Covers and Others:
The Latest Techniques in Manure Processing, Handling and Storage

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Straw covers

In the early 1990s, the Prairie Agricultural Machinery Institute (PAMI, 1993) tested a variety of coverings to control odours associated with earthen manure storages. Their studies examined:

- Performance of various straw types and qualities
- Performance of artificial flotation devices for straw support
- Performance of a shredder/blower device for straw application
- Problems during pump-out caused by straw or flotation devices
- Costs of straw-covering systems

Results showed good quality barley straw to be the most effective material for unsupported cover. Flax and oat straw sank too quickly. Wheat straw lasted about one third of the time of barley straw. As flotation devices, polystyrene sheets and empty plastic bottles performed satisfactorily although leaking bottles caused pump problems during agitation. These devices were found to be too cumbersome and the cover's effectiveness was not sufficiently enhanced to warrant the additional time and expense. From this work, a modified bale processor with a blower cannon called the "top gun" was developed and manufactured by Hyline Manufacturing from Vonda, Saskatchewan. A number of Soil Conservation groups leased a unit for three years to demonstrate the straw covering process to determine its practical usage. The unit requires a 150-hp tractor with a 1000 rpm PTO.

Each year approximately 50 to 60 earthen storages are covered. The success of the straw covering is very dependent on the availability of good quality dry barley straw. Operator experience plays an important part in the longevity of the cover. Being able to apply a uniform layer of 8 to 10 inches of straw particularly with larger storages and under windy conditions becomes an "art" as much as anything. With ample coverage of good quality straw, the cover can last up to 5 to 6 months. Even with 15% of the surface area having "open" or "wet" areas due to straw sinking, odour suppression is considered quite good. However, poor quality straw or insufficient coverage depth can result in the covering lasting as little as one month.

Pump-out of straw-covered earthen storages has been a continuing source of debate. Actual reports of pumps or outlet nozzles on transport tankers being plugged are rare and are generally attributed to insufficient agitation. Directing the agitator nozzle to large straw clumps and having an agitator with chopper blades mounted on the end of the pump help break up and shred straw clumps ensuring a homogeneous pumpable product.

Negative Air Pressure (NAP) covers

In the fall of 1998, the first negative air pressure cover was installed in Manitoba. The system consists of a high-density polyethylene cover that floats on the manure surface and is held in place by the negative air pressure created by small centrifugal fans. Perforated tile is laid around the perimeter on the inside of the downslope of the storage dyke. A number of laterals running down the slope are teed into the perimeter tile, which is connected to the fan. The edges of plastic

are anchored at the top of the dyke by laying the plastic into an excavated trench and refilling the trench with the excavated soil. Precipitation, which remains on the top of the cover, helps hold the cover in place. Water is removed with a small pump at cleanout. Gas bubbles will form under the cover. These pockets of trapped gas eventually work their way to the edge of the storage and are picked up by the fan's ducting system.

Agitation of the storage necessitates the removal and reapplication of the cover after cleanout. An experimental agitation system using compressed air was installed with some success. A modified system is to be installed this coming year. If successful, the cover may not have to be removed or only partially removed to facilitate storage cleanout. This would help extend the life of the plastic as well as eliminate or reduce annual removal costs.

Economics of Straw/NAP Covers

A comparison of the two covers systems was made for a 175 ft. x 250 ft. (1,994,577 imperial gallons) earthen storage. Based on the following:

Custom rate calculation:

	1 Tractor (150 hp)	1 Tractor (70 hp)	FE Loader	Straw Blower
Fixed	24.05	9.02	3.93	21.43
Rep & Mtn	6.00	2.25	1.95	7.83
Margin 15%	4.51	1.69	.88	4.39
Fuel	12.00	6.51	ins.	1.67
Labour	10.00	10.00		
	$56.56	$29.47	$6.76	$35.32

- Custom Rate per hour - $ 128.11

Annual costs of covering with straw:
175 x 250 = 43,750 sq. ft. 1,994,577 gal.

Straw: 1 bale/750 sq. ft.
# of bales - 58 bales
cost/bale - $12
Total $ 696.00

Application: rate - 8 bales/hr.
# of hrs. - 7.25
cost/hr - $128.11
Total $ 928.80

Installation/Removal Costs NAP Cover Requirements

2 tractors (70 hp)
4 individuals @ 4 hours

Installation / Removal Cost calculation:

Tractor rent $19.47/hr x 2	$ 38.94
Labour 16 man hours @ 10.00	160.00
	$ 198.94

Cover cost benefit:

COSTS:	Straw	Plastic
Materials	58 bales	43,750 sq. ft.
	$12/bale	$0.75/sq. ft.
Total Cost	$ 696.00	$32,812.50
Annual cost	$ 696.00	$ 6,302.38
Annual installation cost	0	$ 198.94
Annual application	$ 928.80	0
Total annual cost	$1,624.80	$ 6,501.32
Addition N	10,172 lbs	16,953.9 lbs
Price of N	$.35	$.35
Value of N	$3,560.20	$5,933.87
Net benefit	$1,935.40	$(- 567.45)

Note:

- ammonia nitrogen NH_3 for uncovered storage assumed to be 17 lbs./1,000 gal
- % increase in NH_3 for straw - 30% to 22.1 lb./1,000 gal
- % increase in NH_3 for NAP cover - 50% to 25.5 lb./1,000 gal
- Price of N - $0.35/lb.
- assumes only one covering of straw with no additional agitation or cleanout costs
- based on a seven-year life expectancy for the plastic at a cost of $0.75/sq. foot.

