

# MANURE MANAGEMENT

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Today's specialization with development of large-scale "factory farms," including drylot dairies, beef feedlots, and chicken ranches, plus the spread of urbanization to house an increasing population, have created new problems for both farmers and city dwellers. The city dweller is offended by agricultural odors and insects while production is made more difficult for the farmer by the higher, and more costly level of sanitation demanded. Disposal of livestock manure, the greatest of the problems with agricultural wastes, is discussed in this article.

**N**EARLY ALL BEEF ANIMALS are in feedlots for the last three to five months of their lives. This means that about 25% of their lifetime excrement is defecated in the corral. In metropolitan milksheds hundreds of cows are kept moving between feedyard, loafing corral, and milking barn, with seldom a chance to graze on pasture. Approximately 80% of the egg-laying poultry of California are kept in cages or in wire-floored pens. These birds are confined to 1/2 to 1 sq ft of pen area, and their excrement falls through the wire mesh floor and accumulates on the ground beneath. These manures are all a problem because so much material is concentrated in so small an area at such a rapid, unending rate.

The livestock farmer usually is a specialist without cropland and has no easy way of getting rid of the manure. These large volumes of manure are odorous, very likely breed tremendous numbers of flies, or may dry and blow, causing particulate air pollution. The human health hazard, either directly from the manure, or vector-carried, as well as the animal's well-being must also be considered. Labor efficiency as well as plain esthetics, are also factors which make manure management necessary.

Manure management is seriously limited by costs, however. Homeowners pay approximately 0.9 cent per pound for municipal refuse collection, treatment, and disposal, but at similar rates, a dairyman would have to pay \$200 per cow per year—which is obviously impossible.

Cropland can be fertilized with manure only in spring and fall, although the animals defecate continually. The crop farmer can also usually buy and apply chemical fertilizers more cheaply than he can use free animal manure. The "organic" value of manure is seldom reflected in increased crop yields. In spite of this, most manure will eventually be returned to the soil to recover as much value as possible. The problem is one of managing the manure in a sanitary and satisfactory manner from the time it is defecated until it can be disposed of or used.

Manure cannot usually be allowed to accumulate in the confinement area until use, because of the sanitation hazards of fly breeding, odors, dust, animal health, or potential water pollution. Therefore, four steps in the management of manure need to be considered: (1) collection, (2) processing, (3) storing, and (4) utilization or disposal. These are the same basic operations that sanitary engineers consider in the handling and treatment of municipal and industrial wastes.

## Collection

Collection of wastes is the first step. Dairyman must clean out their milking barns after each milking—twice a day. Swine feeding floors are usually cleaned daily. Some California poultrymen have found it advantageous to clean under the cages every day, although most pres-

ent ordinances specify weekly cleanout (since this will break the fly life cycle if the manure is handled properly after collection). One California beef feedlot is under court order to clean out the corrals monthly.

Collection is a chore amenable to the same systems analysis that the sanitary engineer uses for sewage or for garbage and refuse collection. That is, the farmer may collect and transport the manure with liquid carriage, as in washing out the milking barn, or he may handle it as a solid. The choice depends upon, and affects, how or if the manure will be processed, stored, utilized, or disposed of. The extravagant use of water so typical in conveying human wastes is, of course, not practical—it would take eight gallons of water per chicken and 1200 gallons per cow to dilute the daily excrement of one animal to the concentration of sewage. Although liquid collection and transport of manure may be simple, the chore of treating and disposing of this increased volume may be more difficult. The importance of minimal quantities of water is emphasized in three line graphs, which indicate the weight and volume of various manures as a function of their solids content. (The fresh composite defecation of farm animals is 25 to 30% solids.)

Collection and transport of solid manure is a materials-handling problem. It can be mechanized, as other bulk commodity handling has been. One of the

Manure stockpile of the Dairyman's Fertilizer Co-op, Inc., of Los Angeles County, California.





Manure cleanout machine for undercage removal of chicken manure.

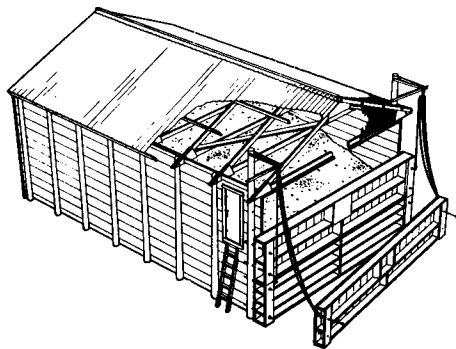
new research developments for the collection of chicken manure under cages is shown in a photo. Commercial designs are beginning to be available for all manure collections.

### Processing

Processing of livestock manure is the most challenging aspect of agricultural sanitary engineering. In some cases processing can be bypassed, as when manure is stored in flytight bins (see drawing of U.C. plan), or is disposed of upon collection. Processing may sometimes be a secondary effect of storage, as in the case of natural drying and composting within the 400,000-cubic-yard manure stockpile of the Dairyman's Fertilizer Co-op, Inc., of Los Angeles county (shown in photo).

