Calculating Nutrient Application from Liquid Manure Irrigations Using GPM and Run Time

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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. Even if you have a professional prepare your annual report, keeping your own running totals of nutrients applied during the cropping season will help you make management decisions that protect yields and avoid surprises at reporting time.

With good records, calculating the nutrients applied to each field can easily be done using a calculator and this simple worksheet.

To find out how much nitrogen you applied to each field, you will first calculate the gallons of liquid manure (lagoon water) that was applied, you will need a measure of the amount (volume, in gallons or acre-inches) of undiluted lagoon water applied to each field, and a laboratory analysis of a representative sample of that same undiluted lagoon water. This worksheet uses the flow rate and run time information to estimate gallons applied.

Since standard pump testing methods don't work with liquid manure, producers may not know the flow rate from their lagoons. Also, the flow rate declines significantly as the pond is emptied. The gpm from a lagoon pump or gravity flow rate by pond depth can be estimated by temporarily shutting off all other inflows and outflows and timing how long it takes for the pond to drop from one depth increment to the next. An easier way is to install a temporary flow meter and observe the record the flow rate at each pond level. Instructions for both of these methods and templates to make a chart of flow rate by depth in the pond are on the UC Manure Nutrient Management website:

http://manure.ucdavis.edu or http://anr.sites/ucmanure.edu

A field data sheet specifically designed to accommodate the information you need to collect during applications when using the gpm or pond drop method can be also download from the UC Manure Nutrient Management website.

Once you have collected the data you need, the following instructions will help you fill out a worksheet to calculate nitrogen application rates by hand using estimated gpm and run time to measure how much went out. Use one of the other guides and worksheets if you use pond drop or a flow meter to measure volume applied. These guides and worksheets are available on the UC Manure Nutrient Management website. Excel-based spreadsheets with automatic calculations are also available.

When using the hand calculation worksheet, it is recommended that <u>one worksheet be used for each field each cropping year</u> so that you can keep a running total of the nutrients applied to each field. This will help you determine if you are meeting your application targets for each field so that you can make in-season adjustments if needed.

GPM and Run Time Measurements Worksheet Instructions

1. **Transfer information from the field data sheet to the calculation worksheet**
2. **Calculate volume applied in 1000 gallons**
3. **Choose a sample analysis to use with each application**
4. **Calculate pounds of total and ammonium nitrogen applied to each field**
5. **Divide total pounds per field by the number of acres to get pounds per acre**
6. **Determine how much of the nitrogen applied is actually usable by the crop.**

1. Transfer the data collected on the irrigation data sheet to the calculation worksheet.

It is best to use a separate worksheet for each field. Transfer the location, acres, start date and time and end date and time for each field. If you prefer, simply record the number of hours that the lagoon water ran. Estimate the flow rate in gpm by using the gpm that most closely corresponds to the depth of water in the pond at the time of irrigation and put that value in column I.

Special Case: The lagoon water flow was split and went to more than one field
You will have to estimate what percent of the total flow went to each field. This can be difficult, and it is recommended that each separate stream be measured and throttled individually when installing flow meters.

Calculate the total gallons applied by multiplying minutes run time by gpm. Multiply the total gallons applied by the percentage that went to each field.

If Field 1=70%, Field 2=30%
Total Kgals x .7 = Kgals for Field 1
Total Kgals x .3 = Kgals for Field 2
Put the calculated Kgals associated with each field in column J

*Kgals = thousand gallons = 1000 gals

2. Calculate the volume of lagoon water applied in 1000 gallons.

Calculate how long the lagoon pump or pipeline ran and put the hours in column H. Multiply the hours run time by 60 to get run time in minutes. Multiply the minutes run time by the average gpm for the field (column I) and divide by 1000 to determine how many Kgals (thousand gallons) were applied to the field.

Make sure the liquid manure volume in column J is in 1000 gallons (Kgals, or gallons times 1000) before proceeding.

