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Sizing and Management of Manure Runoff Storages

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ABSTRACT:

Manure runoff storages on 21 Southern Ontario farms were measured once a month for one year to determine runoff volumes from typical dairy and beef yards and solid manure storages. Current sizing information allows for runoff volumes totalling 45 mm/month x AREA for solid manure storages and feedlots, and 70 mm/month x AREA for roof runoff and direct precipitation into the storage. These numbers proved adequate during 1990/91 when the precipitation was 24% above the 30 year average.

Sizing and Management of Manure Runoff Storages

by: Sam Bradshaw and Ron Fleming, Centralia College

The design of livestock manure storages has changed over the years. One of the enhancements that farmers are accepting now is the runoff storage to contain contaminated liquid from solid manure storages and/or feedlot areas. This liquid results mostly from precipitation. Volumes can be large enough to pose a potential threat to the quality of nearby surface water.

Initially, the sizing of runoff storages was based on information contained in the Canada Animal Manure Management Guide (Agriculture Canada, 1979). This guide contains formulas which base the volume of runoff on: a) the surface area of feedlot or manure storage; b) average precipitation; c) 24 hour precipitation from a 1 in 25 year storm; and d) whether the surface is paved or unpaved. Applying the formulas to typical Southern Ontario conditions yields the following runoff volumes:

25 mm/month x Area for a paved solid manure storage
50 mm/month x Area for a paved feedlot

Experience showed that the volume of runoff from solid manure storages exceeded this number (Fleming, 1987). The current sizing standard is based on the assumption that most Ontario farms receive about 960 mm of precipitation annually. This precipitation tends to be fairly evenly distributed throughout the year.

Currently, tanks are sized to hold:

45 mm/month x Area for a paved solid manure storage
45 mm/month x Area for a paved feedlot
70 mm/month x Area for roof runoff
70 mm/month x Area for direct precipitation into the runoff storage

Several runoff control tanks have been sized in Southwestern Ontario using these standards. Generally, farmers have been satisfied with the capacity of their tanks. However, from time to time, reports come in suggesting that a tank is too small to hold the runoff for the required storage period (usually 200 days). Very seldom does a farmer complain about a tank being too large.

Much design information is available from research completed in the United States. However, many of the calculations are based on a 24 hour duration, and 10-25 year recurrence storms. These studies have been based mainly on runoff from large unpaved feedlots, with provisions for pumping the effluent onto the land after every rainfall (Gilbertson et al, 1980; Koelliker et al, 1975). Ontario climatic conditions dictate that manure and runoff be stored for at least 6 months and preferably two hundred days, or more, to conserve nutrients for crop production and to reduce the possibility of contaminating watercourses.

The value of plant nutrients in manure runoff has also been questioned. Some farmers view this liquid as dirty water only. Runoff storages are an added cost to any farm operation and farmers need to know the approximate value of the contained liquid to be able to determine the payback period of this capital expense.

Objectives

A one year study was begun at Centralia College to determine the quantity and quality of runoff from yards and manure storages of typical dairy and beef farms in Southwestern Ontario. Management aspects were also recorded with a view to determining:

1. The number of times manure was being spread per year;
2. The problems involved and methods used to separate liquids from solids;
3. How many farmers allowed roof water or clean surface water to enter their runoff tanks.

Procedure

Twenty-one farms were chosen over a 6 county area, including 19 dairy farms and 2 beef farms. The first visit was made in May, 1990. The following information was gathered: number and size of animals, type of manure handling equipment, size of manure storage pad, slope of pad, size of yard, type of floor, separation method, and areas contributing to runoff such as roofs, driveways, milkhouse washwater, etc. Liquid storages were measured so that volumes could be calculated.

During the first visit, manure samples were taken. Liquid tanks were sampled at 2 locations, and at 3 depths for each location. Two representative samples of solid manure were gathered. The samples were sent to the Analytical Services Laboratory at the University of Guelph to be analyzed for N, P, K, Ca, Mg, NO_3, NH_4 and percent dry matter. Samples were taken again in October.

Once a month for a year, each farm was visited. On each visit the level of liquid in the runoff tank was measured, conditions of the cattle yard were assessed, and amount of solid manure in the storage was recorded.

Daily precipitation records were obtained from the Canadian Atmospheric Environment Service, using stations located close to each farm surveyed. These records were used in determining total precipitation amounts.

Results

All 21 farms in the survey used a concrete tank with vertical sidewalls to collect runoff. Two had concrete tops. Three tanks were omitted from the survey after 6-7 months. One of these tanks, probably due to management problems, constantly overflowed. Another farm that was omitted used a plunger-type pump to move solid manure from the barn to a rectangular concrete storage. This operator used stop logs to fill the gap in one wall intended for tractor access. This solid storage was connected to a rectangular liquid tank via a pipe. Liquid and solid separation was to be achieved by using vertical planks with 50 mm spacing in one corner of the solid tank. Liquid collected in all corners. When the stop logs were removed from the solid storage to allow tractor access, a quantity of liquid and semi solid manure ran out. The stop logs were not replaced allowing liquid to constantly escape.

