Calculating Nutrient Application from Liquid Manure Irrigations

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As part of an effective nutrient management plan, it is important to document the nutrients applied to *each* land application area to maximize efficiency (water and nutrient management) and yield. Additionally, the Central Valley Regional Water Quality Control Board's Waste Discharge Requirement General Order for Existing Milk Cow Dairies restricts nutrient application and requires documentation of total nutrients applied to each land application area.

An important part of documenting nutrient application is keeping good field records during liquid manure applications. Tools available to assist with field record-keeping can be found in the CDQAP WDR Reference Binder, at http://www.cdqa.org and at http://manure.uddavis.edu. With good records, calculating the nutrients applied to each field is a simple, 3-step procedure:

1. Determine how much liquid manure was applied
2. Find out the nutrient content of the material
3. Calculate the total nutrients applied

Written descriptions of the basic steps are provided below to assist the user in completing the accompanied worksheets. Excel-based worksheets with automatic calculations can also be found at the above mentioned websites.

Step 1: Determine How Much Liquid Manure Was Applied

The volume of liquid manure applied can be measured using three different methods. This guide supplies spreadsheets for calculating applied nutrients based on two of the methods- using flow meter measurements and using pump run time. The third method, measuring acre-inches of pond drop, is a complex method which requires additional information and techniques not provided in this document. Information on that method can be found at http://manure.ucdavis.edu/ in the worksheets section.

The method used for measuring volume applied will establish which worksheet should be used for the entire, three step process. Worksheet 1 provides calculations based on flow meter measurements while worksheet 2 provides calculations based on pump run time. When using the worksheets supplied in this guide, it is recommended that one worksheet be used for each field each cropping year so that you can keep a running total of the nutrients applied to allow for in-season comparisons and adjustments.

Flow Meter Measurements (Worksheet 1):

There is only one calculation required if you have flow meters on your liquid manure application system:

Reading at end – Reading at beginning = 1000 Gallons* applied

*Most meters give a x1000 or Kgal reading, and this is exactly the number you need in order to do the final calculation, don't add the zeros to get unit gallons. You may prefer to set your meter to read in hundred gallons. Divide 100 gallons (hgal) by 10 to get 1000 gallons.

In *Worksheet 1. Calculating nitrogen applied using flow meter readings*, transfer the meter start reading to column I and the meter end reading to column J. Then, calculate:

Column J – Column I = Column K

This is the total volume of liquid manure applied in gallons times 1000. The following nutrient application calculations take into account the x1000 gallons unit, so don't change that.

Pump Run Time Measurements (Worksheet 2):

This calculation gives an estimate of volume applied based on the pump capacity in gallons per minute (gpm) and the length of time the pump ran during irrigation. Using *Worksheet 2. Calculating nitrogen applied using pump flow rates*, write the start date and start time, end date and end time, and the rate of application in gpm in the appropriate columns. Then, figure out how many hours the pump ran. This calculation for volume applied requires two formulas:

1. Run time (hours) x 60 min/hour = Run time (min)

   Column I X 60 min/hour = Run time (min)

2. [Run time (min) x Pump capacity (gpm)] / 1000 = Volume applied (1000 gal)

   [Run time (min) x Column J] / 1000 = Column K (Volume applied in 1000 gal)

   ***Important: calculations must be made in 1000 gal to use the remainder of the worksheet-do not alter units or calculations will be incorrect.

Step 2: Find Out the Nutrient Content of the Material Applied

The WDR General Order requires a minimum of quarterly sampling of liquid manure during land application events. These quarterly samples must be analyzed by a qualified laboratory for: **ammonium-nitrogen, total Kjeldahl nitrogen, total phosphorus, and potassium**. Your crop consultant may request additional analyses to more closely track the nutrient content of the liquid manure for the purpose of enhancing yield. The more samples that were taken, the more information will be available to assist you in calculating accurate results. Evaluating all the samples that were collected, choose the sample which best represents each liquid manure application

Your laboratory reports will show the total Kjeldahl nitrogen (sometimes written TKN) and ammonium-nitrogen (sometimes written NH_4^+-N). The results will be reported in either ppm or mg/L-these units are equal and either may be used in the calculations without further conversion.

Use your worksheet (either 1 or 2 depending on the method used to measure volumes applied in step 1). Write the NH_4^+-N value in column M. Subtract the NH_4^+-N value from the TKN value to get organic nitrogen (Org-N).

total Kjeldahl nitrogen (TKN) - NH_4^+-N = Org-N

Write the Org-N value in column N in the worksheet.

Step 3: Calculating the Amount of Nutrients Applied

Calculations for Nitrogen (using either worksheet 1 or 2)

We have all the information we need to calculate the total nitrogen applied to the field, but we need to make several calculations to get there:

1. NH_4^+-N applied (lbs) = NH_4^+-N (ppm or mg/L) x Volume applied (gal x1000) x 0.008345

   Column O = Column M x Column K x 0.008345

   (Note: 0.008345 is the conversion factor for the x1000 gallons unit insisted upon earlier.)

