Liquid Manure Injection Pros and Cons

Manure can provide an ample amount of nutrients, and knowledge of how to utilize these resources can turn a once thought waste material to dispose of into a resource to be utilized. Nitrogen (N) in liquid manure is largely in the form of ammonium-N which is immediately plant available upon application to the field. This form of N can be easily lost to the atmosphere through N volatilization, therefore understanding this process will help prevent N losses and allow more efficient utilization of N in liquid manure.

What is N volatilization?

N volatilization is a process in which ammonium (NH_4^+) is transformed into ammonia gas (NH_3).

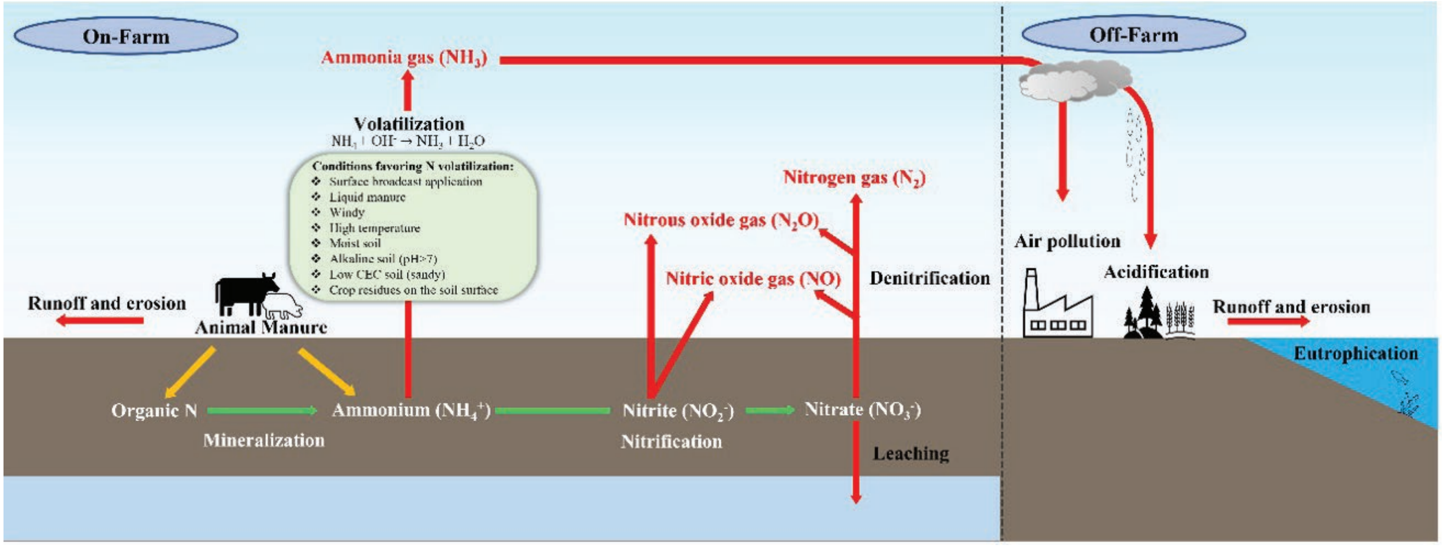

Figure 1: Illustration of how the N in manure is transformed in the soil and how the N is lost from the soil to the environment.

Why do we want to minimize N volatilization?

NH_3, as an indirect greenhouse gas, can be oxidized into a potent greenhouse gas (N_2O), contributing to climate change (Harrison & Yin, 2000; Liu et al., 2017). NH_3 can also increase aerosol formation by reacting with acid pollutants in the air, eventually deteriorating air quality (Smith et al., 2007; McGinn et al., 2008). Furthermore, the deposition of NH_3 may threaten ecosystems via acidification and eutrophication (Vries et al., 2011; Tanner et al., 2022).

What are the factors affecting N volatilization?

In addition to the method of manure application, the intensity of N volatilization can be affected by other factors such as manure types, environmental conditions, soil properties, and the presence of crop residues (Johnson et al., 2005; Mikkelsen, 2009).

