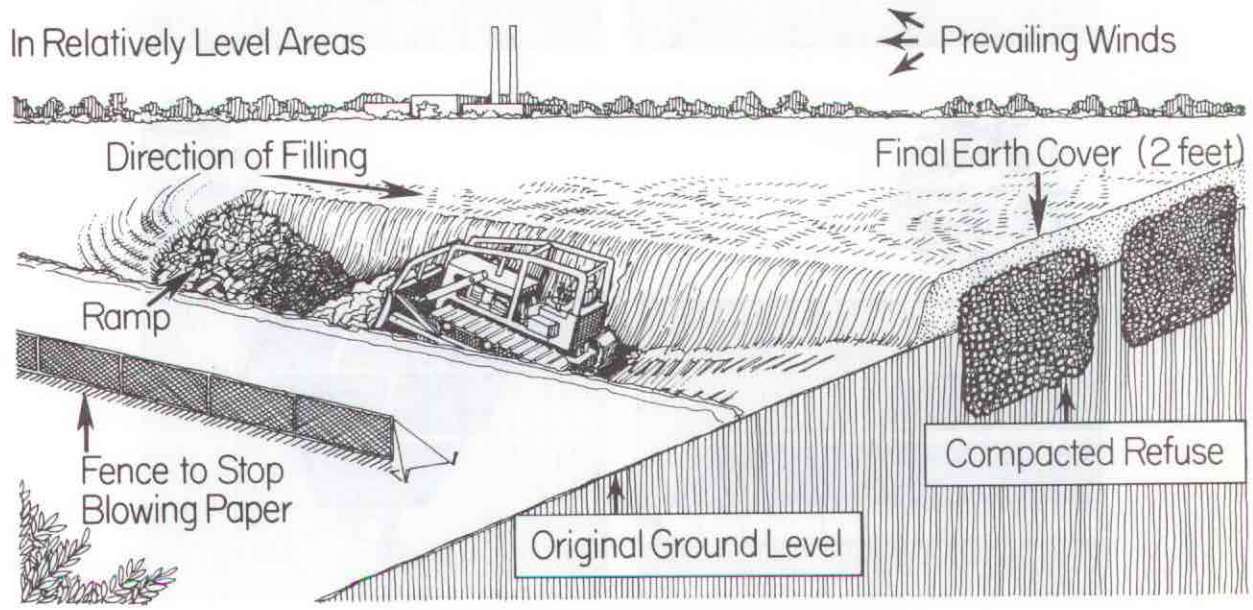


Figure 14. The Trench Sanitary Landfill

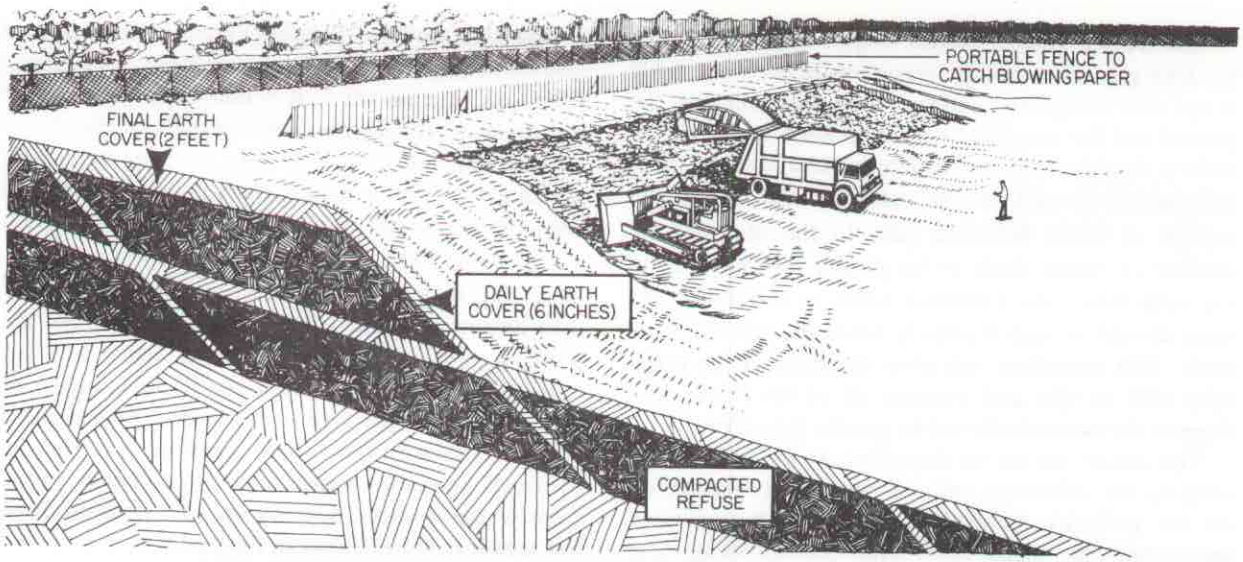


Figure 15. The Area Sanitary Landfill

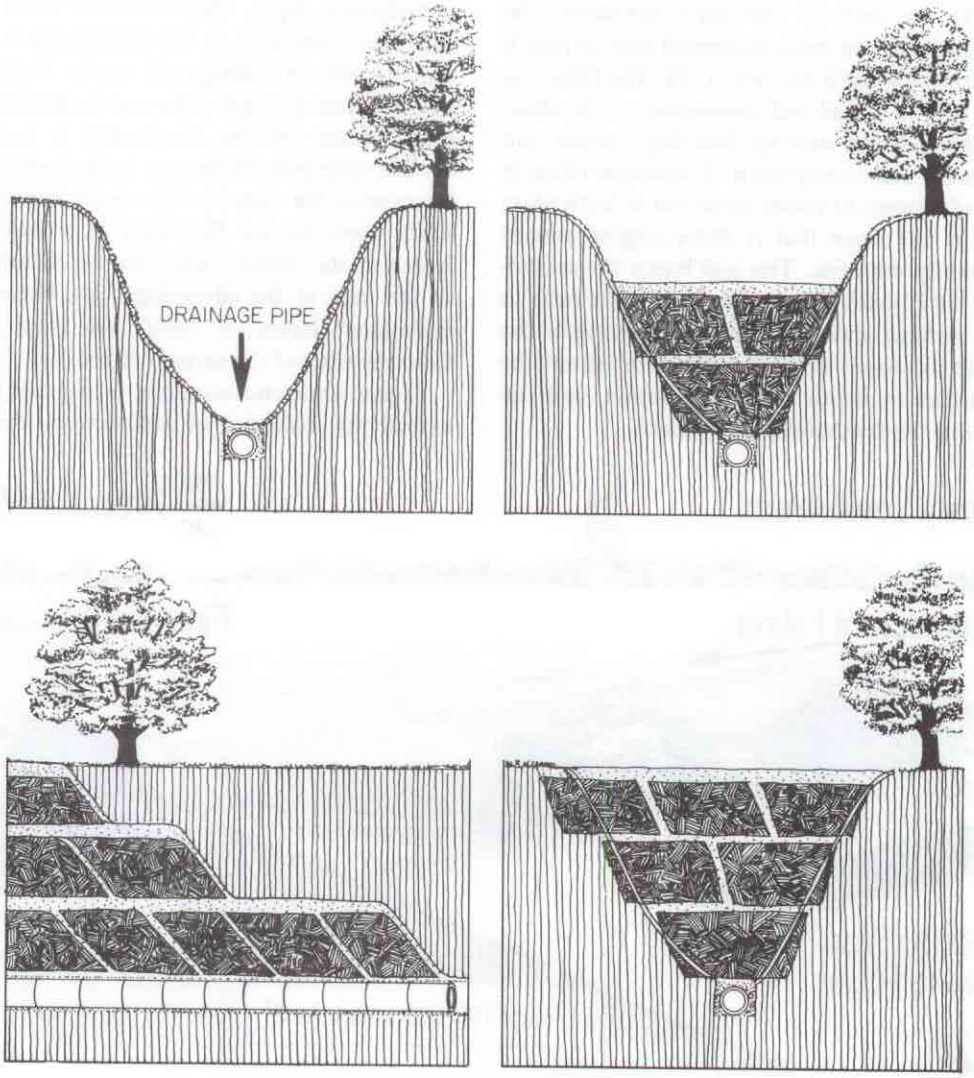


Figure 16. Sanitary Landfill in Valleys and Ravines

of the ravine before construction of the upper layers is begun. In this event, the first layer of cells may be constructed only a relatively short distance from the upper end of the ravine. In longitudinal section this would give the appearance of a series of steps when the top layers are completed. This procedure would permit a portion of the cover for the upper layers to be obtained, if necessary, from the bottom of the ravine ahead of the face of the first layer; then brought up the ramps of the other layers to the operating level. When the upper layers have been completed, the bottom layer can be extended a short distance, and successive layers built over it in the same manner. One advantage of this method of operation in ravines is the reduction in the amount of layered surface area exposed to erosion.

Regardless of the manner of filling ravines, the depth of each layer of cells should usually be limited to 6 to 8 feet and maximum compaction of refuse and cover should be obtained.

Winter and Inclement Weather Operations. Winter months do not prohibit successful sanitary landfill operation. Landfills have been operated successfully in an area where temperatures as low as 44° F. below zero are encountered and with winds as high as 30 m.p.h. The necessary trenches should be dug well in advance of extreme cold weather and cover material stockpiled for use at that time. In some soils it may not be necessary to excavate in advance; and even though very low temperatures prevail, excavation for cover may be accomplished on a day-to-day basis.

In sections of the country where winter temperatures are not severe, the bulk of the annual rainfall may come during this season. Areas near the stabilized entrance roadway should be reserved for operations during this or any other wet season or for short wet periods during normally dry seasons. If trenches are dug in advance to meet this possibility, adequate drainage should be provided. When the weather is favorable, operations may be carried on in areas somewhat remote from the entrance road or the stabilized roads through the disposal tract. A standby supply of cinders, shell, or gravel should always be present for use in emergency situations. Loads of street sweepings, ashes, etc., delivered to the fill should be saved for this purpose also.

