



Fertilizer Nutrients in Dairy Manure

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Many dairy producers fall into one of two categories: 1) they are willing to make high capital and labor outlays to maximize the utilization of their dairy wastes for crop production, or 2) they are willing to minimize the amount of nutrients returned to the land for crop production in exchange for a relatively low-cost and low-labor method of waste disposal.

Producers in the first category usually use slurry systems with tanks for waste storage, and tank wagons with injectors to transport and apply the waste. Producers in the second category use lagoons for storage/treatment, and irrigation equipment to transport and apply the waste to their fields.

To have value, wastes must be utilized in a manner that results in a saleable product. This publication describes methods of recovering a portion of the plant nutrient value of dairy wastes.

To keep the addition of nutrients from waste and fertilizer in balance with the nutrient removal by crops requires a record keeping system, preferably with laboratory tests of the nutrient content of the wastes being applied. The quantities of wastes added and crops removed should be measured; or, at least, estimated as accurately as possible. Reliable nutrient data requires that the waste be kept well mixed during the loading, sampling, transport and land application process.

Fresh manure nutrient production

Typical nutrient production values for various weights of dairy cattle are listed in Table 1 for fresh manure.

Table 1. Daily/Annual Production of the Major Nutrients in Pounds for Various Weights of Dairy Cattle (as Contained in Freshly Excreted Manure; reference ASAE Data D384.1)

Size Pounds	Nutrient Production, Pounds per Day/Year		
	Nitrogen	Phosphate	Potash
150	0.07/24.64	0.032/11.66	0.052/19.05
250	0.11/41.06	0.053/19.44	0.087/31.76
500	0.22/82.12	0.106/38.87	0.174/63.51
1000	0.45/164.25	0.213/77.74	0.348/127.02
1400	0.63/229.95	0.298/108.84	0.487/177.83

Note: Phosphate (P_2O_5) = $2.27 \times P$; Potash (K_2O) = $1.2 \times K$

Nutrient losses/availability

Losses in nutrient value are inherent in any system of manure management, both during the collection and storage phase and the land application phase, especially nitrogen losses due to volatilization and denitrification. In the collection and storage phase, nitrogen can be lost to the air as ammonia and from manure stored in open lots by leaching and runoff. About 20 percent to 40 percent of the phosphorous and 30 percent to 50 percent of the potassium can be lost by leaching and runoff from open lots. Thus, to minimize nutrient losses as well as to reduce pollution problems from rainfall runoff, all operations (feeding, cow loafing, manure storage, etc.) should be

Table 2. Average nutrient levels in dairy waste.

Waste Type	Nitrogen			P ₂ O ₅	K ₂ O
	Total	Organic	Ammonium		
Solid ¹ w/ bedding	9	4	5	4	10
Solid ² w/o bedding	9	5	4	4	10
Lagoon ³	69	23	46	79	144
Liquid (Slurry) ⁴	26	16	10	14	26

¹pounds/ton (21% dry matter, Source: MWPS-18, Table 10-6)

²pounds/ton (18% dry matter, Source: MWPS-18, Table 10-6)

³pounds/acre-inch, ⁴pounds/1,000 gallons (Source: MU publication WQ 201) (Note: P₂O₅ = 2.27 x P; K₂O = 1.2 x K)

Actual values are highly dependent on dilution, bedding and other factors. Variations of 50% from average values are not uncommon.

Table 4. Manure Ammonia-Nitrogen Loss by Days Until Incorporated into the Soil (from WQ 201).

<u>Days until Incorporation</u>	<u>Percent of Ammonia-N Available for Crops</u>
0-2	80
2-4	60
4-7	40
>7	20

lution by runoff is high when manure is applied to frozen soil. Once incorporated into the soil, phosphorous and potassium are bound to soil particles such that the principal mode of loss is by soil erosion.

Solid and liquid manure should be plowed down, or otherwise incorporated into the soil, as soon as possible after land application to minimize odors and volatilization of nitrogen. Lagoon effluent applied by irrigation to soil dry enough to "take water" is assumed to be immediately incorporated.

A comparison of typical nitrogen losses for solid, liquid (slurry), and lagoon systems during handling and storage are given in Table 5. Losses are highly variable due to seasonal, temperature, moisture, climatic and other factors.

kept under roof – no open lots.

Table 2 lists the average nutrients available in dairy waste handled and stored in the usual methods.

Frequently, total nitrogen (N) in dairy lagoon effluent is composed of approximately two-thirds ammonium nitrogen and one-third organic nitrogen. The ammonium nitrogen is equivalent to nitrogen fertilizer, and except for losses to the air, is available to plants in the year of application. Organic nitrogen must be mineralized before it is available to plants. Table 3 shows the percent of organic nitrogen mineralized (released to crops) during the first few years after application. Nearly all of the phosphorus and potassium are available the year of application.

Table 3. Manure Organic Nitrogen Available by Year (from WQ 201).

<u>Manure Applied</u>	<u>Percent of Organic-N Available during Current Year</u>
Current Year	40-60
1 year ago	10
2 years ago	5
3 years ago	5

Most volatilization (ammonia) losses occur within the first 24 hours after land application, if the waste is not incorporated. The rate of loss increases with increasing temperature. Table 4 shows the decrease in plant-available ammonia-N as incorporation is delayed.

Nitrogen applied in excess of crop needs can leach through the soil, after conversion to the nitrate form, and cause groundwater contamination. The potential for nutrient removal and surface water pol-

Table 5. Typical nutrient losses during handling and storage.

