FLUSHED LIQUID DAIRY MANURE NUTRIENT DISTRIBUTION

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ABSTRACT

Some Idaho dairies use flushing systems that result in large amounts of liquid dairy manure that are applied via irrigation systems to adjacent cropland during the growing season. Solids and nutrients found in liquid dairy manure pose challenges to manure handling processes and cause environmental concerns. Separating solids and nutrients from liquid dairy manure is a critical step to improve nutrient use efficiency, reduce negative environmental impacts, and reduce manure handling costs. To better address solids/nutrients separation issue, a critical question needs to be answered: what are liquid dairy manure solid particle and nutrient distributions? Experiments were conducted to study the particle density, particle size, and nutrient (total nitrogen and total phosphorus) distributions of flushed liquid dairy manure. Flushed liquid dairy manure samples were collected from three commercial dairies in the Magic Valley region of Southern Idaho. The particle densities of manure solids were determined by the pycnometer method using a methanol medium. Solid particle distribution was determined using a set of 6 sieves (4, 2, 0.5, 0.25, 0.125, and 0.063 mm) combined with the hydrometer method ASTM D7928-17 for particle sizes less than 0.063mm. Total nitrogen (TN) and total phosphorus (TP) were analyzed using a Hach spectrophotometer (DR 5000) based on Hach methods. The Pipette Methods ASTM D6913/D6913M-17 was used in conjunction with ASTM D7928-17 to exact liquid manure samples. The test results showed that particle densities of flushed dairy manure ranged from 1.32 g/cm^3 to 2.20 g/cm^3, which are smaller than the density of soil particles (2.65 g/cm^3), solids of particles larger than 0.5mm were less than 50% of total solids (dry mass basis) for all three dairies, and liquid dairy manure phosphorus was mainly attached to particles with sizes smaller than 0.5 mm.

INTRODUCTION

Large dairies often use liquid manure handling systems because of their ease of mechanization and low labor requirements. A number of Idaho dairies use flushing systems that result in large amounts of liquid manure that are applied via irrigation systems to adjacent crop-land during the growing season. Solids and nutrients found in liquid dairy manure pose challenges to manure handling processes. Separating solids and nutrients from liquid dairy manure is a critical step to improve nutrient use efficiency and reduce manure handling costs. To better address issues related to solid/nutrients separation, a critical question needs to be answered: what are liquid dairy manure solid particle and nutrient distributions?

The objective of this research was to identify liquid dairy manure solid particle density and distribution, and nutrients associated with each particle size group.

METHODS

Liquid dairy manure samples were collected from a flushing receiving pit on each of three dairies (Dairy SF, Dairy DD, and Dairy SE) in Southern Idaho. Triplicate samples were analyzed for solid content, particle density, particle size distribution, total nitrogen (TN), and total

phosphorus (TP). Solid content was analyzed based on Method 2540B (APHA, 2015). Particle density was analyzed based on the method ASTM D1217-15 (Weindorf and Wittie, 2003) using a pycnometer with a methanol medium for particle sizes of 4, 2, 0.5, 0.25, 0.125, 0.063, and <0.063 mm. Particle size distribution was determined using a set of 6 sieves (4, 2, 0.5, 0.25, 0.125, and 0.063 mm) combined with the hydrometer method ASTM D7928-17 (Days, 2002) for particle sizes less than 0.063mm. TN and TP were analyzed using a Hach spectrometer (DR 5000) based on Hach methods (Hach, 2005). The Pipette Methods ASTM D6913/D6913M-17 (Hellman and McKelvey, 1941) was used in conjunction with ASTM D7928-17 to extract liquid manure samples for analyzing the TN and TP. The apparatuses used for the test are shown in Figures 1, 2, and 3.

