DETERMINING NUTRIENT RELEASE CHARACTERISTICS OF VARIOUS MANURES

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Justification for Research:

Using manure as a nutrient source can be more complicated than using commercial fertilizers since the nitrogen (N) and phosphorus (P) content can vary depending on species, storage and treatment methods, and application techniques. Farmers, particularly those that grow sugarbeets, are also concerned about when the nutrients are released in the growing season which changes depending on soil types and weather. Despite concerns, there are other benefits of manure beyond being a source of N and P, including improving soil health and providing micronutrients. Plus, the up and down price swings of the commercial fertilizer market make manure more attractive, especially if a farmer has a consistent supply which can offset fertilizer costs.

To help farmers understand nutrient management with manure, the University of Minnesota developed recommendations to help determine N and P credits for a variety of manures. These recommendations were developed several decades ago, however, and since that time the diets of animals, storage of manures, and manure application equipment have changed. As one example, the recommendations to determine N availability treat all dairy liquid manure the same. However, some dairies have implemented technology to separate the solids from the liquids, thus changing the nutrient dynamics of the manure. Will liquid separated dairy manure have the same N availability as unseparated liquid dairy? For both N and P, are there differences in mineralization across soil types? These questions are particularly important for sugarbeet growers due to the effect late season N availability in the soil has on the sugar content of their crop. Our goal is to better understand N and P release from manure so that farmers are able to make better decisions about when to apply manure in their rotation to maximize benefits while reducing fertilizer costs.

Summary of Literature Review:

Understanding N availability in manure is complicated. The amount that is available will depend on the animal species that made the manure, what kind of bedding (if any) was used, how the manure was treated and/or stored, and how the manure was applied. The University of Minnesota has recommendations for what to expect for N availability (Hernandez and Schmitt 2012), but may need updated since there are new manure handling technologies and feeding and bedding strategies being used today. For example, Russelle et al. (2009) found that nutrient release estimates for stratified bedded pack dairy manure were not consistent with solid dairy manure guidelines in Minnesota. With new state regulations pending regarding how much fertilizer N is applied to fields, farmers that also use manure will need to take great care in determining how much N is supplied from the manure before determining how much fertilizer they can apply.

Understanding P availability in manure is also necessary, and luckily is not quite as complicated as it is with N, although there are still uncertainties. We assume approximately 80% of the total manure P is available the first year, but even this can vary depending on weather conditions. Recent studies have shown, however, that P availability may also depend on soil texture (Pagliari and Laboski 2014). In a recent study done at the University of Wisconsin, Pagliari and Laboski (2013; 2014) found that from 40% to 100% of P from manure became plant available within 50 days and the difference was primarily due to manure chemistry and soil texture.

Objectives:

The objective of this study is to evaluate N and P release from a variety of manures and soil types to give farmers a better understanding of how manure will behave.

Materials and Methods:

Laboratory incubations were used to assess N and P release characteristics from a variety of manures in several different soil types. The incubation studies were a complete factorial with 4 replications and with manure type, soil type, and temperature as the main factors. This means all possible soil and manure combinations were tested at all chosen temperatures. We also included a control treatment that did not include any manure application to see how much nitrogen and phosphorus mineralized from the soils themselves. We tested 8 manures, including: dairy liquid (separated and raw [non-separated]), swine liquid (from a finishing house and a sow barn), beef manure (solid bedded pack and liquid from a deep pit), and poultry (turkey litter and chicken layer manure). Manure analyses to determine nutrient content were conducted on all samples prior to incubations. Soils for the incubations included a coarse textured soil from the Sand Plain Research Center at Becker, MN; a medium textured soil from a research field near Rochester, MN; and a fine textured soil from the West Central Research and Outreach Center in Morris, MN. Soils were collected from the top six inches of soil at each location in bulk and then air dried and analyzed for nutrient and organic matter content.

To determine how much plant available N and P was released over time, we made subsamples for each manure by soil type by temperature treatment, and then collected one each at predetermined sampling intervals. Each subsample consisted of 200 grams of soil placed into ball jars and brought to about 60% moisture. These were allowed to incubate for a week prior to manure being added. After one week, manure was mixed into the jars to mimic a given amount of nutrient (e.g. 180 lbs of N per acre). We used the University of Minnesota guidelines and manure analysis results to calculate the appropriate application rate for each manure type. Moisture in the samples was kept at 60% of field capacity and was maintained by weighing every 4-6 days and adding deionized water as needed to replace the weight lost. During the incubation study, the temperature inside the incubator was kept at either 25ºC (77ºF), 15ºC (60ºF), or 5ºC (40ºF). We collected subsamples at 0, 7, 14, 28, and 56 days after the experiment had begun. Subsamples were destructively analyzed for potassium chloride extractable ammonium and nitrate and Bray-1 or Olsen extractable phosphate.