The third omitted farm, using a plunger-type pump to move solid manure into a concrete storage, also experienced difficulties separating the liquid fraction from the solid. This farmer used vertical cattle slats with one inch openings as a screen to separate the liquids from solids. The cattle slats formed one wall of the solid storage adjacent to the liquid tank. The openings in the screen plugged and would not allow liquids to run into the tank. The farmer removed the vertical slats. As a result, manure flowed into the liquids tank.

Of the 21 farms, 7 used a plunger pump or an air mover to transfer solid manure from the barn through a pipe to storage. In all 7 cases, the solid storage consisted of a concrete pad with 1 to 2 m high concrete walls around the perimeter. Liquid separation is a problem with these systems. The manure is homogenized when it flows through the pipe and tends to flow like lava when it enters the solid storage. Liquids tend to collect in the corners.

Five of the 7 systems worked. The 2 that didn't work used cattle slats on end or planks on end with 25 mm - 40 mm slots to form one wall of the storage. Neither of these would let liquids through. Of the 5 systems that worked, 2 used slotted openings 125 mm wide by 600 mm long. All 5 solid storages that worked were large enough that the manure did not build up more than 1 meter deep around the edges. They also had an alternative route, in the form of an open channel, for liquids to flow.

All tanks were supposedly sized to hold runoff for a minimum of 200 days. When the sizing of tanks was checked for this study, the average predicted storage capacity was 237 days. However, 7 tanks had predicted capacities of less than 200 days. The actual average (measured) capacity was 219 days. Figure 1 shows average storage capacities for different farm operations. When the storage collected runoff from only a solid manure pad and yard, the measured capacity was considerably less than expected - suggesting that the formula: **45 mm x Area** is still not large enough.

Six of the 18 tanks that completed the study were full to overflowing in April, 1991. These tanks were actually able to hold runoff for much less time than expected. In one case, the tank was capable of storing liquid for only 96 days. It appears that it is sometimes difficult to get the accurate information needed to size tanks properly.

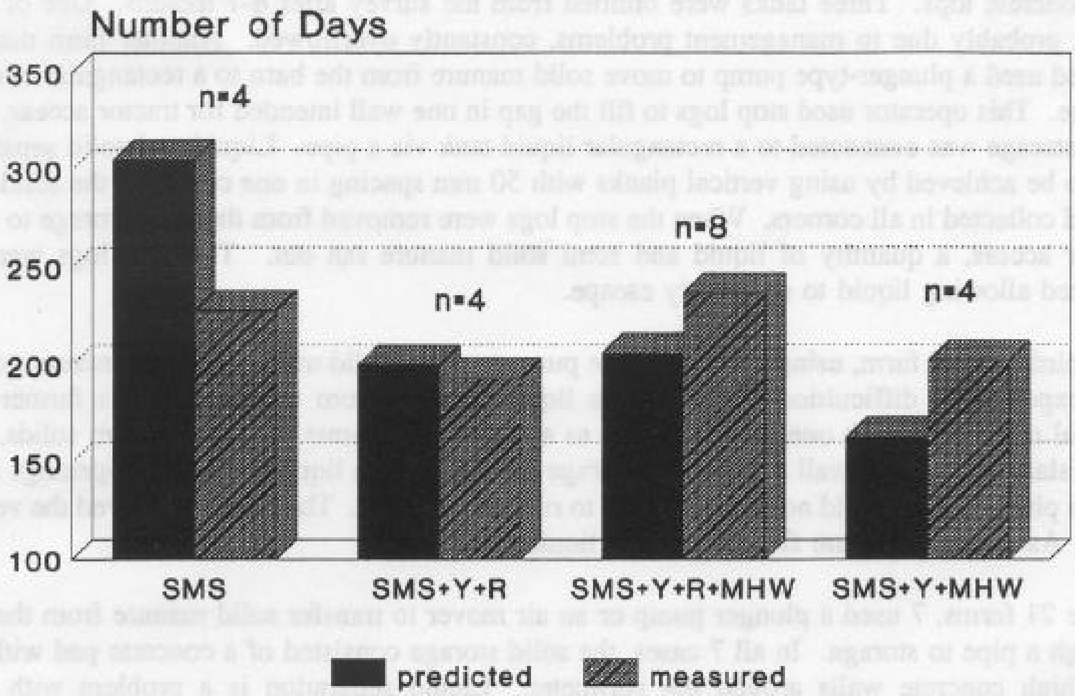

Figure 1 Storage capacities of runoff tanks, predicted and measured (SMS=solid manure storage; Y=yard; R=roof; MHW=milk house washwater)

The average annual precipitation in the study area for the past 30 years was 959 mm. Precipitation for the year 1990 to 1991 was 1185 mm. This is 24% above average. Even with the extra precipitation, most tanks held the runoff for 200 days. This suggests that present design standards are adequate.