Both systems provide effective odour control. Certainly any change in the variables can have a dramatic effect on the economic benefits. The amount of increased nitrogen retention due to the covers is one of the most important variables. There is very limited data available and further research is required. The values used in this example are averages from one study (Small, 2001) and two actual manure samples of each cover type. The NAP cover costs vary from $0.50 to $0.75 per square foot depending on the size and location of the storage. As the area and conversely the volume of storage increases, the unit cost for the NAP cover decreases and the straw cover remains constant. The greater the percentage of nutrient retention, the greater the fertilizer saving. With more answers to these variables and with increased fertilizer costs, covering storages would appear economically viable. Larger volume storages will provide a greater economic benefit.

Biofilters

A bio-filter is simply a bed of organic material, typically a mixture of compost and wood chips or straw. Exhaust air passing through the biofilter results in the microbes on the organic material converting odourous gases to carbon dioxide and water. Biofiltration can reduce odour and hydrogen sulfide emissions by as much as 95% and ammonia emissions by up to 80%.

The Biosystems departments of University of Minnesota (Janni, 1998; Nicolai, 1998) and University of Manitoba (Mann, 2001) have recently studied biofilters for odour control. The work in Manitoba with a biofilter on small finishing hog operation during the winter found good biological activity was maintained even at -30^{o}C to - 35^{o}C temperatures. The study used ordinary wooden pallets for bed support and a modified system that had varying duct depths. There was little performance difference between duct systems. From the study, the straw-based compost was more problematic than the wood-chip compost mix. Odour levels were significantly reduced when air retention time was increased. Dust, rodents and vegetative growth affected the performance of the biofilter. More research needs to be done to evaluate biofilter performance during the summer months. Typically livestock ventilation rates increase 15 to 25 times during the summer period. This creates a whole new set of scenarios, particularly if the depth rather than the area of the biofilter is increased to conserve space. For summer use, fans need to be ducted and booster fans used due to increased static pressure. Different balances in the compost/wood chips or straw mix may be more effective for summer use. Determining the optimal air retention time for a particular mix needs to be evaluated. An enclosed system would enable air filtration and improve control of moisture, rodents and vegetative growth.

Treatment systems

Treatment technologies (Masse, 2001) modify the biological, chemical and physical characteristics of livestock manure; the nature of the changes will depend on whether the treatment objectives are:

- to optimize the value of the manure
- to reduce odour levels
- to protect natural resources such as soil, air and water

Currently Manitoba has an adequate land base for its livestock manure to be applied as an agricultural fertilizer. Some treatment processes, such as aerobic digestion provide excellent odour control but are counter productive to nutrient conservation. In general, aerobic treatment:

- requires that the manure be diluted and therefore increases the volume of manure to be stored and applied
- promotes significant losses of ammonia
- does not always work well in winter
- has high capital and operating costs.

Large operations can find some advantages to separating the solid and liquids from a handling perspective in that:

- the amount of sludge and the agitation required are greatly reduced
- with reduced solids content, the viscosity is reduced allowing the manure to be pumped greater distances
- solids can be easier to store, compost and spread although requiring different storage systems and equipment

Separation is generally done using natural methods such as gravity separators, sedimentation tanks or two-cell storages. Solids are settled out by gravity and the liquid portion is removed. Mechanical methods such as vibrating or inclined screens or sieves, vacuum or pressure filters, or centrifuges and reverse osmosis, can be used but involve expensive equipment.

Dealing with solid accumulation is compounded as storage size increases. For the larger tanks, Managro Harvestor offers an over-the-wall agitator. This portable unit consists of a 40-hp three-phase electric mixer with an optional generator unit available for producers having only single-phase power.

This unit is lowered on a steel mast anchored to the floor structure. Direction and depth of agitation can be controlled from the top of the tank. Weighted units are also available but require a crank to lower into the tank.

For dealing with buildup in earthen storage, Assiniboine Injectors Ltd. has a remote-controlled dredger. The surface dredger augers off layers of solid with mixed surface liquid. It can either be pumped to a drying bed or to nurse tanks for transport to tanker injectors for field application.

Storages

There are many factors to consider when choosing the type and size of manure storage, such as;

- site topography
- depth of water table and bedrock
- soil types or the clay content of soil
- proximity of water and drainage systems
- size, number and type of animals housed
- the collection system in the barns
- labour required and costs

Earthen manure storages, concrete structures, both precast and cast in place, and steel tanks are commonplace. A couple of new storage structures have recently appeared on the Manitoba landscape. “Octaform” is a cast-in-place concrete storage which utilizes a unique “remain in place” vinyl form system. Wall-forming vinyl strips slide into a channeled and open mesh support system. This open mesh support system serves as a snap tie for the wall sections, as well as, a support for the horizontal rebar. Vertical reinforcing bar is installed from the top and the horizontal rebar is threaded through the mesh opening where a vinyl wall strip has been left out. Once all reinforcing is in place and secured, the openings are filled by sliding the vinyl strip back into place.

The “Slurry Pool” is a bolted galvanized steel-wall panel structure supported on screw-in foundation augers and a top-wind ring support. There is a double layered plastic liner sealed to the inner wall. The “Slurry Pool” can be dismantled and relocated to new sites with suitable soil bases or centrally located in spread areas.

Acknowledgements

The authors wish to acknowledge the valuable contributions to this presentation of the following individuals:
Loni Scott, Manitoba Agriculture and Food
Danny Mann - Biosystems Engineering, U of M
Doug Waterston - Managro Harvestor
Ron Jamault - Assiniboine Injectors Ltd.
Doug Small - Encon Technologies Inc.
Rene Rosset - Rosset Machinery Ltd
Bill Schmitke - Octaform

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