2. Org-N applied (lbs) = Org-N (ppm or mg/L) x Volume applied (gal x1000)

   Column P = Column N x Column K x 0.008345

3. Total Nitrogen applied (lbs) = NH_4^+-N applied (lbs) + Org-N applied (lbs)

   Total Nitrogen applied (lbs) = Column O + Column P

Nitrogen applied versus nitrogen available

For agronomic purposes, calculations need to be made to determine the amount of nitrogen *available* to the plant. Crops can only use nitrogen in two forms- ammonium nitrogen (NH_4^+-N) and nitrate-nitrogen (NO_3-N). Organic nitrogen (Org-N) must first be mineralized by soil microbes to available forms (NH_4^+-N or NO_3-N) to be used by plants. Estimating the rate of mineralization can be complicated. The rate will vary depending on the

- soil temperature
- soil moisture content
- if solids remaining went into the soil or remained as a crust
- the time left in the crop season
- the nature of material applied

A common conservative estimate is 30-50 percent, however care should be taken not to assume too much is available and inadvertently short your crop. Once you have created an estimate appropriate for your circumstances, record the value (%) in Column S of your worksheet to allow you to calculate the total nitrogen that was available to the crop. Comparing the amount available to the amount needed will help you to decide whether you need to apply additional nutrients mid-season to meet crop needs. Remember that, if you need to exceed the 1.4x crop removal limit, you must test the plant tissue for total nitrogen prior to any nutrient application.

Calculating the available nitrogen is completing in the worksheet by using the following four steps.

1. Total NH_4^+-N (lbs/acre) = Total NH_4^+-N applied (lbs) / Acres

   Column Q = Column O / Column C

2. Total Org-N applied (lbs/acre) = Total Org-N applied / Acres

   Column R = Column P / Column C

3. Available Org-N (lbs/acre) = Total Org-N applied (lbs/acre) x Mineralization%

   Column T = Column R x (Column S / 100)

4. Available N (lbs/acre) = Total NH_4^+-N (lbs/acre) + Available Org-N (lbs/acre)

   Column U = Column Q + Column T

<u>Calculations for Phosphorus and Potassium (worksheet 3):</u>

Compliance reporting requires total elemental phosphorus and potassium. Enter lab results for these in columns G & H. The calculation for the amount of phosphorus (P) and potassium (K) is completed similar to the nitrogen calculations, by multiplying the concentration by the thousand gallons applied by the 0.008345 factor (columns I and J). To calculate pounds applied per acre divide by number of acres included in the application area. Fertilizer P and K is traditionally reported as P_20_5 and K_2O equivalent. When you discuss fertilizer applications with your crop consultant the P and K needs for your crop will be provided in these units. To convert the elemental P and K values in your liquid manure to their fertilizer equivalents, multiply phosphorus (P) by a factor of 2.27 and potassium (K) by a factor of 1.2 – enter these values in columns M & N.

Worksheet 1. Calculating nitrogen applied using FLOW METER READINGS

Farm: ____________________________________

Field: ____________________________________

Year: ______________________

B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Location	**acres**	irrigation number	**date start**	**time start**	**date end**	**time end**	**1000 gallons at start**	**1000 gallons at end**	**1000 gallons applied (J - I)**	average recorded gpm	ppm or mg/L NH4-N	ppm or mg/L Org N	total lbs NH4-N applied (K x M x .008345)	total lbs Org-N applied (K x N x .008345)	lbs NH4-N per acre (O / C)	lbs org-N per acre (P / C)	est. % Org.-N available	estimated avail. Org. N per acre R x (S /100)	total avail. N per A (Q + T)	Total N applied per acre (Q+R)	hours run time (G+H) - (E+F)	gpm (K / W x 16.7)

Worksheet 2. Calculating nitrogen applied using PUMP RUN TIME & GPM

Farm: ______________________________

Field: ______________________________

Year: ________________

B	C	D	E	F	G	H	I	J	K	M	N	O	P	Q	R	S	T	U	V
Location	**acres**	irrigation number	**date start**	**time start**	**date end**	**time end**	hours run time (G+H) - (E+F)	average recorded gpm	1000 gallons applied (I*60*J)/1000	ppm or mg/L NH4-N	ppm or mg/L Org.-N	total lbs NH4-N applied (K x M x .008345)	total lbs Org-N applied (K x N x .008345)	lbs NH4-N per acre (O / C)	lbs org-N per acre (P / C)	est. % Org.-N avail-able	estimated avail. Org. N per acre R x (S/100)	Total avail. N per acre (Q+T)	Total N applied per acre (Q+R)

Worksheet 3. Calculating the amount of Phosphorus (P) & Potassium (K) applied

Farm: ______________________

Field: ______________________

Year: ______________

B	C	D	E	F	G	H	I	J	K	L	M	N
Location	**acres**	irrigation number	**date start**	1000 gallons applied (from N sheet)	P mg/L	K mg/L	total lbs P applied (F x G x .008345)	total lbs K applied (F x H x .008345)	lbs P per acre (I / C)	lbs K per acre (J / C)	lbs P205 per acre (K * 2.27)	Lbs K20 per acre (L * 1.2)