

Winter Manure Application: Management Practices and Environmental Impact

2016 Manure and Soil Health Working Group Data Brief

Background

The application of manure to frozen impermeable soils can increase the risk of manure nutrients and contaminants running off of fields during the spring thaw. Additionally, the loss of nutrients to spring thaws means a loss of soil productivity for farmers in addition to potentially impacting local water bodies (Thompson et al., 1979). As such, organizations such as the US Environmental Protection Agency (EPA) and the Natural Resource Conservation Service (NRCS) have traditionally discouraged manure application during winter (NRCS, 2013). However, winter manure application has several key benefits to farmers (Fleming and Fraser, 2000):

- Reducing the size and number of manure storage structures.
- Spreading the manure when logistics suite the farmer.
- Reducing soil compaction by avoiding equipment use on compressible soil conditions.

Winter manure application can also make a great financial impact on small farmers. A 2016 survey conducted in Michigan found that a total ban on winter application would cost small farms in the State an estimated \$30 million a year collectively, with 27% of small dairy farms replying that they would need to suspend operations in the event of such a ban (Miller et al., 2017).

Despite these benefits, the preponderance of evidence suggests that applying manure to frozen or snowy impermeable soils carries an increased risk of releasing contaminants of concern via runoff in the spring (Komiskey et al., 2011; Lewis and Makarewicz, 2009; Owens et al., 2011; Williams et al., 2010). This is especially relevant given recent findings out of the National Oceanic and Atmospheric Administration (NOAA). In an effort to better predict the presence and extent of harmful algae blooms (HABs) in Lake Erie, NOAA conducted a series of regression analyses comparing factors commonly attributed to algae

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blooms with the observed bloom density. These regressions found that the most predictive single factor was spring influent of phosphorous to the lake system (Stumpf et al., 2012). In short, the very time that winter manure application is likely to run-off is the single most sensitive time for the lake system. Manure is far from the only potential source of spring phosphorus to the Great Lakes, but it still reinforces the message that we as agriculturalists need to reduce the risk of runoff events. To that end, a literature review was conducted by Smith et al. (2017) to determine the state-of-the-science regarding risk factors, policy, and best management practices. Below is a bulleted list of the report findings categorized by key issue areas.

Effect of Application Timing

- With regard to timing, spring and fall appear to be preferable to winter for manure application. If winter application must be conducted, application in early winter is generally considered less risky. Manure application with close proximity to a thaw event is to be avoided at all costs.
 - » A 4 year study in Wisconsin (Komiskey et al., 2011) showed that nitrogen and phosphorus losses were heavily dependent on timing of manure application for both liquid dairy and solid beef manure. Late fall and early winter applications were much preferred to late winter. Applications within one week of runoff events were found to be catastrophic.
 - » Pappas et al. (2008) found that enterococcus and *E. coli* levels in drainage water were greater on winter applied manure when compared to spring and fall, though this was likely due to the lack of manure incorporation for the winter spreading event (winter manure was broadcast, spring and fall were incorporated).
 - » Phillips et al. (1981) spread liquid dairy manure onto a 0.8% slope varying the time of year applied with fall, winter, and spring being the periods of investigation. The runoff values for all nutrients investigated (nitrogen, phosphorus and potassium) were statistically significantly higher for winter spread plots than for spring or fall application plots.
- Some studies have shown potential benefits to winter manure application though it should be noted that these studies are outliers.
 - » Young and Holt (1977) and Young and Mutchler (1976) found that solid manure application on top of snow resulted in less sediment and nutrient loss than manure under snow or bare soil conditions. It is theorized that the manure provided a barrier to the soil (at a 9% slope) that helped to reduce runoff effects.
 - » Lauer et al. (1976) showed that snow covered manure displayed no ammonia volatilization, though work from Owens et al. (2011) suggests this ammonia may be lost through runoff in any event.