Recommended Operating Practices

1. A sanitary landfill should be an engineered project and its operation and maintenance should be performed by a trained person. Local health and/or environmental agencies should have the authority to assure, by working through proper channels, that operations meet public health requirements at all times.

2. The persons responsible for operations should determine local sources of equipment for short term use in the event of breakdown or major overhaul.

3. The face of the working fill should be kept as narrow as is consistent with proper operation of trucks and equipment so that the area of waste material exposed during the operation day will be minimal. The refuse should receive as much compaction as possible. This will facilitate the application of a solid, even layer of earth cover and minimize settlement.

4. The exposed refuse should be covered with earth as promptly as is consistent with proper operation, but certainly by the close of each day's operation, so that each day's deposit makes a closed cell. Each day at least six inches of earth cover should be thoroughly compacted to prevent newly emerged flies from working their way from the compacted refuse through to the surface (*7*).

5. The final covering for the surface and side slopes should be maintained with a minimum depth of 24 inches of compacted earth.

6. The final level of the fill should provide a 0.5 to 1 percent slope to allow for adequate drainage. Much steeper slopes should be avoided as they are subject to greater erosion. In case the finished fill has a boundary and/or side slope, it should be as gradual as possible to prevent erosion. These slopes should be seeded promptly and covered with straw to minimize erosion until vegetation becomes established.

7. If water under pressure is available, the roadways may be watered when necessary to allay dust.

8. As a rule, each layer of refuse should not exceed an average depth of about 6 to 8 feet after compacting. Where successive "lifts" are necessary, special attention should be given to obtaining good compaction so that subsequent layers may be constructed almost immediately with a minimum of settlement.

9. Control of wind-blown paper should be adequately maintained. This can be accomplished by the use of movable fencing such as snow fencing or portable chicken-wire fences, and also by careful location of the fill in favorable terrain.

10. Inspection for and control of insects and rodents should be carried on until fills are stabilized. All collections of surface water resulting from landfill operations should be drained, filled, or treated with effective chemicals so as to prevent mosquito production and allay disagreeable odors. Treatment with chemicals should be a temporary measure only, and efforts should be made to regrade the fill or take other permanent corrective measures as soon as possible.

11. After operations are completed, a maintenance program should continue until the fill has become stabilized. This should include prompt repair of cracks, depressions and erosion of the surface and side slopes. Seeding of finished surface as soon as possible is highly desirable, for a good stand of grass will decrease erosion, improve appearance, and decrease surface cracking.

12. A separate area or trench may be provided for the disposal of such objects as tree stumps and large limbs, mattresses and bed springs.

13. A separate trench or pit may be desirable for the disposal of dead small animals, truck loads of spoiled foods, dead chickens, entrails, eggs, and large quantities of other putrescible materials, which should be covered immediately.

14. Generally the rate of decomposition of refuse in a landfill precludes re-use of the same location for many years. In some areas little decomposition of materials has been observed even for a period of 10-15 years. Moisture content in the fill area and local temperatures appear important in the rate of decomposition.

15. A bulk container, or containers, provided near the entrance for decomposition of refuse brought by the public at times when the facility is closed, contributes to a more attractive entrance and minimizes labor requirements for clean-up of this area.

ACCESSORY FACILTIES

In addition to equipment and personnel, certain facilities are needed, or are usually found desirable, at a sanitary landfill site. They include the following:

1. Shed or other shelter for equipment and personnel
2. Rest room facilities
3. Signs directing trucks
4. Portable or semi-portable fencing
5. Scales for weighing trucks (optional)
6. Power sprayer for insecticide application
7. Rat control equipment, particularly permanent bait stations with anticoagulant rodenticides
8. Portable pump for removing accumulations of surface water
9. Fire extinguishers and fire hydrant
10. Telephone or 2-way radio
11. Electricity

ADVANTAGES AND BENEFITS OF SANITARY LANDFILLS

1. The sanitary landfill is the most economical disposal system acceptable to environmental and health authorities, usually operating at considerably less than the cost of incineration.

2. The initial investment is low compared to that for other approved methods.

3. The landfill system is flexible; it can accommodate increases in population.

4. It may result in lower collection costs, since it permits combined collection of garbage and rubbish.

5. All types of refuse may be disposed of in the sanitary landfill.

6. The disposal site may be located close to or in populated areas, thus reducing the length of haul and the cost of collection.

7. Submarginal land can be reclaimed for future use, thereby benefiting the community. Completed landfills have been used for airports, parking lots, parks, playgrounds, and other recreational purposes.

8. Completed landfill areas may also be used for agricultural purposes.

9. The installation of any facility on reclaimed land should avoid, if possible, trenching into buried refuse. Should an area be used for recreation, buildings requiring footings should be constructed just off the fill area. However, with proper engineering considerations, even heavy buildings may be constructed on completed fills.

10. Unsightliness, health hazards, and nuisances of open dumps are eliminated.

11. Sanitary landfills can be established quickly.

12. The sanitary landfill is a complete or final disposal method as compared to incineration and composting which require additional treatment or disposal operations for residue, quenching water, unusable materials, etc.

Disadvantages of Sanitary Landfills

1. Suitable land at reasonable cost within economical hauling distance may not be readily available.

2. Proper sanitary landfill standards must be adhered to daily or the operation may become an open dump.

3. Improper construction may permit surface cracking and uneven settling, resulting in difficulty for trucks traveling on the surface in bad weather and giving an untidy appearance.

4. A landfill may settle from 10 to 25 percent depending on the degree of compaction, during the first 2 years, thereby requiring regrading and maintenance.

5. Fills generally present some difficulties for subsequent heavy construction.

6. If not properly located, seepage from fills (leachate) may increase stream pollution or contaminate ground water but may not show up for some time. This pollution should not be permitted to occur (*27*).

7. Excavation in old fill areas may be objectionable because of obnoxious odors.

8. Problems in constructing buildings on former landfills are created, since methane, an explosive gas, is generated as decomposition proceeds.

9. Relatively large areas of land are required.

10. An adequate supply of good earth cover may not be readily accesible.

11. The idea of the sanitary landfill often is difficult to sell because people think a sanitary landfill and a dump are synonymous.

INCINERATION

Incineration provides another method of reducing the volume of refuse. For many years incinerators played a key role in reducing the volume of refuse, particularly in the larger cities. However, many of the incinerators were built without satisfactory pollution control equipment and were operated with inadequate staff and finances. As a result, at many plants, there have been problems of smoke, odor, impure air, and fly ash. The use of incinerators to process solid waste came, and still is, under great pressure from environmentalists and citizens' groups throughout the United States. Therefore, in many communities, incineration of any type was banished regardless of performance level (*31*).

On the other hand, with the continuing energy crisis, there is increasing concern that the millions of tons of solid waste be converted into energy as steam to heat or air condition buildings, generate electricity, or operate industries. The land needed for sanitary landfill is decreasing rapidly. The increasing cost of coal, oil, and gas makes the use of solid waste as fuel increasingly desirable. Therefore, much research has been devoted to the use of incinerators to dispose of solid waste and produce energy.

Municipal refuse is composed primarily of combustible organic matter such as garbage and rubbish (paper, plastics, wood, and yard trimmings). Garbage frequently contains a high percentage of moisture; rubbish has the lower moisture content. It is this rubbish content that makes incineration practical by providing free fuel to reduce the refuse to a sanitary, easily handled, nuisance-free residue. If this energy value is recovered, sufficient electricity could be produced to light many of the homes and businesses throughout the nation, with significant savings in oil, gas, and coal.

A "new generation" of incinerators has been designed and built which overcome the problem of smoke, odor, impure air, and fly ash through the use of air pollution control facilities. These newer incineration plants are architecturally pleasing, will handle mixed refuse containing both garbage and rubbish, and can be maintained in a clean and sanitary condition. Some incinerators use solid waste as the primary fuel. Others use a mixture of pulverized solid waste and coal. In still others, the furnaces have been designed to use solid waste as the usual and primary fuel, but have oil or gas as standby fuels.

Advantages and Benefits of Incineration:

1. Incinerators may be located close to, or in the center of, refuse production areas, thereby minimizing haul distances.
2. Incinerators reduce the volume of refuse at the same site year after year, if the residue can be disposed of either at a sanitary landfill, or by the sale of the salvageable portion such as scrap metal.
3. Modern incinerators eliminate the need to collect garbage and rubbish separately, thus reducing collection costs.
4. Incinerators may be designed with capacities large enough for future population increases or may be built so as to facilitate subsequent enlargement of plant capacity.
5. The energy recovered can be utilized to produce steam for generating electricity or for steam heating. This may be an important item in the future "energy crisis."
6. Incineration considerably reduces the volume of material for ultimate disposal. The residue may be used for filling, for local road construction, or for manufacturing building blocks. The scrap metal may be recycled and sold at a profit.
7. Some plants may realize enough income from the sale of steam and scrap metal to pay operation costs of the processing plant, but not collection costs.

Disadvantages of Incineration:

1. High initial investment in the land (because it is centrally located) and in the incinerator plant
2. High salaries for some of the plant personnel
3. Maintenance costs for the large complicated plant, greater than for equipment used at most sanitary landfills
4. At improperly operated incinerators, problems of air, water, and environmental pollution

COMPOSTING

Composting is a biological method for converting municipal, agricultural, and industrial wastes into a usable humus-like material. Economically, composting does not compete with either the sanitary landfill or incineration as a method of solid waste disposal. However, composting is the only solid waste disposal process that salvages the organic fraction without significant pollution of land or water. Furthermore, if the costs and restrictions for the landfill or incineration methods of refuse disposal continue to increase, and if communities have problems obtaining sufficient new land for landfills, composting may be a partial answer to municipal solid waste disposal in the future (*11, 38*).