- Liquid manure has a greater potential for N volatilization than solid manure because N in the liquid manure is mostly present as ammonium (NH_4^+) and is readily available for N volatilization. The N in solid manure is largely tied up in the organic N form which requires mineralization before it can be lost to volatilization.
- Windy and warm conditions favor N volatilization (Brunke et al., 1988; Macnack et al., 2013).
- The rapid loss of NH_3 has been observed in soils at high pH levels (pH>7) (Rochette et al., 2013) or at high moisture levels (Martine et al., 2010). Most agricultural soils in the Atlantic region are naturally acidic, and therefore liming becomes a common practice. Mkhabela et al. (2006) demonstrated that NH_3 loss from volatilization will be increased if the soils are limed; however, N_2O emissions may increase if the soils are un-limed. Sandy soils with low cation exchange capacity (CEC) generally have higher N lost via volatilization than clay soils with high CEC, as organic matter (humus) and clays can retain ammonium ions through electrostatic attraction (Cameron et al., 2013).
- A high amount of crop residues on the soil surface can enhance urease activity, leading to increased N volatilization (Hargrove, 1988; Pinheiro et al., 2018).

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What are other pathways of N loss?

- Denitrification is a process where NO_3- is converted to gaseous forms of N (NO, N_2O, and N_2) under anaerobic conditions (i.e. waterlogged soils). N_2O is a potent greenhouse gas, which can contribute to climate change and ozone depletion. Temperature, carbon supply, and NO_3- supply also play important roles in denitrification (Gillam et al., 2008).
- Leaching is the loss of NO_3- from the soil to groundwater, which can cause groundwater contamination problems. Fertilization, crop uptake, soil properties, and precipitation or irrigation all have great influences on leaching (Dong et al., 2022).
- Surface runoff and soil erosion are also potential pathways of N loss. N carried by eroded soil particles and water runoff can have a negative effect on surface water quality (Zhu et al., 2020).

Advantages of liquid manure injection over conventional surface broadcast:

1. Liquid manure injection provides more precise placement of nutrients to the fields and limits the contact area between the manure and the atmosphere, leading to a reduced risk of N volatilization. Injection can reduce N loss through volatilization by 90% or more when compared to conventional surface broadcast (Huijsmans et al., 2003; Mattila & Joki-Tokola, 2003; Dell et al., 2011; Duncan et al., 2019). With less N being lost as NH_3 to the atmosphere, liquid manure injection can have lower negative impacts on the environment and human health than conventional surface broadcast. Additionally, more plant-available N can be retained in the soil, leading to greater N use efficiency.
2. N can be lost through other pathways, such as denitrification, leaching, surface runoff, and soil erosion. Phosphorus (P) can also be lost through leaching, surface runoff and soil erosion. Liquid manure injection can reduce both N and P losses after heavy rainfalls or snow melts (Jahanzad et al., 2019; Sherman et al., 2020), which is particularly important for the Atlantic region, as extreme rainfall/wet condition events are common (Gregorich et al., 2005; Mekis & Vincent, 2011). Reducing these losses not only improve nutrient use efficiency, but also minimizes nutrient loading in surrounding water bodies.
3. Liquid manure injection can reduce odour nuisance emissions and help keep neighbors happy. In Nova Scotia, more than half of the agricultural complaints received by the government are due to manure odours (Nova Scotia Department of Agriculture, 2006). Orzi et al. (2018) reported that direct injection of liquid manure could reduce odor by 50-74 %, compared to conventional surface broadcast.

Figure 2: Drag-hose liquid manure

4. Liquid manure injection can be operated by tanker spreader systems or dragline systems (also called drag-hose systems) (Wilson et al., 2021). Compared with conventional surface broadcast and tanker spreader systems, dragline systems can bring more benefits to the environment. By removing heavy equipment (i.e. tanker) and large volumes of liquid manure in the equipment, dragline systems decrease the risk of soil compaction, especially on soils with high clay and moisture contents. With low levels of soil disturbances, dragline systems can also help preserve soil organic matter and improve/maintain soil carbon sequestration (Jayasinghe et al., 2022). By eliminating the time needed for manure reloading and transporting, dragline systems enable a continuous application and thus improve the application efficiency and reduce the transportation cost (Pfarr et al., 2020).

Main disadvantage of liquid manure injection:

The estimated overall costs associated with injection systems are higher than conventional surface broadcast due to the high equipment costs (Inagaki, 1998; Amin et al., 2020). Applying manure by injection can cost 6% more than surface broadcast with incorporation, and 28% more than surface broadcast without incorporation (Hadrich et al., 2010). However, in the long term, the higher costs could be compensated by the reduced need for N fertilizers and manure hauling (Maguire et al., 2011).

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