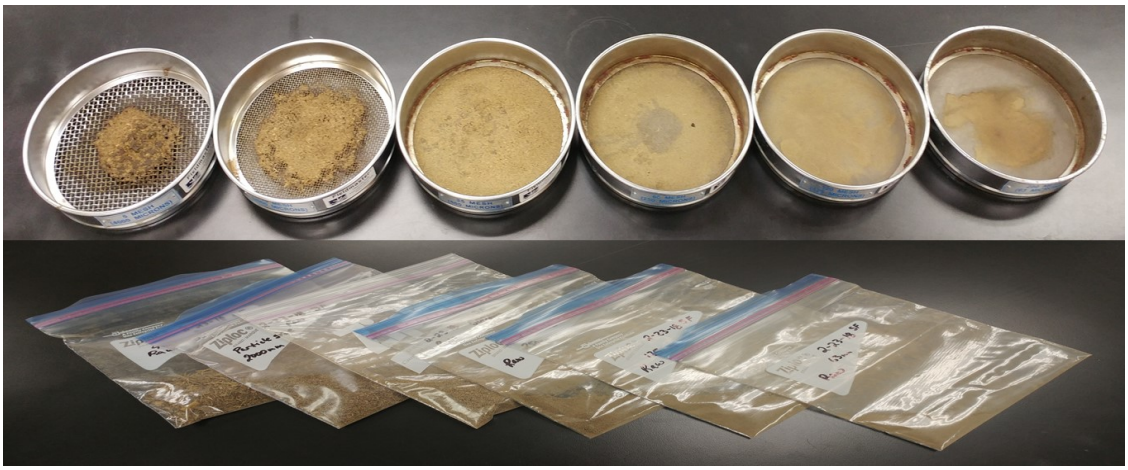

Figure 1. Sieved particles for density analysis.

Figure 2. Stacked sieve set (left) and liquid dairy manure sieve filtration apparatus (right).

Figure 3. From left: pycnometer for particle density analysis, pipette method for extracting manure samples, ASTM 152-H hydrometer, hydrometer reading of the meniscus.

RESULTS AND DISCUSSION

The particle densities (Figure 4) were found to be similar ranging from 1.32 g/cm^3 for particle sizes larger than 4 mm to 2.20 g/cm^3 for particles less than 0.063 mm.

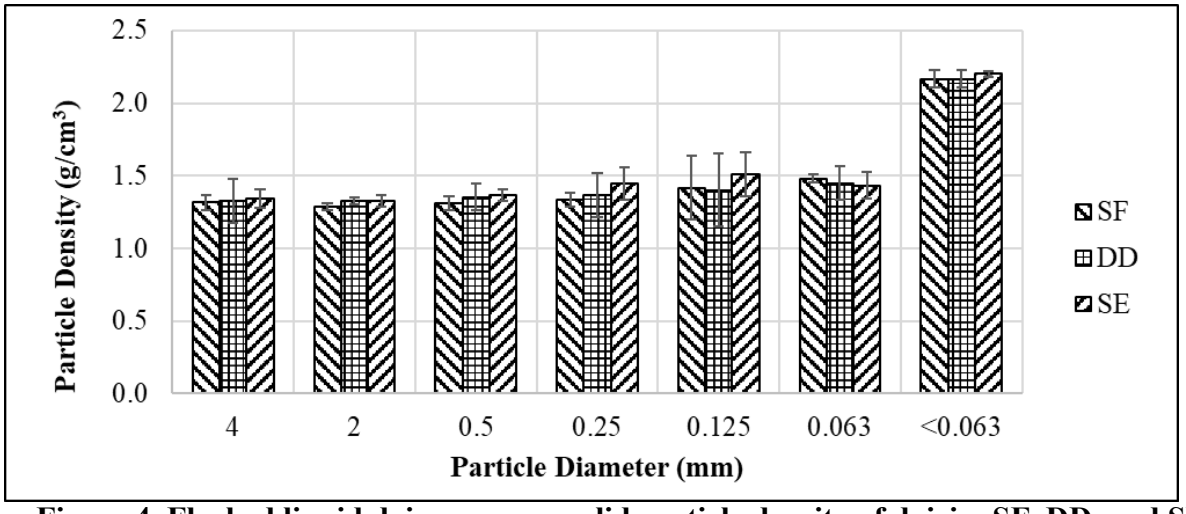

Figure 4. Flushed liquid dairy manure solid particle density of dairies SF, DD, and SE.