Although manure processing may be similar to sewage treatment in physical, chemical, and biological phenomena, there is a fundamental difference in purpose. Sewage treatment is designed to upgrade the quality of water which is polluted with organic matter. Manure processing is based on the need to stabilize

Flytight manure storage bin (University of California Agricultural Extension Plan No. 10).



waste organic matter which is contaminated with water. If the manure were dry, much of the sanitation problem would be nonexistent. Dry manure is stable and relatively odorless, and breeds very few flies, as shown in the bar graph.

Drying manure by using fuel for heat is likely to be prohibitive in cost. It is estimated that manure processing, by artificial heat drying, plus pelleting and bagging, would cost over 1½ cents per pound of dried manure. California farmers have been quite successful in accelerating natural sun drying of manure, however. One modern way this is being done is shown in the photo of a center-pivoted rotary tiller. Recently this natural-drying principle was extended by research into spreading the manure so thinly that it will dry in one day without stirring, and additional manure may be added each day. Daily layers 1/10 inch thick will dry in summer, but in the fall this must be reduced to about 1/20 inch. Modifications of this principle should be possible, even in summer-rainfall areas, and the new side-delivery manure spreaders make such thin-spreading possible.

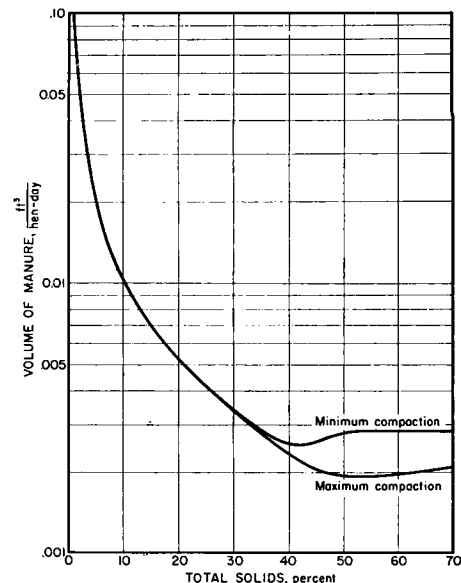
Composting is another technologically feasible proposal as a method of stabilizing manure. However, freshly collected manures are usually too wet to compost well. They must either be partially dried first or a dry filler material added. Also, the carbon-to-nitrogen ratio of fresh manures is only 8:1 to 12:1, which is too low in carbonaceous matter to compost well. (Good composting requires an initial C:N ratio of 20:1 to 30:1.) Thus, when composting pure manure, there is either excessive loss of nitrogen or incomplete stabilization.

Manure can, of course, be mixed with carbonaceous material such as straw or municipal refuse, and will then compost very well. However, the livestock farmer is not usually interested in, or capable of, running such an operation in conjunction with his animal enterprise. If composting is ever to become a widespread manure processing technique, it will probably have to be conducted by a governmental agency or by a private entrepreneur accepting and treating municipal, industrial, and agricultural wastes.

Other schemes proposed for solid manure processing include incineration. Incineration of poultry manure is theoretically self-generating at a solids content of 35% or more. The end product—the ash—contains phosphorus and potassium and has some value. Such processing would also not likely be done by the farmer, but by some central operation.

Processing methods for liquid-carried manure include: digestion, anaerobic lagooning, and possibly aerobic treatment akin to the activated sludge process. Laboratory experiments indicate digestion is engineeringly feasible, and the parameters of operation are similar to those of sewage sludge digestion. That is, digestion is satisfactory with 0.10 lb volatile solids loading/cu ft digester capacity per day, and month-long detention at 95°F—also the same as in municipal digestion where a 30 to 50% reduction in volatile solids, (12 to 16 cu ft gas/lb volatile solids) destroyed, a 6.5 to 7.0 pH. Dairy manure stabilized well, but did not undergo the volatile solids reduction expected because of the high lignin content and the fact that it is the excrement of a ruminant and therefore has undergone extensive anaerobic digestion within the animal.

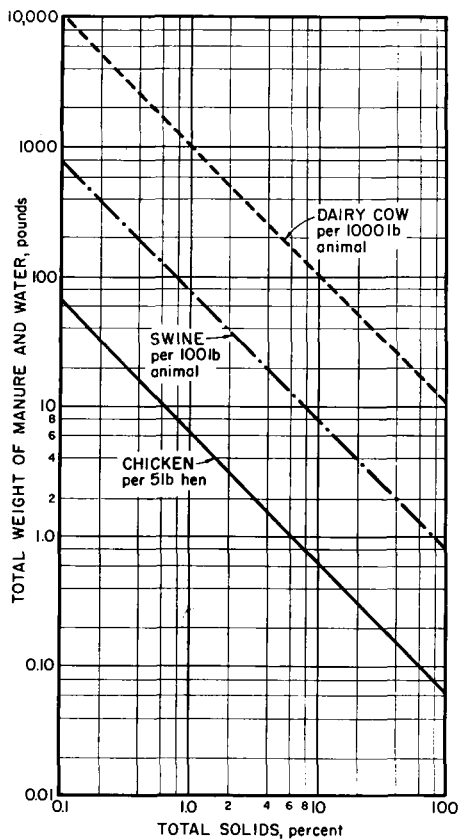
Digestion on the farm has the same drawback as composting—the expensive and complicated equipment and skilled labor necessary make it unlikely that it will have widespread farmer acceptance.



