MANURE MANAGEMENT

from an important workshop at the Conference on Alternative Agriculture by

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Maine Organic Farmer & Gardener November 1976

There are some one billion odd tons of farm-animal manure being produced annually in the United States. Just how much of this is actually getting back to the land or, conversely, is being wasted, is not clear; however, it is obvious that this quantity represents a significant potential in terms of fertilizer constituents and acreage it could cover. Manure can be distinctly appreciated when we realize that farm animals actually fail to utilize the greater percentage of minerals found in their feed, and these are excreted in both the solid and liquid fractions. In general, the figures for this recovery of elements in manure are: nitrogen, 80%; phosphorus, 80%; potassium, 90%; and organic matter, 50%[1].These figures are somewhat surprising and even ironic when we think of all the energy, labor, and money expended in getting the minerals to the soil to feed the plants to feed the animals. In any case, it is clear that proper recycling of manure waste back to the land is a necessity and represents, theoretically, at least, a real asset, both economically and with respect to soil fertility.

From an ecological viewpoint, this is intrinsically correct. The problem today is to reconcile this with the fact that manure has largely become a liability within farm systems. One of the long-recognized reasons for this is the fact that improper handling of any animal wastes may lead to severe losses of fertilizer value, losses that seem to offset any possible benefits to be accrued from making use of it. Under conventional handling methods, it is typical that 50% of this value may be lost prior to application to the soil.[2] This means that comparable yields are obtained only by doubling application rates, which in many operations represents a practical handicap. The situation was fairly well stated as early as 1938 in the Yearbook of Agriculture, *Soils and Men:* "The economic possibilities of preventing much of this loss have been conclusively demonstrated, both experimentally and practically. The wasteful and inefficient methods of handling manure seen in all sections are evidence that many farmers still do not understand the true nature of manure, the perishable character of its most valuable constituents, and the direct money losses incurred through its improper treatment."

Manure Merits

In discussing proper manure handling, one of the first questions to arise concerns what the actual merits of manure are. There are many theories on this subject, most of which make complete sense when viewed in context of the situations out of which they developed. The question must remain open for this reason and others: Manures vary in composition and the situations represented by each farm's mini-climate are also different. However, this does not prevent making a few strong general remarks.

- **Fresh manure contains a high percentage of readily soluble minerals.** It also contains a number of the so-called "stink compounds" (skatols, indols, etc.). Applied too soon in advance of crops, these may cause physiological changes to take place in plants leading to decreases in food quality that are actually measurable.
- **Many manures, especially that of ruminants and with the marked exception of chicken manure, are already 25-50% humified when they are excreted.**[3] This is owing to the formation of lignin-proteins which are almost identical to true humus. The advisability of further composting such material is questionable since further losses of organic matter, nitrogen, and other minerals will occur.
- **Through improper use of bedding material under animals—especially in poultry houses—plus improper storage of manure under very wet or very hot conditions, huge losses of organic and inorganic constituents are incurred.** Nitrogen and organic matter are readily volatized and potassium readily leached. It has proven more economical to scrap the manure under these conditions than to attempt to use it.
- **Raw poultry manure is more damaging to soil than helpful.** Reports of severe weed problems, loss of texture and crusting, pathogen development, and bad-tasting food belong to the hen-manure syndrome. By the same token, this manure is one of the richest in mineral constituents. Proper handling, including a period of breakdown, is essential. The best example of an alternate management system for poultry wastes is described in the article "Composting Poultry Litter and Manures, An Indiana Viewpont," which appeared in the October, 1976, issue of *Acres, USA.*

Controlling Losses

The more serious and difficult to control losses from manures are those occurring through volatization of organic matter as CO_2 and nitrogen as ammonia, NH_3. Potash and phosphorus are not subject to gaseous loss but are leachable under wet conditions. Since loss of constituents by leaching is relatively easy to control, the focus of attention in manure handling must always be nitrogen chiefly, but also organic matter. The conditions conducive to any of these losses are interrelated, so it is generally possible to control all of them through some single measure. We can assume that when a pile is dry no losses from leaching will occur. The point, then, is to consider under what circumstances volatization can take place.