At pilot research projects the solid waste is subjected to preliminary sorting to remove bulky and salvageable items such as wood, tires, and glass. Ferrous metals are removed by magnetic separators. Then, at many projects, the refuse is ground to reduce particle size for better handling, digestion, and mixing of the materials.

Raw or digested sewage sludge, or animal manure, or cannery wastes, may be added in liquid form to provide moisture, often 45 to 60 percent moisture by weight. Digestion or decomposition is carried out either in windrows or enclosures, usually by an aerobic process involving mechanical turning to expose the material to oxygen. The aerobic process is generally considered to be faster and better than the anaerobic method, often used in Europe. The aerobic process generates temperatures of approximately 160°F. This heat accelerates fermentation, reduces dangers from pathogenic organisms, kills fly eggs and larvae, and makes the mass unattractive to vermin. Control of moisture content, oxygen, pH, and temperature is important to the efficiency of the process. Screening, grinding, or a combination of similar processes is then carried out to remove plastic, glass, and other undesirable materials. The final compost cannot be considered a fertilizer. Its nitrogen and phosphorus content is too low. However, because of its high organic content, it may be considered as a soil conditioner, which may provide poor soils with better tilth, water-holding capacity, a source of trace elements, and improved nutrient-holding capacity. A number of composting projects have been started on a commercial scale, but, for numerous reasons, most have been discontinued (*11*).

MILLING

Garbage, tin cans, bottles, cardboard, and small plastic containers (residential and light commercial refuse) are milled, or "shredded," or "pulverized" by special milling equipment. The milled refuse is placed in the landfill site **without daily cover**. Amazingly the milled refuse apparently is not acceptable food for rats and does not produce offensive odors or large numbers of flies under normal operating conditions. In their final report on the Madison milling project, Reinhardt and Ham (*43*) reported that "there are several mechanisms which would lead to reduced fly populations at landfills with milled refuse without cover. First, the milling process destroys the great majority of maggots. Second, freshly milled refuse can support the fly cycle only under optimal environmental conditions that are not normally found in a landfill. Finally, when refuse has aged for several months, even this ability under optimal conditions is destroyed." If flies or birds such as starlings or seagulls become problems at disposal sites with uncovered milled refuse, the addition of at least 6 inches of compacted earth at the end of each day's work, as at properly operated sanitary landfills, should solve these difficulties. When milling is the method of processing refuse, great care must be taken to prevent leachate problems and ground water pollution.

GRINDING

An excellent method of garbage disposal for homes, restaurants, and some other businesses is by grinding and discharging it into a sanitary sewer. In some communities there are regulations requiring that all new homes must have garbage grinders. A few cities have used strategically located central grinding stations for disposal of this type of waste, flushing the ground material into the city sewer or directly into the sewage treatment plant. However, this method of disposal does not eliminate the need for adequate premises storage of cans and bottles (which may have bits of food for insects and rodents) and rubbish and their frequent collection.

Under certain conditions, disposal of garbage through the sewage treatment plant may be advantageous to its operation by increasing gas production. However, garbage grinding, either at homes on a large scale or at a central grinding station, requires that certain of the sewage treatment plant facilities (e.g., digestion and drying) be of greater capacity than would ordinarily be required. When garbage from the home grinder is conveyed to a private sewage system, the capacity of the septic tank needs to be increased by about 50 percent.

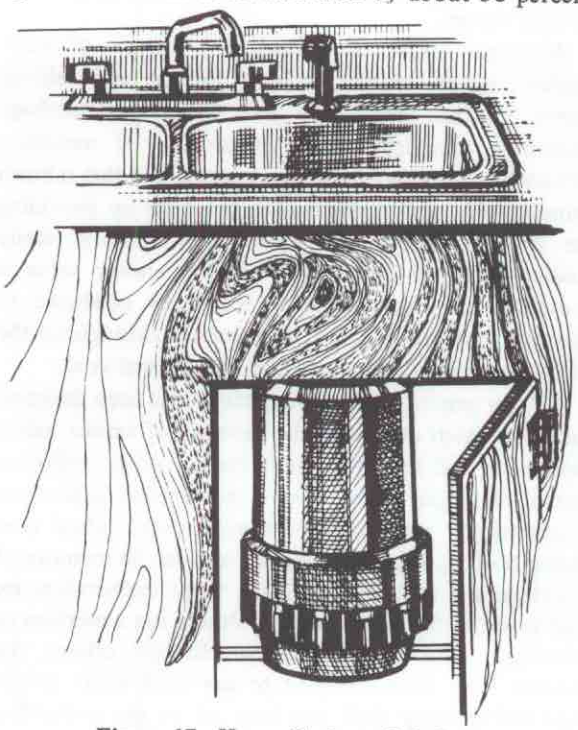


Figure 17. Home Garbage Grinder

RECYCLING

Recycling and reclamation of usable materials (sometimes called salvaging) have received much attention in recent years. Many cities segregate a number of items before refuse collection: newspapers, magazines, cardboard, scrap iron and aluminum, glass, rags, used tires,

and old automobiles. In Atlanta, Georgia, large bulk containers have been placed strategically throughout the city for the collection of newspapers which are baled and sold at a profit. Many civic and private organizations are involved in the collection and sale of newspapers, magazines, cardboard, glass, scrap iron and aluminum, and rubber. Huge new machines have been built which can shred and compress old automobiles into scrap iron which is sold for a profit. Along the seacoast, boatloads of old tires have been dumped into the ocean to form artificial reefs which serve as hiding and breeding places for fish. At incineration plants, the residue is subjected to screening and electromagnetic sorting to segregate the scrap iron from aluminum, both of which are sold at a profit.

THE OPEN DUMP

Despite great progress in solid waste management in recent years, the open dump is still one of the principal methods of refuse disposal in the United States. The open dump is an eyesore and blight upon a community. It offends the aesthetic sense and gives off objectionable smoke and odor. It is also a very important breeding place for rats and flies and may produce hordes of mosquitoes. These vermin are capable of carrying organisms that cause disease to man and constitute a serious nuisance to residents of nearby areas.

The National Survey of Community Solid Waste Practices made in 1968, revealed that 14,000 communities relied for their solid waste disposal on open dumps. Many of these were, by design or accident, open burning dumps. Therefore, in 1970 the Environmental Protection Agency started Mission 5000 with the objective of eliminating 5000 open dumps (*25*). This project has had the backing of citizens' groups and many governmental agencies at the local, state, and federal level. When dumps are closed, frequently there are problems of rats migrating to the surrounding neighborhood in search of food. Procedures to be followed in closing open dumps have been described in detail (*13*), particularly the poisoning of rats to prevent their movement into nearby areas as they forage for food (*6*).

DUMPING IN WATER

This method has had considerable use in the past, especially in coastal cities. As recently as 1972 Ruckelshaus (*44*) wrote "Our evidence indicates that coastal communities annually have barged close to 50 million tons of solid wastes and sludges out to sea, and seldom in treated form." Dumping at sea resulted in the littering of the shore lines with garbage and rubbish and was vigorously opposed by resort cities, both as a health and accident hazard and as a deterrent to the tourist trade. Some of the towns and cities located inland along streams and rivers have often established open dumps along the shores. This method contributes to the pollution of the streams with liquids leached from the site or with solid refuse washed downstream by flooding. Ruckelshaus (*44*) wrote "we know . . . of seven large open dumps that have been closed under EPA's Harbors and Refuse Act and existing evidence would indicate that this trend will increase in areas where dumps are located adjacent to rivers and waterways."

HOG FEEDING

For centuries the feeding of garbage to hogs has been one of the traditional methods of disposal. Frequently garbage contracts with hog farmers were a source of considerable revenue for municipalities. The feeding of garbage, particularly of uncooked pork scraps, is of greatest importance in the transmission of trichinosis (or trichiniasis) among swine. Similarly, the eating of uncooked, or incompletely cooked, pork or pork products is the single, most important factor involved in human cases of trichonosis caused by the helminth *Trichinella spiralis*.

In 1947 Stoll estimated that 20 million people in the United States were infected with trichinae, three times as many as in the rest of the world (*49*). A recent study (*52*) indicates a remarkable decline in the incidence of trichinosis in this country. In a National Institute of Health survey (1936–1941) it was estimated that 12 percent of the population (15,900,000 persons) was infected with trichinae, whereas a Veterinary Medical Research Institute study (1966–1970) estimated that 2.2 percent (4,400,000 individuals) had detectable trichinae. Data from autopsies indicated a decline from 16.1 percent in 1936–1941 to 4.2 percent in 1966–1970, a reduction approaching 75 percent. Stated differently, this reduction was from about one in every six persons in 1936–1941 to approximately one in every 25 individuals in 1966–1970. This study estimated that as many as 1 to 2 million persons became infected with trichinae in 1940, whereas in 1970 only 150,000 to 300,000 people acquired these infections (*52*). In 1973 124 cases of trichinosis were reported in the United States (*17*).

In 1952, widespread outbreaks of vesicular exanthema, a serious virus disease of hogs, occurred in the United States, largely through the feeding on uncooked garbage. In the 1960's there were epidemics of hog cholera. These two diseases lead to the enactment and enforcement of garbage treatment regulations in most states. As a result, "There has been a 60 percent reduction in the number of swine fed commercial garbage since 1955, including a 92 percent reduction in

the number of swine fed raw garbage." The prevalence of trichinosis decreased from nearly 1 percent in farm-raised swine in the 1930's and 11 percent in garbage-fed swine during 1950, to 0.125 percent in farm-raised swine and 0.5 percent in garbage-fed swine in 1970 (*52*).

These laws require the heating of garbage to a temperature of 212°F for a period of 30 minutes. Well designed equipment should be used for cooking the garbage, since some equipment, especially "home made" and improvised devices, do not always distribute heat equally throughout the mass. This results in "dead spots" which may remain below 212° for some time after other portions of the garbage have reached the required temperature. Heat treatment, when carried out properly for the control of the virus of vesicular exanthema, will also kill trichinae encysted in the tissues of pork scraps, as well as any fly eggs, larvae, or pupae that may be present.