<u>System</u>	<u>Nitrogen lost Percent</u>	<u>P lost Percent¹</u>	<u>K lost Percent¹</u>
Solid:			
Daily scrape and haul*	5-35	5-15	5-15
Manure pack*	20-40	10-20	10-20
Solids on open lot:			
Scrape once/year**	50	20-40	30-50
Daily scrape and haul**	25	10-20	15-25
Separated Solids,			
90 days storage**:	30	10-20	10-20
Liquid (Slurry):			
Anaerobic pit*	15-30	5-20 ²	5-20 ²
Above-ground storage*	10-30	5-15	5-15
Manure Basin; or runoff:			
storage pond, 120-180 days			
storage**	40	5-50 ³	5-50 ³
Liquid - Lagoon*:	70-80	50-80 ³	30-80 ³
Lagoon, 365 day storage**:	90	50-80 ³	30-80 ³

¹Authors' estimates. ²From Oregon State University Publication EC-1102. ³Losses vary widely, pending on degree of agitation during pump-out. *From MWPS-18. **From Missouri Manual 121, for MDNR approval, use design data from Missouri manuals.

Solid manure systems

In the future, it is likely that only the smaller dairy operations will be handling dairy manure as a solid. To handle dairy manure as a solid, one practice is to add about 4 pounds of dry straw per cow, per day, to reduce the moisture content of fresh manure to allow it to be handled as a solid. When this manure is applied to the land, all available nitrogen may be “tied up” by soil microorganisms during the process of decaying the straw. If the decaying process takes place during crop production time, a nitrogen allowance should be made for the decay process, in addition to the nitrogen required for crop production. A second and common practice employed to allow manure to be handled as a solid is to store semi-solid manure and allow the liquids to drain off to a holding pond. The liquid is frequently drained through a “picket fence” dam.

Liquid manure systems

Liquid systems (also called slurry systems) offer greater utilization of nutrients, if maximizing nutrient utilization is the goal. Therefore, liquid systems require the maximum soil-plant filter acreage for disposal. Storage losses with a manure slurry are lower than with solids or lagoons, especially if stored in above-ground tanks (Ref. Table 5). Knifing liquid into the soil minimizes application losses (Ref. Table 4). The addition of nitrification inhibitors to the manure can slow the conversion of ammonium nitrogen to nitrate nitrogen by certain soil bacteria, thus reducing nitrogen losses by leaching and denitrification. This is the system of choice for operators wishing to obtain the greatest utilization of the plant nutrients in their dairy waste. Table 6 lists typical nutrient availability per year for lagoon and liquid systems for three herd sizes.

Lagoon systems

This is the system of choice for producers wanting to minimize one or more of the following: 1) the required soil-plant filter acreage, 2) labor costs, and/or 3) capital investment. Manure management systems employing lagoons for long-term storage are the least efficient in respect to nutrient utilization (Ref. Table 5). Losses up to 90 percent of the nitrogen during storage is typical. Up to 80 percent of the phosphate may remain in the lagoon bottom sludge if the lagoon is not agitated when pumped. Land appli-

Table 6. Typical nutrient availability per year for lagoon and liquid systems for three herd sizes*.

For a lagoon system:	Herd Size		
<u>Nutrients produced (lbs/yr)¹</u>	<u>100</u>	<u>200</u>	<u>300</u>
1. Ammonia nitrogen	2,623	3,912	4,876
2. Organic nitrogen	1,312	1,956	2,438
3. Phosphorus	1,994	2,973	3,710
4. Potassium	6,838	10,198	12,770
<u>Pounds of fertilizer nutrient equivalent available</u>			
5. Ammonia nitrogen (In 1 x 50% ²)	1,312	1,956	2,438
6. Organic nitrogen (In 2 x 70% ²)	918	1,369	1,707
7. Phosphate (In 3 x 2.3 ³ x 75% ¹)	3,440	5,128	6,400
8. Potash (In 4 x 1.2 ⁴ x 90% ¹)	7,385	11,014	13,792
<u>For a liquid manure tank system:</u>			
<u>Herd Size</u>			
<u>Nutrients produced (lbs/yr)⁵</u>	<u>100</u>	<u>200</u>	<u>300</u>
15. Ammonia nitrogen	7,027	14,054	21,081
16. Organic nitrogen	11,225	22,450	33,675
17. Phosphorus	4,212	8,424	12,636
18. Potassium	15,444	30,880	46,332
<u>Pounds of fertilizer nutrient equivalent available</u>			
19. Ammonia nitrogen (In 15 x 50% ⁶)	3,514	7,027	10,541
20. Organic nitrogen (In 16 x 70% ⁷)	6,735	13,470	20,205
21. Phosphate (In 17 x 2.3 ³ x 75% ²)	7,266	14,531	21,797
22. Potash (In 18 x 1.2 ⁴ x 90% ²)	16,680	33,350	50,039

* From Missouri Extension Publication MP-666.

¹Average analysis of lagoon waste. ²Average percent available to plant.

³Conversion of phosphorus to phosphate. ⁴Conversion of potassium to potash.

⁵Average analysis of tank liquid manure. ⁶Assumes 50% incorporated with 80% loss and 50% incorporated within two days with 20% loss. Value will increase if 100% incorporated within two days.

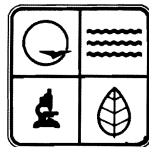
⁷Assumes not spread on same fields each year (50% available year 1 plus 10% year 2).

cation from lagoons via pipes, pumps and sprinkler irrigation is quite efficient in time, cost and nutrient utilization, since mechanical incorporation is not required to prevent excessive volatilization losses (Ref. Table 4). Table 6 shows the estimated nutrient availability per year for lagoon and liquid systems for three herd sizes.

References

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