When manure is first voided by animals, a majority of the nitrogen contained in it is present as urea. This is readily transformed into ammonium by microorganisms inhabiting the manure and bedding. Under moist conditions, ammonium combines readily with dissolved CO_2 (carbonic acid) to form ammonium carbonate. It exists in this form so long as conditions are moist; upon drying, this unstable salt decays, releasing ammonia as a gas. A second process, that of nitrification or production of nitrate, is going on at the same time, provided an aerobic situation exists. If all the ammonia could be transformed into nonvolatile nitrate, then losses would be prevented entirely (nitrate, however, is very leachable). The entire issue of manure handling surrounds the understanding of these two processes.

This becomes clear when we imagine a practical situation: Behind a barn is a great stockpile of very wet, slightly warm manure. Under these conditions, nitrogen is trapped as ammonium carbonate; the pile is wet for any transformation into nitrate to occur. Everything is alright until the minute the manure is exposed to the air, as happens when it is spread on the field. Almost immediately the ammonium carbonate decomposes and the nitrogen escapes as ammonia. **If it is warm and breezy, these losses will amount to at least 25% within 24 hours.** This is why it is ruinous to let manure lie on the field as is often done.

That is one situation. An opposite is represented by the composting process. Here manure, in a moist but not overly-so state, is heaped in loose piles and allowed to decompose under strictly aerobic conditions, the piles being turned frequently to aid aeration. A typical aspect here is the generation of heat approaching 160°F. **According to a number of sources, however, losses of nitrogen as ammonia may approach 50% before the compost is ripe.**[5] Ammonification almost invariably exceeds nitrification in any pure manure compost and this is why losses can actually be tremendous. The numerous air surfaces to which ammonium compounds are exposed throughout the pile invite this loss.

At this point, a number of questions arise. As anyone may have observed, chicken manure composts seem to stink of ammonia all the way through the period of composting. Other manures do not seem as bad. The reason behind this is that nitrogen losses are entirely conditional depending on the initial nitrogen content. Chicken manure, with the greatest amount of nitrogen, will lose more ammonia simply because there are not enough organisms and lignaceous materials to hold it back. The late O. E.

Rasmussen, Danish researcher and biodynamic consultant, worked out the relationships shown in Table I.

Rasmussen took an interesting approach to these findings. He pointed out that in northern climates soils are generally seriously deficient in total nitrogen; therefore, nitrogen conservation of manure takes first priority. Going further, he pointed out that these northern soils are deficient in nitrogen largely because the free-fixing nitrogen bacteria fix practically no atmospheric nitrogen when temperatures are below 25°C, or 77°F.[6] Therefore, in warmer climates, farmers can afford to treat manure badly because the free-fixing organisms will more than compensate for the losses incurred! In the north we do not have this good fortune.

With respect to Table I, it is clear that the efficacy of any composting process must depend on the extent to which nitrogenous material is diluted with carbonaceous matter; the important threshold lies somewhere around 1.5% nitrogen on a *dry matter* basis. **The material used for dilution is of significance insofar as it has a high absorbing capacity and is readily attacked by microorganisms. Wood chips and sawdust are poorest in this respect; straw is alright if it is chopped; peat moss is superior.** Some characteristics of litter materials are shown in Table II. **Of course, it must be seriously questioned whether it is practical for farmers to attempt to dilute quantities of manure with litter materials. Often enough, this can be managed in the barn. However, most American designs fail to incorporate a system whereby urine is separated from solid wastes, as is practiced in Europe (see photos B and C). It may therefore take huge quantities of a litter material to get the manure dry enough to prevent stagnation and putrefaction, to dilute the nitrogen content, and to make composting possible.** This is where problems arise. However, in many situations plenty of bedding is used and the manure may become *too* dry, and subsequently, very hot. Clearly, some happy medium exists that would allow farmers to stockpile manure with the confidence that undesired putrefaction will not occur, or that it will not become too hot and dry and thus lose nitrogen.

This requirement has led to the formulation of a method of handling manure in ways very similar to the process known as ensiling, which calls for compaction of medium dry manure to the point that fermentation, rather than aerobic oxidation, takes place. Organic acids produced by the process of fermentation of carbohydrates—especially in later stages—combine with ammonia to form more stable compounds that resist volatization to some extent. Although early researchers reported that one must always expect some volatization when such fermented manure is spread on the field, later work by Rasmussen suggested that, if done properly, the preservation would be nearly complete. Table III illustrates his conclusions.