Hog farms where garbage feeding is practiced, are often in such an insanitary condition as to allow much fly and rat breeding and some mosquito breeding. The odor originating from the typical insanitary hog farm is a decided nuisance to adjoining properties.

In order to control fly and rat breeding and, to a certain extent, the odor nuisance, several additional measures need to be taken. First, all feeding should be carried out on platforms constructed of acid-resistant concrete, brick with asphalt filler, or other impervious, easily washable materials. These platforms should be equipped with splash curbs and drains. All uneaten garbage, together with hog excrement on the platforms and in the pen area, should be removed after each feeding and disposed of by burying, incineration, or composting. The feeding platforms should be washed with water under pressure after removal of the uneaten residue and the liquid conveyed by drains to a septic tank, tile-field disposal system, a leaching pit, a sanitary sewer, or a sewage lagoon. When done thoroughly, dry cleaning of feeding platforms may be satisfactory. Inedible objects that may be contained in the gargabe, such as cans, bottles, and crockery, should be disposed of in a manner that will not provide rat harborage or permit mosquito breeding.

All material offering rat harborage should be removed or stored in an orderly manner on racks at least 12 inches off the floor or ground. Grains and feed should be stored in ratproof bins.

REFUSE HANDLING IN SMALL COMMUNITIES AND IN RURAL AREAS

REFUSE HANDLING IN SMALL COMMUNITIES

Many small towns and the fringe residential areas of the larger cities have no organized refuse collection service. Usually the service is available on an individual basis from private contractors, but coverage is incomplete and disposal frequently is uncontrolled. The conditions that result are conducive to insect and rodent production.

Premises storage is often below average because of inadequate facilities and poor maintenance. Frequently there is no community organization to promote good refuse storage. Occasionally, the schedules of collectors are unreliable, with the result that storage facilities become overloaded. Consequently, fly breeding material and rat food and harborage are likely to be available in greater amounts than in towns and areas where local control of storage and collection is exercised, or in areas where populations are less concentrated.

Disposal is an especially troublesome problem in small towns and fringe areas. Persons not subscribing to private collection service dispose of their own refuse. Frequently the refuse is dumped along some back road, or even along a major highway, within flight range of the community for the flies that it will breed and within migration range for the rats which may become established. This litter provokes an adverse aesthetic response from travelers and responsible citizens.

The solution to this problem in small communities probably lies in activating public interest to promote better refuse handling, and in governmental regulation, if not actual participation.

A good example of how the problem may be satisfactorily solved is illustrated in highly populated fringe areas of a large eastern city. Here collection service is provided by the local sanitary commission, which also provides water and sewerage facilities. Adequate disposal is accomplished at one incinerator and several sanitary landfills. Some small adjacent sections in this area have private collection service, but the collectors are required to haul the refuse to approved disposal sites. Incorporated towns in the area that have their own collection service deliver their refuse to the sanitary commission's disposal facility that is nearest them and are billed monthly. Another adjoining county with few incorporated towns but numerous highly populated areas has refuse collection service provided by the county commissioners under contract. The contracts are contingent on the county health officer's approval of collection equipment and disposal method. Some counties have operated sanitary landfill disposal areas using equipment and personnel of the county highway department.

Numerous small towns have refuse collection service provided by a local contractor who serves on a part-time basis and uses his vehicle for other activities on noncollection days. The refuse is hauled to the nearest approved disposal site, where it may be deposited for a small fee, or for no fee at all. Some smaller towns may operate their own sanitary landfills. For their use, medium-weight equipment which is capable of carrying out all phases of landfill operation in a satisfactory manner is available at a cost that is not prohibitive. Good used equipment has frequently solved a small town's problem.

Two or more small communities have worked together with one collection and one disposal system for all areas involved. In some cases, relatively long-term contracts to serve several towns justify the contractor's purchasing compactor-type collection equipment. The towns may locate a landfill site approximately equidistant between them and share the expense of acquisition and operation in proportion to the population served.

REFUSE HANDLING IN RURAL AREAS

The collection methods used in urban areas have little applicability to rural areas because of the smaller populations involved and the greater distances between stops. In rural areas five techniques have been used for solid waste management:

1. Disposal of refuse by residents on their own property. In many rural areas residents haul their refuse to a remote part of their property and dump it. Sometimes they burn it; at other times they may bury it. Whatever method, this procedure is conducive to fly and rodent production, to open dumps, to littering along roadsides, and to air pollution.
2. Hauling of refuse by residents to landfills. Many rural residents haul their own refuse to a central sanitary landfill. However, the distance, the time, and the money (particularly for gasoline) discourage many people from this system. Roadside littering often results if there is traffic at the disposal site, or the entrance to the landfill is locked on a weekend.

3. Bulk container system. A bulk container system, sometimes called the "Green Box System" because the bulk containers were painted green, was instituted in Chilton County, Alabama, in 1968. It has served as a model in many other states (*9*). The bulk containers are located strategically along roads easily traversed by a collection vehicle. Each resident is required to transport his own waste to the bulk containers. Then, the collected wastes are collected by bulk bin collection vehicles and transported to a central sanitary landfill.
4. Small rural transfer station. In some areas of the South, as in northern Georgia, bulk containers on wheels are placed beside a ramp. The residents dump their refuse from this ramp into the bulk container, which, when full, is towed to a central sanitary landfill. Another empty bulk container on wheels is towed in as a replacement.
5. Mailbox system. In Alabama and other parts of the South, a house-to-house system (called the mailbox system) has worked very well. The system is based on the premise that a collection vehicle can travel by the same roads used by the rural mailman. On designated days and by specific times, each rural householder brings his refuse out to the mailbox where it is picked up by the collection vehicle and transported to a central sanitary landfill.

OTHER SANITATION FACTORS IN THE CONTROL OF INSECTS AND RODENTS

STORED PRODUCTS

One of the most important problems in commercial areas is rodent and insect infestation in warehouses and storerooms. Enormous quantities of food for human and animal consumption must be protected from this hazard. To do so is a tremendous task, but a number of sanitation techniques have been developed to help control infestations.

The use of wooden pallets which elevate the boxed or sacked materials 6 to 8 inches off the floor is a highly recommended sanitation technique. Their use also increases the speed and ease with which stored products can be handled with mechanical fork-lift trucks. In some storerooms, permanent racks 18 inches off the floor elevate stored food products. The open space beneath, if kept clean, discourages rat movement and allows for necessary periodic inspections. The stored materials should be stacked compactly, unless this creates a fire hazard, thus minimizing voids and reducing rat and mouse harborage. Material stored in warehouses and storerooms should not be stacked all the way to the ceiling. Instead, a space of at least 2 feet should be left to allow for adequate ventilation.

Aisles at least 2 feet wide should be provided along all walls, through the center of the warehouse, and elsewhere as necessary. A white band 6 inches wide, as in Figure 18, will serve as a reminder not to stack materials along the wall and will facilitate cleaning and inspection. Dead insects and mouse and rat droppings are easily seen against a white background. If control measures become necessary, the method of stacking described here makes the operation less difficult and, in addition, makes the inventory of stocks easier.

Rotation of stored products is a practice that is most helpful in both insect and rodent control. The materials that have been in the warehouse the greatest period of time are shipped out first. This frequently does not allow sufficient time for them to become infested with stored product insects or for these insects to spread from older products to newly arrived materials. Moreover, new rodent infestations may be discovered earlier if rotation is practiced.

Spillage that results from damage to sacks and containers can accumulate in corners and along walls of warehouses. This provides easily accessible material for stored product insects, food for rats, and if it becomes moist, a breeding place for flies, beetles, and mites. Such spillage should be removed promptly. If the method of storage just described has been followed, cleanup will be much easier.

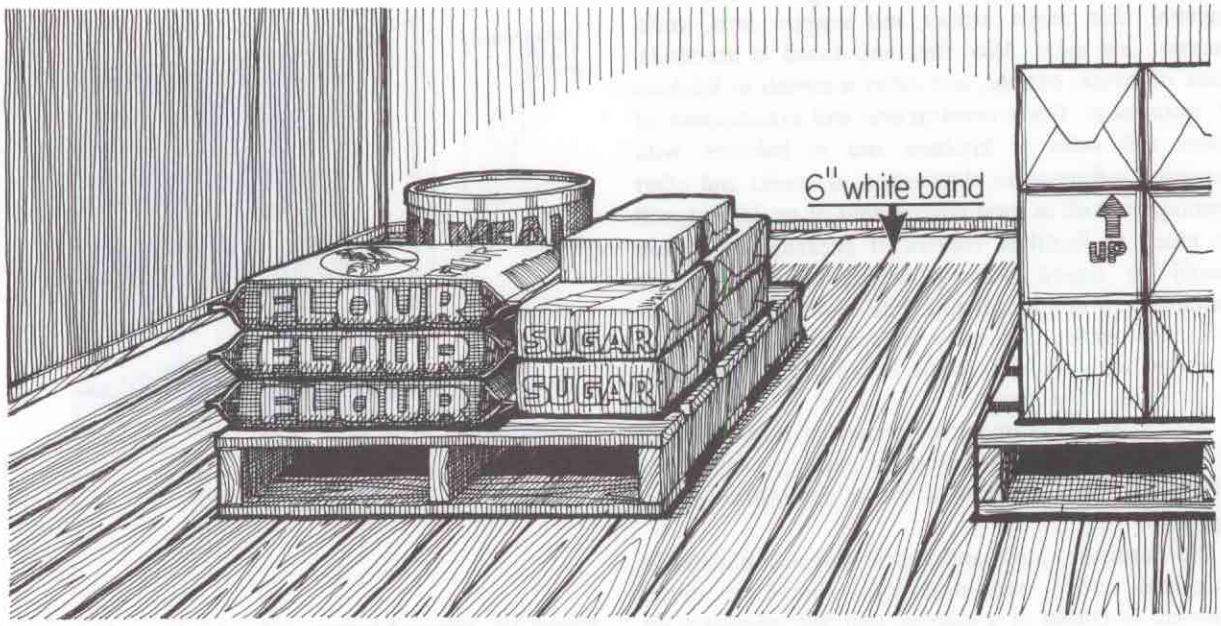


Figure 18. Proper Warehousing with Food on Pallets and Aisles for Easy Access and Ventilation

Warehouses and storerooms for food products should be of ratproof construction. Inside structural features that provide harborage for rats, such as enclosed areas under stairs and under shelving, should be eliminated. Cracks in floors where insects may hide and where spilled materials would accumulate should be filled and sealed.