Coote et al (1976) reported that total annual runoff, averaged over a 2 year period, from a paved solid manure storage was 2150 m^3/ha (.22 m/m^2) and 3359 m^3/ha (.34 m/m^2) from a paved feedlot. This was 31% and 48% of total annual rainfall, respectively. Our study combines the flow from paved solid manure storages and paved feedlots. Runoff averaged .84 m/m^2 or 71% of the total annual precipitation received in 1990-91. This is based on 4 farms.

Information on the nutrient content of the solid manure and runoff liquid is shown in Fig. 2. What this graph tells us is that the concentration of nutrients was much higher in the solid manure than in the liquid. It also points out the drop in values (especially with solid manure) in the fall sampling compared to spring. Dickey et al (1976) reported the same findings. The geometric mean dry matter concentrations were 20.5% for solid manure and 0.62% for the liquid.

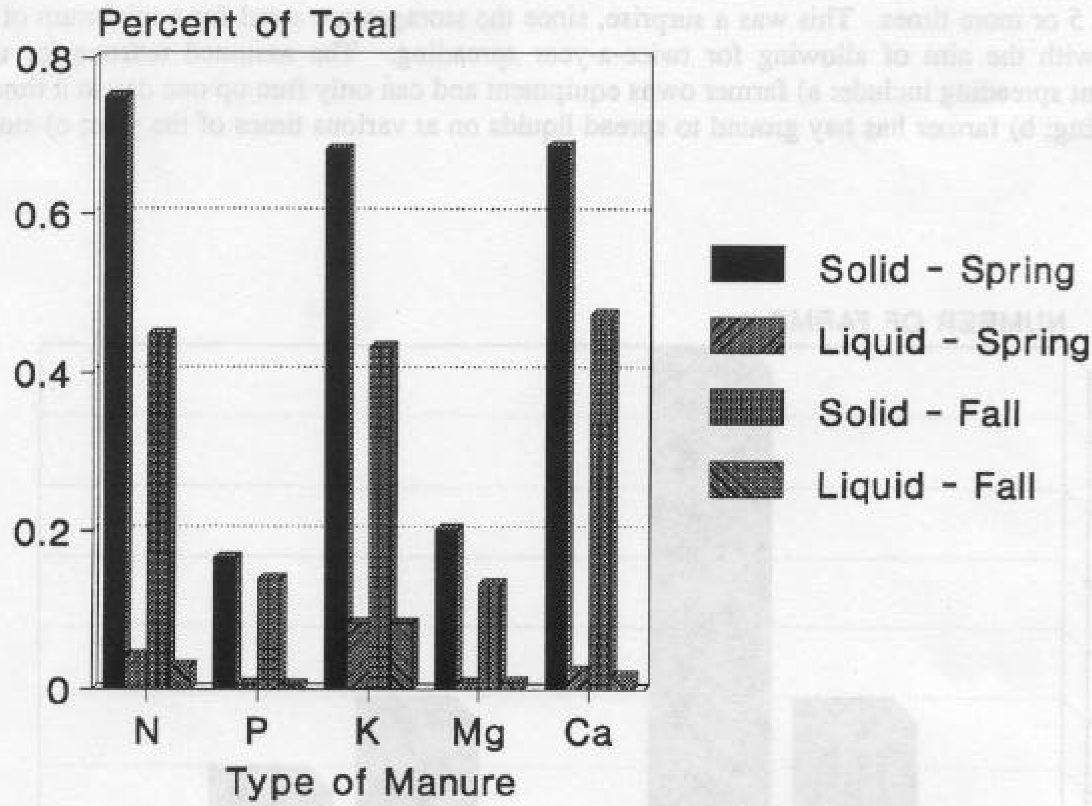

Figure 2 Concentration of nutrients in solid manure and runoff liquid sampled in spring and fall

This value for total solids concentration in runoff is much lower than the 3.5% estimated by Gilbertson et al (1980). The large amount of dilution with the liquid explains why the concentration of nutrients is so low compared to the solid manure. Expressed as a percentage of total solids, the total N for the liquid is actually 5.6%, and for the solid manure is 2.8%.

Only a portion of the total manure-N is available to the growing crop at the time of manure application. It is usually assumed that most of the ammonium form (NH_4-N) is available for crops. The geometric mean concentration of NH_4-N was 68 mg/kg for liquid and 30 mg/kg for solid manure. These numbers represented 20% and 0.5% of the total N for the liquid and solid, respectively.