A naturally occurring situation in which the conditions of optimal preservation as described in Table III are fulfilled is that found with loafing-shed manure that has been allowed to pile up, to become somewhat dry, and to be compacted by the animals. To create this condition it is exceedingly important that the manure be just barely moist, which can be facilitated by the addition of acid peat (acid matter is desirable). This must then be compacted by animals or with a tractor driving over the heaps. If properly done, no heat or offensive odors should be detected. This is important.

As Table III shows, the problem with manure compost is that many losses occur while the composting process is going on, especially with high temperatures and forced aeration. However, this is in no way intended as a denigration of the composting method. The traditional garden compost contains no manure or only a small proportion and therefore no problems will exist. Composting is unique in being able to synergize materials of diverse origin into one common humus. There is no evidence, however, that composting *manure* (with a few exceptions, as mentioned) is necessary or practical. (It may be that the composting method has been extrapolated too widely since its inception.) The ideal state of so-called preservation or fermentation, which has also been called "half-composting," has risen to meet the need for a conservative and practical method of storing manure; breakdown into humus does occur, but more slowly and by other means. This avoids twice-handling of manure, which on many farms today—especially biodynamic farms in Europe—is proving impossible. It also averts losses that would otherwise occur if the manure were allowed to either "rot" or "compost."

This discussion of manure handling has left many unanswered questions—questions that can only be answered from the standpoint of each individual situation. Two avenues exist, however, for someone wanting to retain as much as possible of the original value of manure. One is to dilute it highly with well chopped, carbonaceous material and compost it under such conditions. The other is to get it dry enough to facilitate compaction and creation of the preserving conditions described. In the latter condition, the manure is reported to hold good almost indefinitely, and may thus be spread at the farmer's convenience. Depending on the size of the operation, one or the other of these methods will prove the more practical.

FOOTNOTES

1. H.D. Foth and L.M. Turk, **Fundamentals of Soil Science;** John Wiley Sons, NY, 1972.
2. *Ibid*
   Soils and Men, United States Agricultural Yearbook, 1938; pp. 445-461.
   O. Elstrup Rasmussen, **Frischmist-Stalldunger—Kompost, Wann - Wie - Wo?** (Fresh Manure-Stall Manure—Compost, When - Why - How?); Berichte aus der Forschung Band 2, Schrifftenreihe Lebendige Erde, 1973.
3. Prof. Hugo Schandel, **Botanische Bakteriologie und Stickstoffhaushzit der Pflanzen auf neuer Grundlage** (Botannical Bacteriology and the Nitrogen Threshold of Plants: A New Basis); Germany.
4. *Op. Cit.* Foth and Turk; *Op. Cit., Soils and Men.*
5. *Op. Cit., Soils and Men.*
6. *Op. Cit.,* Rasmussen.

Additional Reference: "Wastes in Relation to Agriculture and Forestry," USDA Miscellaneous Publication 1065, 1968; p. 41.

Photo C: The urine holding tank on the farm of MOFGA marketing coordinator Tony Bok is shown here. The crank nearest Tony's hand agitates the liquid and suspends sediment that collects on the bottom of the tank. The urine is pumped out of the tank and stored in 55-gallon drums in the garden, where it is used directly as fertilizer. (It is not clear what the other handle is for or why the drainage pipe at the lower left is not used.) The basic design of the entire system is very simple.

TABLE I*

Initial nitrogen as a % of dry matter basis†	Example	N-loss
1.5	Any manure mixed with peat moss	0%
2.5	Cow manure mixed with straw	5
3.0	Cow manure mixed with peat moss	10
3.0	Pig or chicken manure with peat moss	20
3.5	Pig manure mixed with peat moss	30
3.5	Chicken manure mixed with peat moss	40
4.0	Chicken manure mixed with peat moss	50
4.5	Pure pig manure (no additions)	40
5.0	Pure chicken manure	60

* After O. E. Rasmussen, 1964.
† Percentages are quite different on a wet matter basis.