Food products that become contaminated by rodent feces or urine or damaged by gnawing should be destroyed or reprocessed for animal feed.

Although the measures described here may be supplemented by judicious use of insecticides, rodenticides, and fumigants, the sanitation principles set forth are basic for rat and insect control in storage areas. Maintaining warehouses and storerooms in a rat-free condition protects the public by preventing rodent contamination of foodstuffs and at the same time safeguards employees against on-the-job exposure to rodent-borne diseases.

HOUSEHOLD AND PREMISES SANITATION AND MAINTENANCE

Interior Premises Sanitation and Maintenance. The extent of rodent and insect infestation in and around homes and businesses may vary from only an occasional mouse, fly, or mosquito to heavy populations of rats, mice, cockroaches, flies, mosquitoes, and other vermin.

Once disinfestation has been achieved, interior sanitation and building maintenance will materially reduce the possibility of reinfestation. The housewife or restaurant operator must be regular in the practice of good housekeeping. Kitchen and dining areas should be cleaned daily to remove all crumbs, grease, and other material that might attract and support ants, cockroaches, and mice. Also, flies may breed in accumulations of grease, crumbs, and other materials in kitchens of restaurants. Good construction and maintenance of floors and walls in kitchens and in bakeries, with particular reference to elimination of cracks and other openings, as well as good arrangement of equipment, will do much to facilitate control of cockroaches. Refuse should be stored only in sound metal or plastic containers with tight-fitting lids, and the containers should be cleaned frequently. In homes, the metal refuse container with the self-closing lid and inner removable can provides good storage.

All foodstuffs normally purchased in bulk or boxes should be stored in metal or glass containers with tight fitting lids, especially where rodent infestation exists, Figure 19.

Old furniture, junk, and debris that accumulates in basements, attics, and storerooms should be either removed or stored in a manner that will eliminate rat harborage.

Concrete-floored basements that occasionally become flooded may provide a breeding place for pest or disease-carrying mosquitoes. When flooding occurs, the water should be removed as soon as possible. If drains are present in basements, they should be kept cleaned out to prevent clogging and accumulation of water. In basements where drains are not provided, sump pumps are sometimes used. However, the small pits in which they are located will breed mosquitoes and should therefore be screened or treated regularly with chemicals. Adequate screening of basement windows and other windows in use might make screening or treatment of sump pits unnecessary. Occasionally, cisterns will be present. They are usually located in basements or under back porches. The tops and all inlets to these cisterns should be screened to prevent mosquito breeding.

Householders growing plants in water inside the house or on porches are frequently guilty of "raising mosquitoes." When plants are grown in this way, water in the containers should be changed about every five days to prevent mosquito production. However, many of these plants will grow as well or better if the water is replaced with earth.

Exterior Premises Sanitation and Maintenance. This includes sanitary refuse storage and the storage of building materials and other objects on racks 18 inches off the ground to prevent rat harborage, Figures 21 and 22. Uneaten dog or cat food should be removed shortly after the pet has finished its meal. If such foodstuff is allowed to remain, it will provide food for flies and rats and a breeding place for flies. Animal shelters should be kept clean, as accumulated droppings will provide a breeding medium for flies and fleas. Dogs should be