Converting Gallons to Acre-Inches
(gallons ÷ 27,154) ÷ acres = acre-inches
(Kgals ÷ 27.154) ÷ acres = acre-inches

3. Choose a sample to correspond to each application.

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**. You may have taken additional analyses to help you manage your nutrients more accurately. Evaluating all the samples that were collected, choose the sample which best represents each liquid manure application. Write the sample identification in column K, and the total Kjeldahl nitrogen (sometimes written TKN) and ammonium nitrogen (sometimes written NH_4^+-N) concentrations in columns L and M. The laboratory results should have this data reported in either mg/L or ppm; these are exactly the same and either can be used without further conversion.

4. Calculate the amount of nitrogen applied per field

a. TKN (Total N)

TKN is a measurement of total nitrogen. It includes both the ammonium and organic forms of nitrogen. The water board determines compliance based on total nitrogen applied.

TKN-N applied (lbs) = TKN-N (ppm or mg/L) x volume applied (gal x1000) x 0.008345

column J x column L x 0.008345 = column N

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

Atoms vs. Molecules

The "-N" designation means that this is the concentration of just the nitrogen in the ammonium or TKN. If the concentration of the entire molecule that contains the nitrogen atoms were reported, it would be written as NH_4. It makes a difference because NH_4-N will always be in lower concentration than NH_4. When working with more than one form of nitrogen, it is easier to deal with just the nitrogen portion of the molecules. Be sure to check which reporting method is being used by your laboratory.

b. Ammonium-N

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

column J x column Mx 0.008345 = column O

5. Calculate the amount of nitrogen applied per acre.

Divide the total pounds of TKN N and ammonium-form N applied to the field by the number of acres in the field.

Total lbs TKN or ammonium per field ÷ acres/field = lbs/acre N applied

column N ÷ column B = column U

column O ÷ column B = column P

Do your results look like they are reasonable? If not, check to see if the data was transcribed accurately and recalculate as needed. The calculations that you have completed to this point are all you need for reporting to the water board. However, in order to manage your crop, you will also need to calculate how much of the total nitrogen applied is in a form that the crop can actually use.

6. Calculate the amount of available nitrogen applied

While all forms of nitrogen applied need to be reported, crops can only use nitrogen in two forms- ammonium nitrogen (NH_4^+-N) and nitrate-nitrogen (NO_3-N). A significant portion of the nitrogen in liquid manure and most of the nitrogen in dry manure is in the organic form, which must be broken down by microbes into ammonium or nitrate before the crops can use it.

TKN, or Total Kheldahl Nitrogen, measures the nitrogen in both the organic and ammonia forms. Calculate the amount of organic nitrogen applied by subtracting the ammonium content from the TKN.

TKN-N lbs/acre - NH_4^+-N lbs/acre = Organic-N applied lbs/acre

column U – column P = column R

Now that we know the amount of organic nitrogen that was applied, how much of it will become available to this crop? The process of converting organic nitrogen to crop-available nitrogen is called mineralization. How fast this occurs depends on

- How much entered the soil vs what remained on the surface in the crust
- soil temperature
- how resistant the material is to being broken down by microbes
- the time left in the crop season
- soil moisture content

A common conservative estimate is that 30 to 50 percent will become available for the current crop. However, be careful not to assume too much is available right away and inadvertently short your crop. Record your estimate of what will percent of the organic nitrogen will become available to the crop either in the next couple weeks or for the crop season in Column S. Divide the percent by 100 and multiply by the pounds per acre of organic form nitrogen to calculate estimated available nitrogen.

Organic nitrogen lbs/acre x % available = available N lbs/acre from organic N

(column S ÷ 100) x column R = column T

Add the available N lbs/acre from organic N to the ammonium-form N that was already in the available form to find the total amount of available nitrogen from this application:

column P + column S = column T

Compare the amount of available nitrogen you applied to the amount that your crop needs. Remember that significant losses of nitrogen can occur during irrigation if the amount of water applied exceeds the amount of water the soil can store. Available nitrogen that was present early in the season may not still be there when the crop needs it.

If you need to exceed the 1.4 x crop removal limit, regulations require that you must test the plant tissue for total nitrogen prior to any nutrient application.