Cover Crops

- Though cover crops can be a valuable tool in reducing sediment loss and should not be discounted as a general best management practice (BMP), evidence suggests they may cause increased risk of nutrient loss on winter manured soils.
 - » Runoff velocity reduction benefits can be negated by snow or ice pack that covers the crop. If impervious layers of snow and ice overtop the cover crops, all such benefits are lost.
 - » Dormancy negates the ability of cover crops to uptake nutrients (Bechmann et al., 2005).

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- » In some instances, cover crops can act as a catchment for snow thus generating a large volume of water for spring melt and subsequently increasing runoff, as was observed by Lorimor and Melvin (1996).
- » Exposure to repeated freeze-thaw cycles has been shown to release soluble phosphorus from living cover crops such as ryegrass (Bechmann et al., 2005; Smith et al., 2016).
- Results are conflicting whether cover crops improve or hinder the soil's ability to allow infiltration at time of first thaw.
 - » Storey (1955) mentions that cover crops have the ability to reduce the incidence and depth of “concrete freezes” or completely impervious soil layer.
 - » Young and Mutchler (1976) noted that alfalfa fields stayed frozen longer than bare soil.
 - » More research is needed on this phenomena.

Pathogens

- Results are conflicting as to whether or not exposing pathogens in manure to freeze thaw cycles will result in pathogen kills.
 - » Field research by Kibby, et al. (1978) found that freezing conditions were lethal to fecal bacteria.
 - » Bicudo (2003) found that freezing and thawing a manure/soil mixture reduced *E. Coli* levels by 90%.

Slopes and Setbacks

- To the best of the author's knowledge, slope has not been the primary variable of interest in any winter manure application study. It is likely that researchers have viewed this as a trivial variable, as several existing models suggest that runoff risk during any season is directly proportional to slope.
- Unfortunately, this has led to a lack of empirically backed standards correlating winter manure application risk with slope.
- States have established guidelines regarding permissible slopes for winter manure application (Srinivasan et al., 2006).

Policy

The ambiguity in standard practices for winter manure application has led to several different state policies. Table 1 shows the states that have established a total or partial ban of winter manure application as of 2017, as well as any conditions placed upon the ban.

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State	Ban Duration	Implementation Info
Vermont	Dec 15 – April 1	Established in 1995
Iowa	Dec 21 – April 1	Frozen and snow covered ground Emergency spreading is allowed
Maryland	Dec 15 – April 1	Slated for 2016 Enforcement (CAFO only)
Indiana	Dec 15 – April 1	Emergency spreading is allowed
Minnesota	Dec 1 – Thaw	Solid manure not included
Wisconsin	Frozen or Snowy Ground, February – March	Unless incorporated, Total ban - Liquid manure

Table 1: States with Winter Manure Application Bans

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Table 2 lists northern U.S. states that have attempted to utilize risk management strategies or best management practices to address winter manure application issues. States not listed have policies that are identical with NRCS standard 590.

State	Notes
Ohio	<p>NRCS Standard 633</p> <ul style="list-style-type: none">• 10 tons/acre limit• 90% surface residue cover required• No more than 20 contiguous acres• 200 ft setback• Additional restriction apply to fields with >6% slope
Pennsylvania	<ul style="list-style-type: none">• 25% residue cover• 100 ft setback• No more than 5000 gal/A of liquid manure.• No more than 20 ton/A of dry non-poultry manure.• No more than 3 tons/A poultry manure• No greater than 15% slope
Michigan	<ul style="list-style-type: none">• Michigan Generally Accepted Ag Management Practices (GAAMPS)• CAFO winter manure application must be approved.• CNMPs include an assessment of all fields by the Manure Application Risk Index (MARI) to determine runoff risk during winter application.
Illinois	<ul style="list-style-type: none">• Illinois recommends avoiding applying manure on frozen or snow covered soil.• Winter manure application should be limited to areas with a 5 percent slope or less and where there are acceptable erosion control practices.• Manure should not be applied in the winter if the livestock wastes will runoff to the waters of the state.

Table 2: States with Winter Manure Application Standards or Guidelines

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