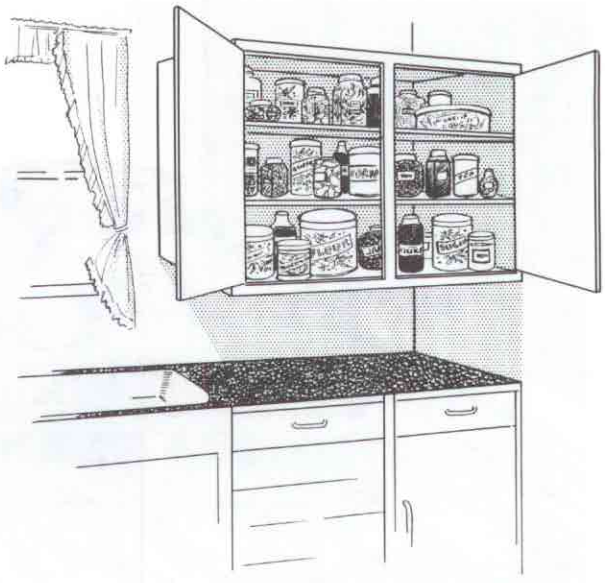


Figure 19. Proper Storage of Foodstuffs in Tight Metal and Glass Containers

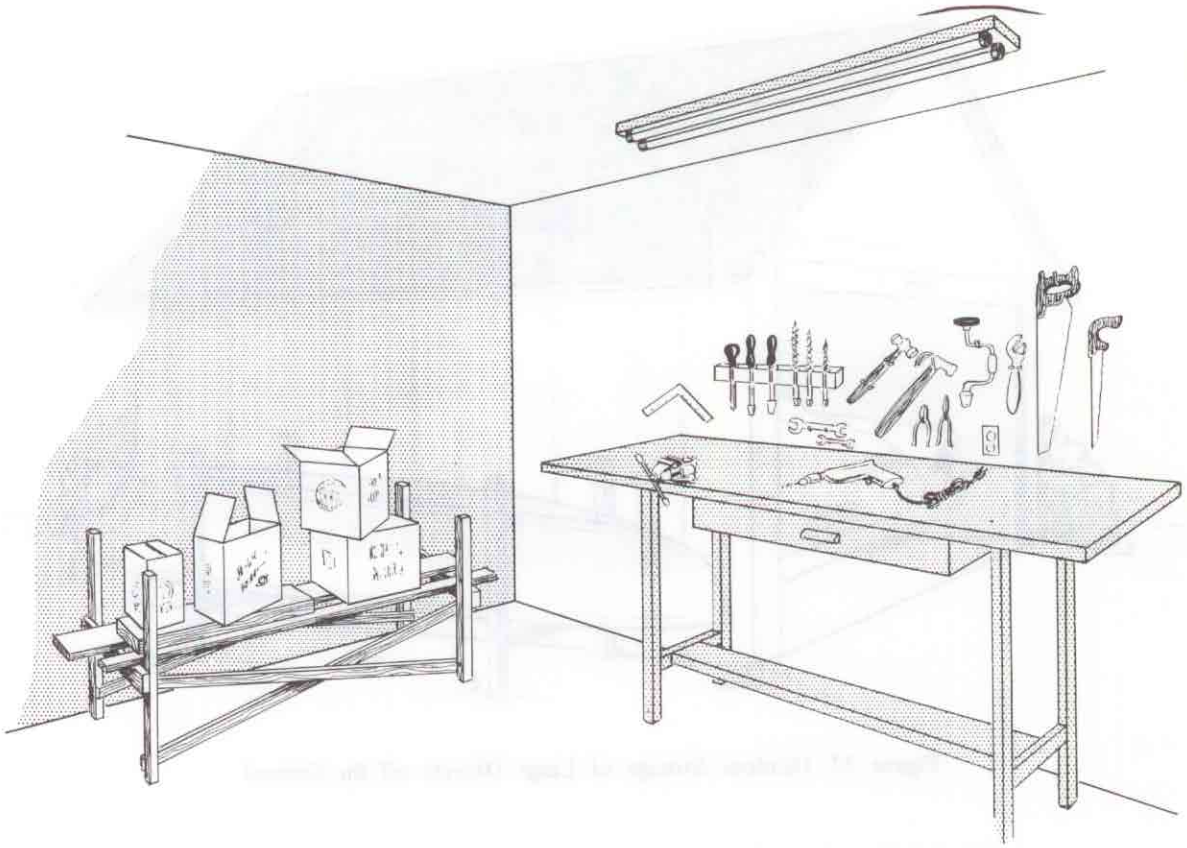


Figure 20. Indoor Storage of Usable Items on Racks off the Floor

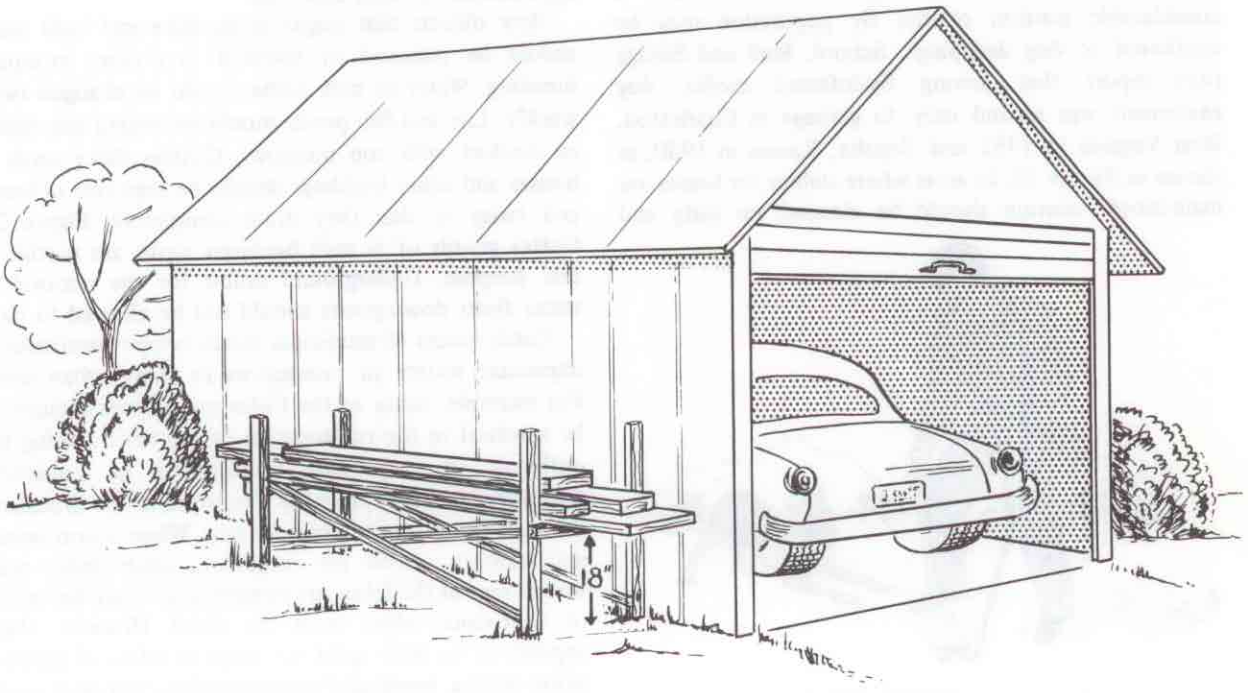


Figure 21. Outdoor Storage of Usable Materials off the Ground

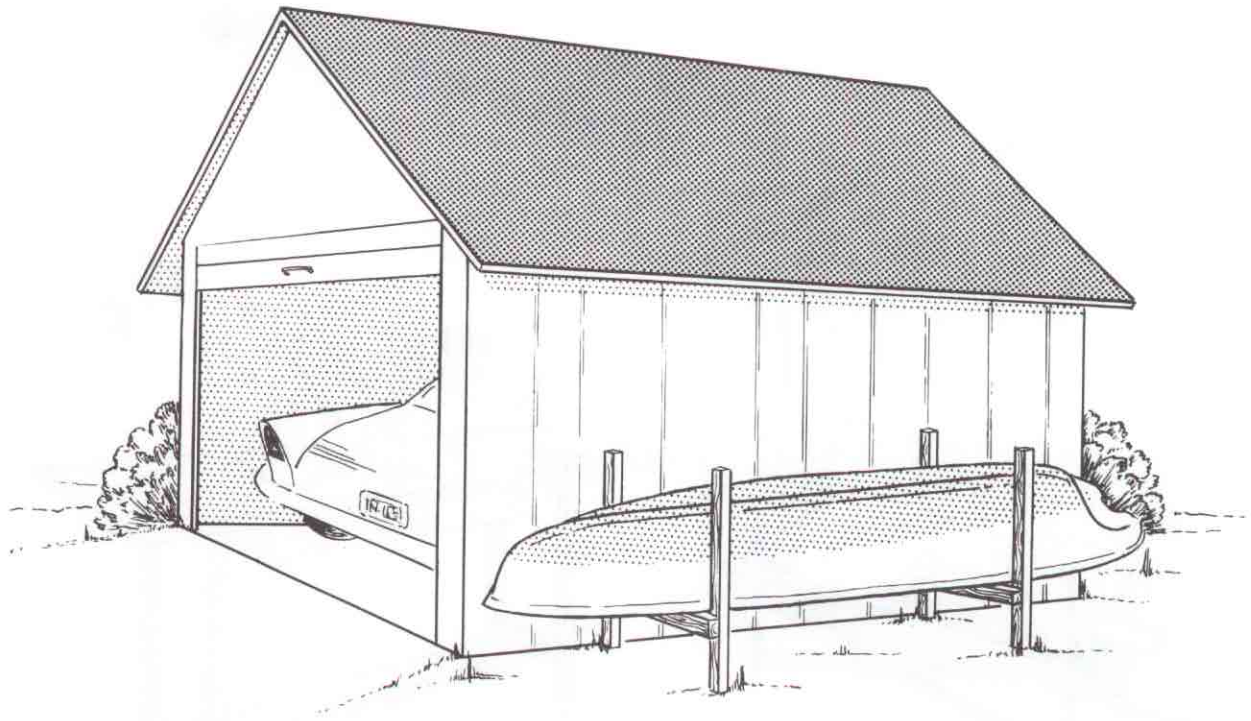


Figure 22. Outdoor Storage of Large Objects off the Ground

confined to the owner's premises. Their feces should be picked up from the lawn or yard daily, deposited in plastic bags or wrapped in newspaper, and either placed in the refuse container or buried, Figure 23. In residential areas where dogs are numerous, a considerable portion of the fly population may be attributed to dog droppings. Schoof, Mail and Savage (*45*) report that among fly-infested media, dog excrement was second only to garbage in Charleston, West Virginia in 1952 and Topeka, Kansas in 1950, as shown in Figure 24. In areas where stables for horses are maintained, manure should be cleaned up daily and properly disposed of or stored in tight metal containers until collected. Rabbit hutches and other animal pens contribute to the fly population unless they are cleaned frequently. Again, the droppings should be stored in tight containers until collected.

Figure 23. Animal Waste Control

Any objects that might accumulate and hold water should be removed or inverted to prevent mosquito breeding. Water in bird baths should be changed twice weekly. Lily and fish ponds should be treated chemically or stocked with top minnows. Gutters along roofs of houses and other buildings should be kept free of leaves and twigs so that they drain completely, Figure 25. Gutter guards of ¼ inch hardware cloth are useful for this purpose. Underground drains for the removal of water from downspouts should not be allowed to clog.

Catch basins of municipal storm sewers constitute an important source of mosquitoes in many urban areas. For example, many of the *Culex* mosquitoes thought to be involved in the transmission of the virus causing the outbreak of St. Louis Encephalitis in Louisville, Kentucky, in 1956 probably developed in the thousands of catch basins throughout the city. Where storm sewers and sanitary sewers are combined, catch basins with water traps at the inlets are needed to prevent the escape of obnoxious odors from the sewer. However, there appears to be little need for traps in inlets of separate storm sewers, especially in communities with well paved streets. The inlets to separate storm sewers may be

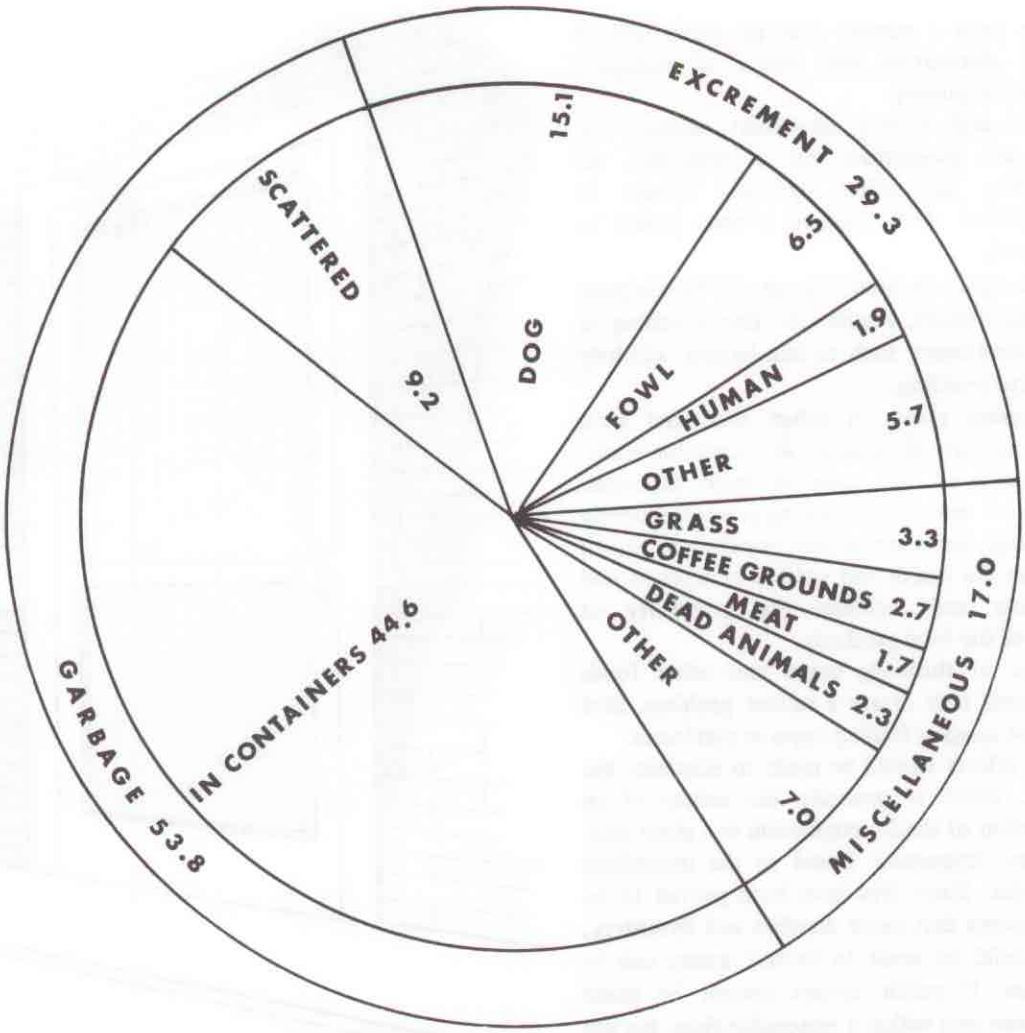


Figure 24. Relative Percentage of the Various Types of Fly Infested Media (665 samples) at Charleston, West Virginia in 1952, from (45)

Figure 25. Removal of Leaves From Gutters Aids Mosquito Control

constructed in such a manner that no water will be retained, thus eliminating one source of mosquito breeding in the community.

Screening is still a very important measure for keeping flies and mosquitoes out of buildings. All windows, doors, and other openings should be adequately screened, and damaged screens should be promptly repaired.