Flushed liquid dairy manure solid particle distributions are shown in Figure 5. It was noticed that high bedding fibers were presented in the liquid manure from Dairy DD which resulted in 32.6% of solids with particle sizes larger than 4 mm. For both Dairy SF and Dairy SE, the

percentages of solids (dry weight basis) with particle sizes larger than 4mm were 8% and 17.2%, respectively.

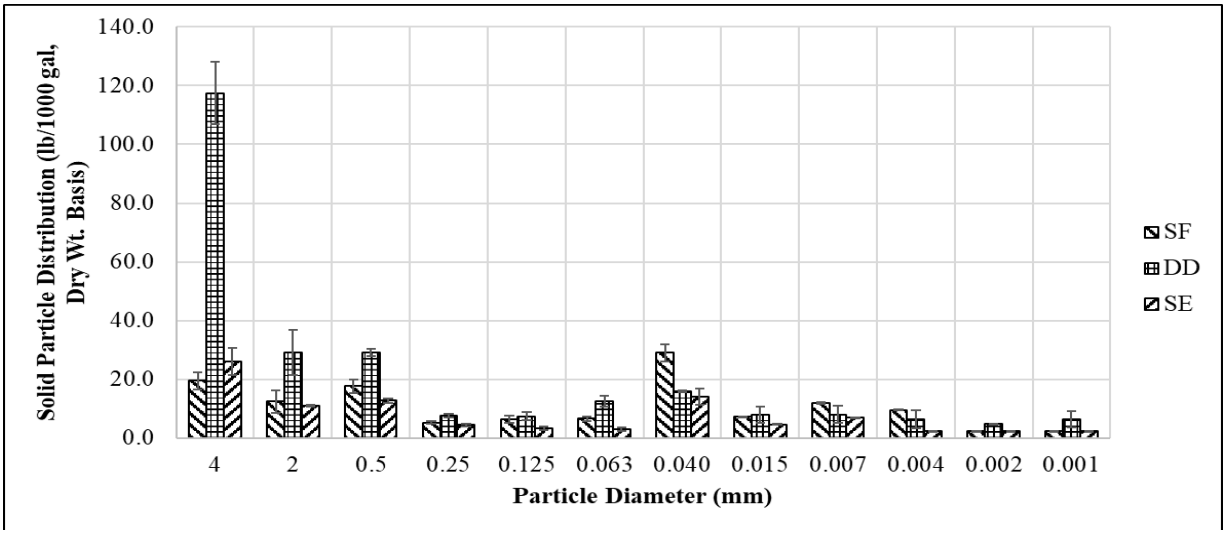

Figure 5. Flushed liquid dairy manure solid particle distribution of Dairies SF, DD, and SE.

Flushed liquid dairy manure TN and TP associated with different particle groups are shown in Figures 6 and 7. There were 4.9 lb. (or 33.6%) and 4.3 lb. (or 43.9%) of TN associated with particles larger than 0.5 mm in 1,000 gallons of flushed liquid manure for Dairy SF and Dairy SE, respectively. There was 0.8 lb. (or 6.5%) of TN attached to particles larger than 0.5 mm in 1,000 gallons of flushed liquid manure for Dairy DD. Most TP was attached to fine particles with sizes less than 0.5 mm for the three dairies. In order to separate more TP out of liquid stream, advanced separation methods beyond inclined screens are needed.