Volume of wet chicken manure produced per day by a 5-lb hen when the manure is dried or wetted to specific solids contents.

In addition, both the digested sludge and the supernatant liquor must be stored, dried, or otherwise handled until they can be disposed of.

Today the so-called "manure lagoon" offers the greatest promise as a method of treating and disposing of liquid-carried manures. These manure stabilization ponds are strictly anaerobic since their biochemical oxygen demand (BOD) loading is about 20 times that of aerobic "sewage lagoons." Manure stabilization ponds are typically loaded at about 0.016 lb



Weight of wet manure produced by farm animals per day when the manure is wetted or dried to specific solids contents.

volatile solids/cu ft capacity per day—about two-thirds the loading rate for Imhoff tanks or unheated municipal digesters. The manure stabilization ponds perform similarly to digesters; they may be somewhat odorous but they accept the waste with minimal attention and difficulty. Infiltration and evaporation usually suffice to dispose of the excess water, and the sludge layer builds up at a reasonably minimal rate. Ground-water pollution has not yet been considered seriously, but may alter the situation in the future.

The activated sludge system of treating liquid-carried manure has been studied in a laboratory test. A 70 to 80% reduction in BOD was readily obtained, but the design parameters were not completely worked out. More research work is needed, and will undoubtedly be done.

### Storage

As a unit operation, storage cannot be omitted or ignored because it occurs even when manure accumulates in the corral or chicken house. The emphasis in manure management is that storage, when and where it occurs, must be sanitary. It does no good to process manure after it has bred out a colony of flies, nor is it satisfactory to put fly-attractive manure into

storage without processing it or preventing fly breeding from occurring during this storage.

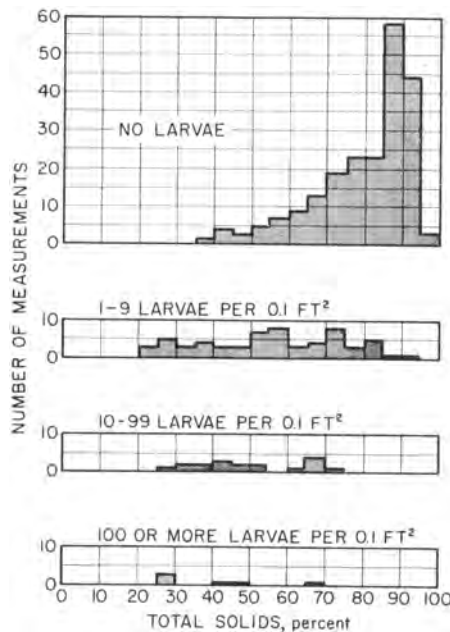
### Utilization-disposal

The major disposal for most manure will be its return to the soil. Some small part of the manure may be sold at high prices for home gardening, but the greatest volume will be utilized on agricultural land.

Since manure cannot compete well with chemical fertilizers, its use or disposal, as far as the livestock farmer is concerned, will have to be subsidized. This means that the livestock farmer will have to pay more and more of the costs of collection, processing, storing, and hauling and spreading the manure on the crop farmer's fields.

Processing by drying reduces the weight and volume, and concentrates the fertilizer nutrients. Dry manure may thus command some reasonable price during

### Occurrence of fly larvae in dairy and chicken manures.



the foreseeable future, but even so it is unlikely that this price will completely cover the costs of sanitary manure management. The price potential is considerably dimmer for other processing methods, such as composting, incineration, and digestion.

One of the reasons why manure stabilization ponds (manure lagoons) are so popular is that the livestock farmer does not have to be concerned with disposing of the manure. The lagoon acts as its own disposal sink, and is expected to need minimal sludge removal and disposal.



Hastened natural drying of chicken manure using a center-pivoted rotary tiller.

Research on better manure utilization for crops is now underway by agronomists, olericulturists, and other specialists. In previous research, manure was merely compared with chemical fertilizers—and it usually came out second best, particularly as a nitrogen source. However, scientists are now beginning to pose their research in terms of what crops and in what manner the manure can best be utilized—since most of it must be disposed of upon cropland.

Some of the manure may have a use other than its return to the land for fertilization. Vitamins, hormones, and some drugs are recoverable from manure, but the method is not economical to date. Manure is used for fuel in India, and other alternative uses for it may well be developed here that could change the manure management picture completely in the future.

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### Manure bulk density values using established standards and testing techniques.