When screen doors are used, they should be equipped with self-closing devices, Figure 26. The screening of outside water containers, such as rain barrels, will help prevent mosquito breeding.

Food processing plants in urban and rural areas should provide sanitary disposal of all putrescible waste. Improper handling of this material from canneries, abattoirs, and crab and oyster packing plants frequently contributes to high insect and rodent populations, which in turn endanger the health and welfare of workers and nearby residents and increases the possibility of contamination of the food products.

The practice of throwing bread and other foods outdoors for birds may create a rodent problem. Bird lovers should use hanging feeding cages or platforms.

All possible efforts should be made to eliminate the outdoor privy, which is generally the source of an appreciable portion of the fly population in a given area. Rat burrows are frequently found in the immediate vicinity of privies. Since flies have been proven to be carriers of organisms that cause diarrhea and dysentery, every effort should be made to extend sewers and to eliminate privies. If public sewers cannot be made available to a given area within a reasonable time, the use of septic tanks with absorption fields should be encouraged.

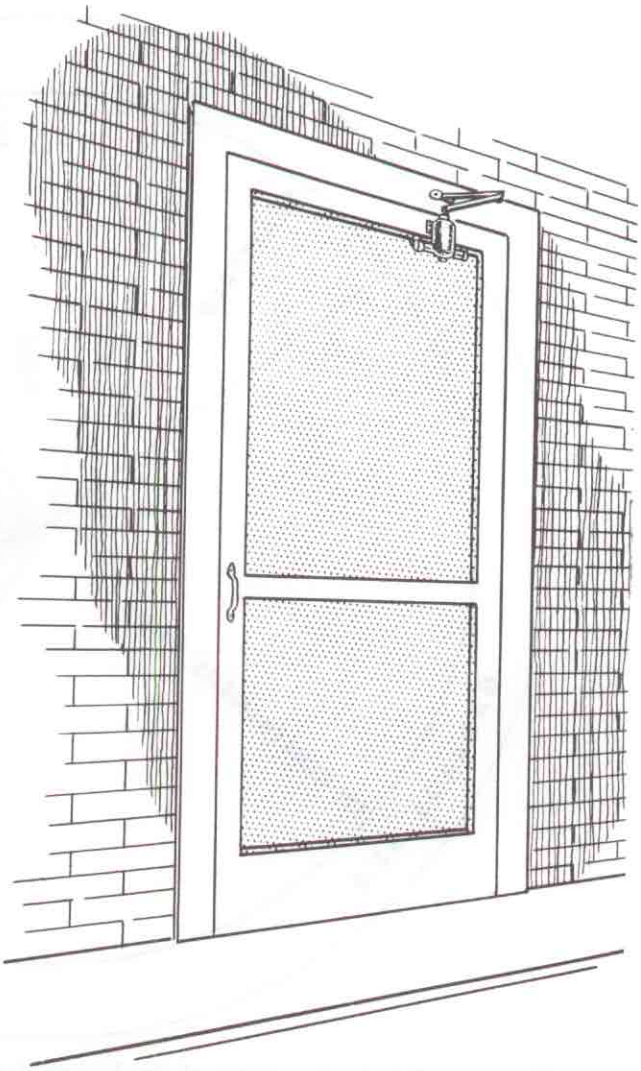


Figure 26. Good Screen Door With Self-Closing Device

SANITATION AS RELATED TO INSECT AND RODENT CONTROL IN BUSINESS, INDUSTRIAL AND INSTITUTIONAL ESTABLISHMENTS

Much of the material presented in the preceding sections has definite applications to business, industrial, and institutional establishments. However, certain types of establishments have characteristics that present sanitation problems related to insect and rodent control not found in other situations. Some examples of these are presented here.

Each category of industrial activity has its own insect and rodent problems. Most of these result from operational procedures and material-storage practices, building structure, equipment and its location, lack of maintenance, improper housekeeping including inadequate storage and disposal of putrescible wastes.

Food processing plants frequently have infestations of rodents and insects whose presence leads to contamination or adulteration. In the control of insects, cleanliness of the whole plant is especially important. The floors, walls and ceilings should be kept scrupulously clean. The processing machinery should receive special attention, since it often becomes heavily infested with insects when cleaning is inadequate.

The cleaning of the floors and walls may be difficult because of cracks, crevices, and small holes. These can hold food particles attractive to both insects and rodents and can also provide ways for insects to enter and leave rooms and buildings. The use of a caulking compound or other similar materials to seal these small crevices and holes will facilitate cleaning, prevent entrance of insects, and reduce their harborage in breeding places.

Cleaning may also be hampered by inconvenient placement of equipment. Frequently equipment that cannot be moved is installed close to walls, and the space between, which therefore is seldom cleaned properly, may provide harborage for insects and rodents. Meters, fuse boxes, pipes, braces, and conduits installed on or near walls or floors provide many hiding places for insects and rodents.

Frequently, other conditions favoring insect and rodent infestation are found in food processing plants. These include false ceilings, poorly fitted doors and windows, boxed-in areas under counters and stairways, and improperly screened doors and windows. All of these conditions favorable to insect and rodent life can be eliminated by proper arrangement of equipment and storage of material and by minor structural alterations and good housekeeping and maintenance.

In the seafood industry, large piles of oyster, clam, and crab shells containing fragments of flesh provide an attractant and a breeding place for flies, as well as a source of food for rats. Oyster and clam shells should be collected twice weekly during the fly breeding season and either processed for industrial use or returned to the beds. Crab shells should be delivered to the fertilizer plant at least as frequently. It is important that cooling rooms and picking rooms in crab processing plants be rat-proof and well screened against flies.

Feed lots, abattoirs, meat packing plants and **associated stockyards of the slaughtering indsustry** are frequently troubled by rodent and insect infestations. The rats feed on inadequately protected and carelessly handled animal feed, and flies breed in large numbers in manure and in moist spilled feed. Correcting these conditions involves improvement of physical facilities. Easily cleaned concrete pen areas, with drains leading to sanitary sewers should be provided. Feeding troughs should be so constructed that they are easily filled and cleaned. To reduce the rodent and insect problem, frequent cleanup of manure is required. It should be stored in fly-tight containers or removed promptly to a disposal site where it should be buried, burned, or spread thinly on fields as fertilizer.

Until such time as unwanted meat scraps and viscera from slaughter houses can be removed for proper disposal, they should be stored in a manner that makes these inaccessible to insects and rodents.

Hog farms, described in a previous section, dairy plants, and chicken farms are other animal industries that suffer insect and rodent infestations as a result of human carelessness, poor arrangement of equipment, improper storage of materials, and inadequate disposal of wastes.

Other types of commercial enterprises may sometimes have severe insect and/or rodent infestations. In foundries, for instance, food for rodents is supplied where foundry flour, used to seal the top and bottom side of a mold to prevent the escape of molten metal at the parting line, is frequently allowed to fall to the floor where it becomes scattered around the area. Sometimes the foundry flour is not stored in rodent-proof bins. Consequently, both stored and waste flour provide food for rats and a feeding place and breeding site for insects, especially grain beetles and other stored-food insects.

Ample harborage for rats is often present in foundries in the form of improperly stored scrap, old flasks, bottom boards, and slip jackets.

In flour mills and powdered-milk plants, it is important to vacuum-clean all overhead beams and other locations at frequent intervals to help reduce insect and rodent infestations.

A problem common to all industries, in fact any enterprise or office where people are employed, is the storage and disposal of lunch-time food scraps. Tight metal garbage cans should be provided in adequate numbers and their use, in place of open waste containers, should be enforced. Otherwise an infestation of rodents and insects, particularly of roaches, will be encouraged.

Mosquito annoyance may be important in and around industrial plants. In addition to mosquito breeding places previously mentioned, these insects may breed in stagnant waters, in cooling towers and settling basins, in waste waters from industrial processes including coal mines and oil fields, in lagoons, and in poorly drained areas around the plant. Many of these breeding sites can be eliminated by filling, draining, and alteration of construction or storage. These breeding places that cannot be eliminated or modified should be treated periodically with chemicals.

Junkyards, particularly those with large numbers of old automobiles and used tires, are places where *Culex* and *Aedes* mosquitoes frequently breed in enormous numbers and spread out into the community. The yellow fever mosquito (*Aedes aegypti*), which transmits the viruses causing dengue and yellow fever, and the house mosquitoes (*Culex pipiens* complex), which transmit the virus causing St. Louis encephalitis, often breed in collections of stagnant water in old auto fenders, trunks, open cabs, and in junk tires.

In hospitals, nursing homes, and other institutions, basic sanitation, again, is the answer to insect and rodent control. Cleanliness of the main kitchen, ward kitchens, and storeroom areas is especially important in control of cockroaches, rats and mice. Cleanliness of individual rooms and wards is also important. Refuse storage with adequate facilities and proper care and maintenance will do much toward fly, mosquito and rodent control. The disposal of contaminated waste, dressings, sputum, and similar materials is of cardinal importance, because insects and rodents can easily spread pathogenic organisms from these sources. Heavy galvanized metal containers with tight fitting lids, or heavy hard-rubber containers with screw-type locking lids are satisfactory for storage of contaminated materials, but storage should be of very short duration. These materials should be disposed of at least twice daily by efficient incineration. All institutions producing biologically contaminated refuse should have well designed incinerators using accessory fuel, which will insure destruction of pathogenic organisms and complete combustion of these wastes.

PROMOTING PUBLIC COOPERATION

GENERAL

Insect and rodent control may be effected in a community in two ways. It may be set up as an independent endeavor with its own staff and operating procedures or it may be integrated with the existing environmental sanitation program. If established as an independent unit in a local health department, its activities must be coordinated with those of other local governmental units working in related fields. For example, local fire departments have given valuable assistance in improving refuse storage, especially in downtown business areas where improperly stored refuse frequently constituted a definite fire hazard. A vector control program, to be effective, must have the support of local officials, civic groups and the residents and businessmen of the community.