Of most interest to the farmer will be an approximation of the nutrient application rate for a specific volume of liquid. Using the average results of this study, for every 10 m^3 (2200 gal.) of runoff liquid spread onto the land, the amounts of N, P_2O_5, and K_2O available to the crop would be 1.7, 0.6, and 9.1 kg, respectively. This assumes availabilities of 50%, 40%, and 90% for N, P_2O_5, and K_2O respectively. The corresponding amounts of nutrients for the same weight of solid manure would be 28, 14, and 58 kg.

Of 18 farms that completed the study, 15 spread liquids 3 or more times a year (see Fig. 3). Six spread 5 or more times. This was a surprise, since the storages are sized for a minimum of 200 days, with the aim of allowing for twice-a-year spreading. The assumed reasons for more frequent spreading include: a) farmer owns equipment and can only free up one day at a time for spreading; b) farmer has hay ground to spread liquids on at various times of the year; c) storage

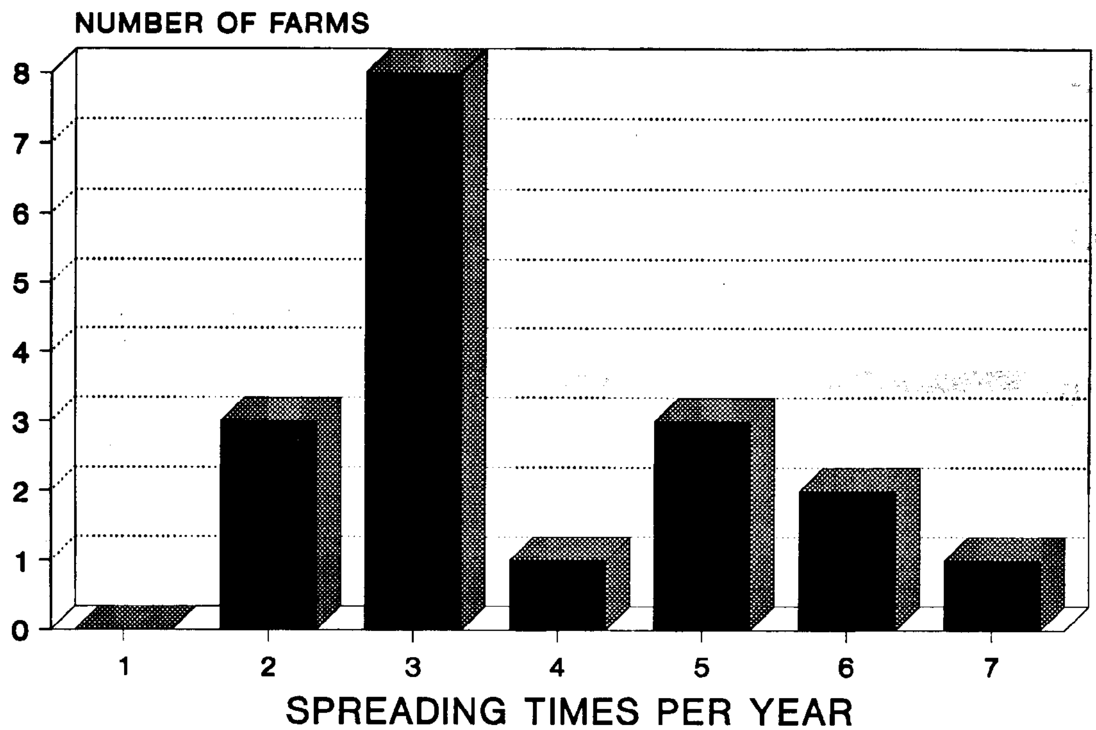

Figure 3 Number of times farmers spread liquid in one year

wasn't big enough, in some cases.

Different methods were used to separate liquids from solids. These included concrete cattle slats on end with 40 mm slots, concrete walls with 120 mm x 600 mm slots, and open channels. Generally, the smaller openings plugged quickly, especially when solid manure was pumped into storage. In all cases, open channels or gutters worked best at directing the liquids into the tank.

Twelve out of 20 farms allowed roof water to enter the storage. On average, roof water accounted for 20% of the volume in these storages.

Conclusions and Recommendations

1. All contaminated liquid runoff should be stored for at least 200 days and spread on the land to avoid possible contamination of streams and watercourses.
2. The existing standards for sizing runoff storages appear to be adequate.
3. Uncontaminated roofwater accounted for 20% of the volume of some tanks. Roofwater should be directed away from yards and storages.
4. Separation of liquids from solids is easiest when the solid manure doesn't build up to a significant depth (< 1 meter) at the storage sides, and where the separation fence contains large openings (200 mm+). Open channels and gutters work best in all cases for directing liquids into the tank. When designing a new system where solid manure will be pumped into storage, consideration should be given to handling the stored material as a liquid. This would avoid the problems associated with separating the liquids from the solids.

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