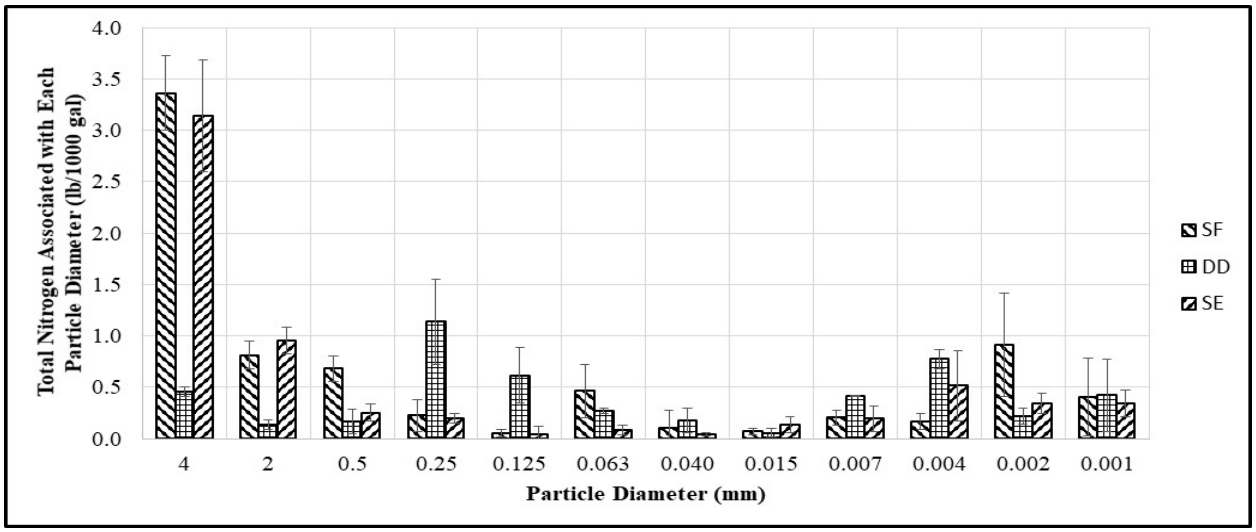

Figure 6. Total nitrogen (TN) associated with each particle diameter group in flushed liquid dairy manure.

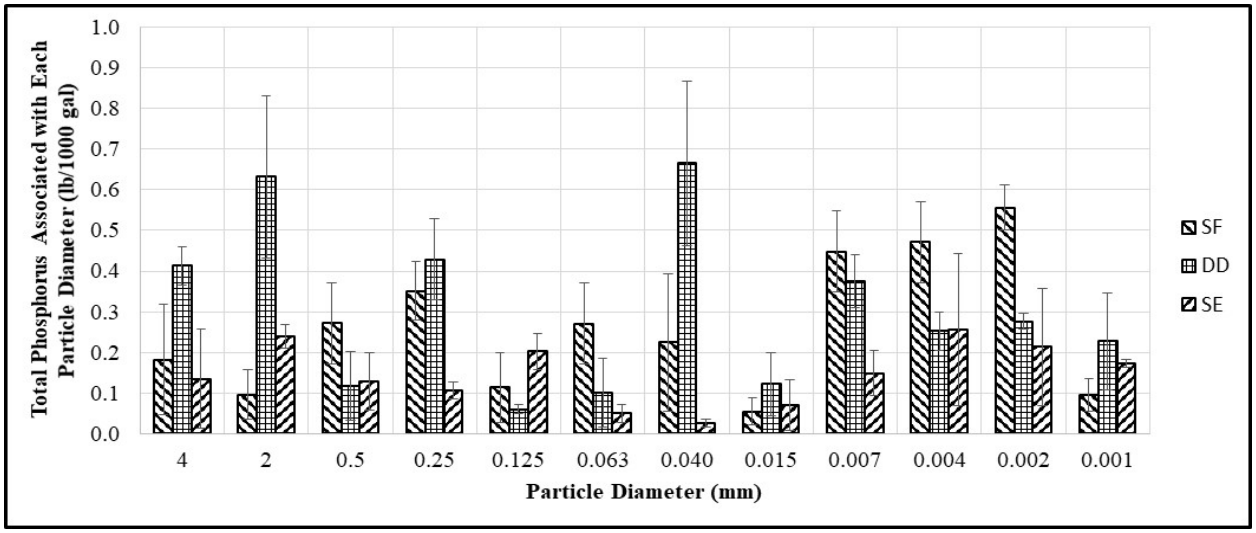

Figure 7. Total phosphorus (TP) associated with each particle diameter group in flushed liquid dairy manure.

The test results showed:

1) flushed dairy manure particle densities ranged from 1.32 g/cm^3 to 2.20 g/cm^3;
2) TN and TP distributions varied from dairy to dairy;
3) Most TP was associated with fine particles that cannot be screened out by screens;
4) Advanced separation technologies are needed to capture more TP from flushed liquid dairy manure.