EDUCATION AND INFORMATION

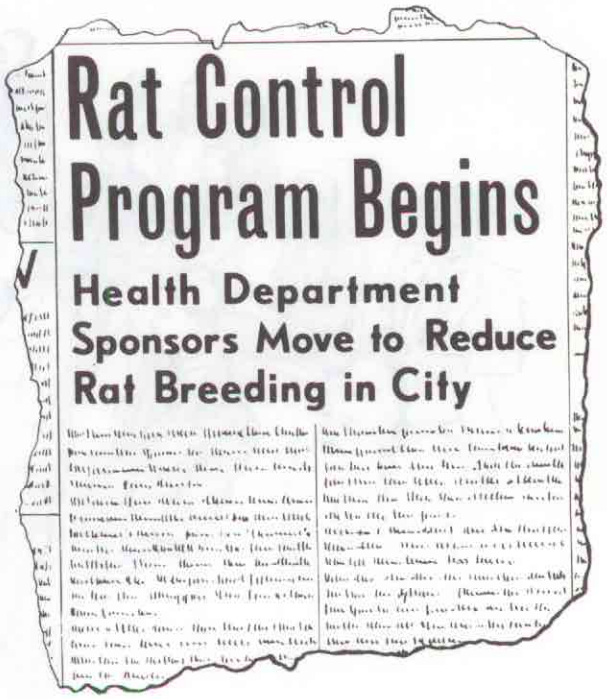
Any successful program for raising the level of general sanitation depends on public awareness of the problem and its solutions, and the benefits that will accrue to the individual and the community. Consequently, a forceful, sustained, well organized, informational phase is necessary to obtain full cooperation of the whole community. Without this public cooperation and without continued informational and promotional efforts by responsible authorities, a sanitation program for vector control will not receive an adequate start, nor will it be able to sustain sufficient interest to keep it going the year around.

One method for initiating such a program is to carry out a combination "Cleanup" and "Garbage Can" Campaign, or a "Paint Up, Cleanup and Fixup" Campaign. Considerable enthusiasm can be generated by an activity of this nature, but it is especially important to take measures to avoid letdown after such efforts. Every means should be used to emphasize to the public that the campaign is just a symbol of an activity that should be practiced day after day, year after year. The informational program begun before the "Cleanup Week" should continue actively after the campaign closes.

Numerous devices have been used successfully to stimulate interest and participation. The mayor may officially declare a specified week as "Cleanup Week." Full use should be made of radio, newspapers, and other news media to announce the campaign and to familiarize the citizens with its purposes and its benefits, Figure 27. Schedules of the days and hours when city vehicles and other collection vehicles will cover various sections of the city to collect junk, debris, and other useless items should be published in the newspapers and announced over radio and television.

Prior to the campaign, talks in civic groups, PTA's, and church groups should be made to enlist cooperation and active support both for the cleanup campaign and the program as a whole. An active civic minded group composed of leading community citizens might make the support of the whole program one of its projects. This assistance would be welcomed by the responsible agencies, which frequently are short of personnel.

A good plan is for active civic groups to divide the city into districts, with one person responsible for each district. These district supervisors then appoint "block captains," residents of individual blocks, responsible to the district supervisor. The professional personnel of the local health department work with the district supervisors by aiding in the orientation, motivation and



Rat Control Program Begins

Health Department Sponsors Move to Reduce Rat Breeding in City

Figure 27. Good Newspaper Article

instruction of the groups of block captains. One or more civic groups cooperating in this or a similar manner can help immeasurably in achieving the desired sanitation improvements. While coordinating the efforts of these voluntary workers during and after the "kickoff" campaign, the local health department carries on its own activities toward attaining its goals. Utilization of radio, television, newspaper articles with photographs, posters, and literature is an essential part of the local health department's permanent public relations program.

Other methods have been used with good results for alerting the public to the need for good premises sanitation and maintenance. Printed cards or instruction sheets covering refuse handling practices and containing excerpts from the city ordinance can be distributed to a large proportion of the town's residents by mailing them in the envelopes with city or county water or tax bills. These sheets or cards describe proper prestorage treatment of refuse and approved storage facilities, give collection schedules, and provide other useful information.

If enough health workers are available, their personal visits to individual premises to explain the program, to distribute the cards and other literature, and to answer questions will stimulate more public interest than can be developed by merely sending literature. Distribution of any literature could be accomplished through civic volunteer groups who have been properly oriented and briefed, as previously suggested. It might be desirable for volunteer groups such as the boy scouts to do this work in the residential areas, while the local sanitarians distribute the cards or other literature in the business districts during the course of their routine activities. Personal visits allow discussion of refuse handling techniques, and other conditions on the premises that may be conducive to rat and fly breeding and mosquito production. Changes in attitudes and behavioral patterns are difficult to achieve and require long-term efforts using all available techniques. Meetings of civic groups can often be used to improve community sanitation (Figure 28). Program committees of these groups generally appreciate guest speakers. Parent-Teachers Associations, civic clubs, church groups, and service organizations welcome programs that demonstrate ways of attacking problems of general interest. With the various visual aids available on sanitation and the vector and pest problem in general, a very interesting and informative program can be presented at these meetings, and appropriate pamphlets and leaflets can be distributed.

School children, also, can be interested in sanitation projects. This can be done through assembly programs or art projects. Literature on breeding and control of flies, mosquitoes, cockroaches and rats can be distributed to school assemblies and introduced by talks to these groups. Then, by requesting the students to take the literature home with them, wide distribution can be achieved. In some cases, instruction in general sanitation and its effect on insect and rodent control has been given as an integrated part of hygiene, civics, general science, or general biology classes. Guest speakers whose

Figure 28. Talks at Civic Organizations Aid Good Sanitation Programs

talks are illustrated by movies or slides are welcomed by teachers as a change for the students and as an enrichment of the course or curriculum.

In conjunction with the teaching and promotion of sanitation, poster design contests have proven beneficial (Figure 29). Acceptable posters for use in subsequent portions or phases of the program can thus be produced. Frequently, local merchants may provide modest awards for the contest winners.

A form of public education which deals with only one phase of sanitation is the tagging of unsuitable refuse containers (Figure 30). The large tags usually used for this purpose inform the owner that his refuse storage is inadequate. In addition, they frequently carry a brief list of common deficiencies which may be checked to indicate specifically what action is required of the owner. Sufficient publicity to inform the public regarding the action to be taken should precede and accompany a tagging campaign. Good publicity is, in fact, an essential part of all phases of a sanitation improvement program. As the operation proceeds, the local newspapers could publish daily or weekly reports showing such data as number of premises surveyed, and number of premises with inadequate refuse storage. The work and record keeping could be carried out by the refuse collection agency, if necessary. Subsequent checkups could also be reported to the people through newspapers, radio, and television, revealing the percentage of compliance in different sections of the city or town (Figure 31). For greatest impact, tagged containers which people continue to use should be collected and destroyed. Of course, legal basis for such action must be present in the code or ordinances of the area.

Date _____ Nº 1095

Location _____

Type Container _____

Condition _____

_____

_____

By _____

Nº 1095

City of Takoma Park

Official Notice

This container is unfit for use as a refuse container.

For Further Information Call

872-6999

Date _____

Location _____

SANITATION DIVISION
CITY OF TAKOMA PARK

Per _____

Figure 30. Refuse Container Tag

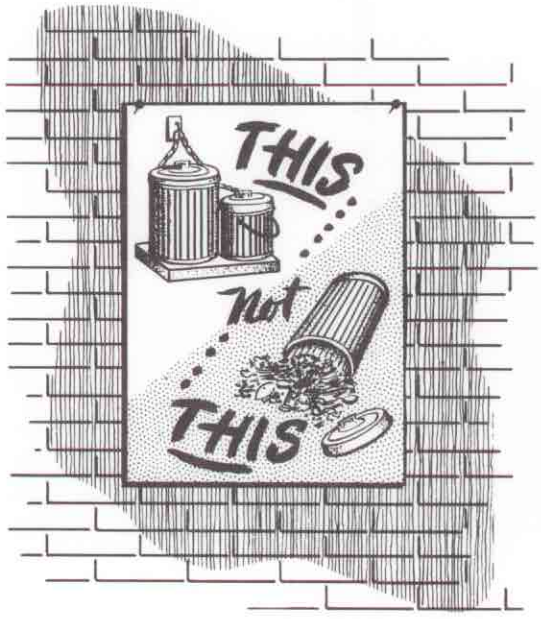


Figure 29. Poster

Figure 31. Radio and Television Talks

ORDINANCES

Ordinances, especially those providing sufficient penalty for offenders, help insure public cooperation. The backbone of an effective sanitation program should not rely on the city ordinances to accomplish its aims. The major portion of desired improvements should be attained through a well-planned, tasteful, continuing educational program. The well-balanced information program will bring large segments of the population to realize the value of the benefits that will accrue to them, their families, and the community as a whole through their compliance with the requests for improved sanitation. There are, unfortunately, always a few stubborn or unreasonable persons in each community and, to obtain compliance by this group, legal action generally is necessary.

SUMMARY

Environmental sanitation is a modification of environment in such a manner that a maximum of health, comfort, safety, and well-being accrues to man. Conversely, these same modifications tend to make the environment less favorable for the continued existence of insects and rodents.

Sanitation is a problem of the community as well as the individual. Continual disregard on the part of either will certainly result in unnecessary disease and annoyance. Frequently, individual effort is fruitless without public control. At the same time, efforts of public health agencies are doomed to failure without support of individual citizens.

Lack of understanding, carelessness, and indifference are largely responsible for all insanitary conditions. Therefore, a well organized, forceful informational program is essential to the realization of good community housekeeping.

When the desired sanitation standards are attained, the community will have reduced the numbers of vectors and pests, the incidence of disease and annoyance, and will have become a much more pleasant place to live. Consequently, there will be greater attraction for new industry and desirable residents, more opportunity and disposition, for work and relaxation, increased property values, and a greatly increased individual pride in home and community.

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