TABLE II*

Material	Pounds of litter required to absorb 100 lbs. liquid	Pounds of nitrogen held per ton of litter	Carbohydrate activity
Wheat straw	45	4.5	High
Oat straw	35	7.1	High
Chopped straw	20-30	—	High
Cornstalks	25-35	5.3	High
Sawdust	25	0.0	Med.
Wood shavings	25-45	0.0	Med.
Leaf litter	25-60	26.6	Med.
Peat moss	10	40.0	Med.
Peat (sedge and woody)	15-25	30-60	Low

* From *Soils and Men*, 1938; compiled from various sources.

TABLE III*

Method	Conditions	Ammonia losses while piled	Ammonia losses when spread
Composting—breakdown into humus	Warm, aerobic, moist	Great	None
Fermenting—no putrefaction	Cold, anaerobic, half-dry	None	None
Rotting—putrefaction occurs	Warm, anaerobic, very wet	None	Great

* After O.E. Rasmussen, 1964.

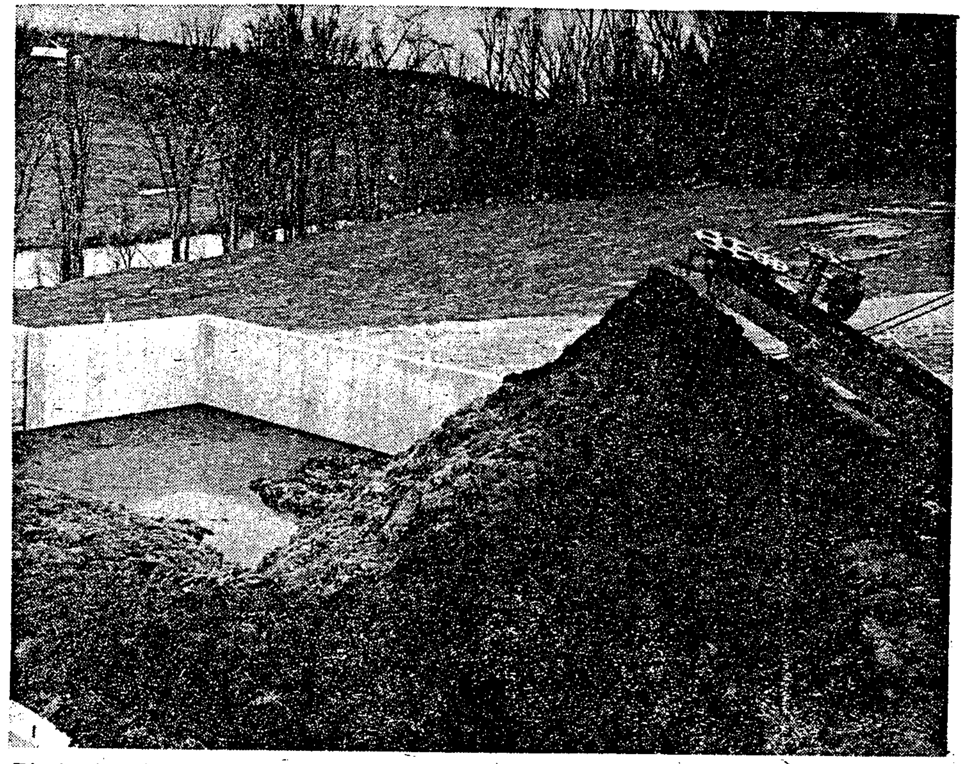

Photo A: Storing manure in this wet, loose form results in heavy losses of fertilizing elements and requires expensive concrete holding bins to prevent leaching of nitrate. Additional bedding material and urine removal would solve several problems of the storage method illustrated.

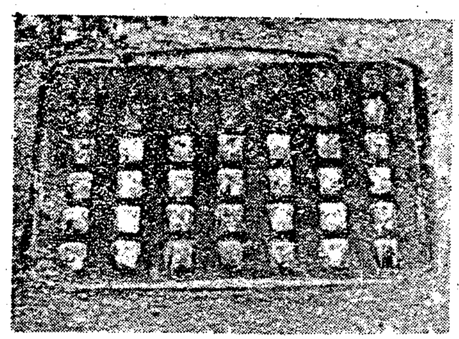

Photo B: This 10″ x 10″ drain plate allows urine in the stalls to be gravity fed to a large holding tank outside the barn.