Preliminary Results:

At the time of writing, the experiment has only been run at one temperature, 25ºC (77ºF) and subsamples for days 0-28 have been collected. Ammonium and nitrate have been analyzed for subsamples for days 0-14. The remaining treatments will be completed later in 2019. Statistical analyses have not been conducted at this time.

The results of the initial soil and manure tests can be found in Tables 1 and 2, respectively. This will give an idea of the starting conditions of the soils and manures. For the incubation at 25ºC, the amount of ammonium-N, nitrate-N, and inorganic N (ammonium + nitrate) from each treatment from days 0-14 can be found in Table 3. For visual reference, Figure 1 shows the inorganic N (ammonium + nitrate) from each treatment from days 0-14. The control samples showed that more inorganic N was present in the medium textured soil than the other soils. In general, the swine manure from both finisher and sow barns released the most inorganic N compared with other manures. Of the beef manures, the liquid deep pit manure tended to release more inorganic N than the bedded pack manure, likely due to the lack of bedding to tie up nitrogen. Of the dairy manures, the raw and liquid separated tended to release inorganic N similarly, except in the medium textured soil where the liquid separated manure released more inorganic N. Across soil types, the inorganic N release tended to be stable in the coarse textured soil, while in the medium and fine textured soil, it appears to have increased initially then slowly decreased. It is unclear why this may have happened but could be due to volatilization of ammonium, denitrification of nitrate, or immobilization of N into organic forms. More tests are needed and will be completed later in 2019.

References:

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Table 1. Initial characteristics of three soil types used in this study: coarse textured soil from Becker, MN; medium textured soil from Rochester, MN; and a fine-textured soil from Morris, MN.

Soil Characteristics	**Soil Textural Class**		
	Coarse	**Medium**	**Fine**
Organic matter (%)	1.1	1.0	3.3
pH	5.1	5.2	7.9
Phosphorus - Olsen (ppm)	11	8	7
Potassium (ppm)	95	101	140
Magnesium (ppm)	42	49	570
Calcium (ppm)	274	310	3482
Ammonium (ppm)	3.4	2.8	8.6
Nitrate (lb/acre)	3.0	2.5	8.5

Table 2. Initial characteristics of eight manure types used in this study. The units of nutrients will be in pounds per ton for solid manure and in pounds per 1000 gallons for liquid manure.

Species Type	**Manure Type**	**Moisture**	**Total N**	**Ammonium-N**	**Total P (as P_2O_5)**	**Total K (as K_2O)**	**C:N Ratio**
		(%)	(lbs per unit)	(lbs per unit)	(lbs per unit)	(lbs per unit)	
Beef	Bedded Pack, Solid	60.5	13.43	2.37	9.59	18.01	22:1
	Deep Pit, Liquid	86.6	56.72	36.7	23.43	30.83	9:1
Dairy	Separated, Liquid	93.2	32.7	15.8	13.31	29.26	7:1
	Raw, Liquid	88.9	33.17	15.66	13.08	31.29	13:1
Swine	Finisher, Liquid	86.8	59.16	41.63	37.63	27.35	9:1
	Sow, Liquid	99.3	16.5	15.69	1.38	11.34	1:1
Poultry	Chicken Layer, Solid	48.6	55.51	14.39	35.78	25.91	7:1
	Turkey Litter, Solid	53.0	28.2	13.16	26.69	28.65	12:1

Table 3. The amount of ammonium-N (NH_4-N), nitrate-N (NO_3-N), and inorganic-N (the sum of ammonium-N + nitrate-N) in soil mixed with various manure types in three different soil textural classes.

Species Type	Manure Type	Day 0			Day 1			Day 7			Day 14		
		NH_4-N	NO_3-N	Inorganic -N	NH_4-N	NO_3-N	Inorganic -N	NH_4-N	NO_3-N	Inorganic -N	NH_4-N	NO_3-N	Inorganic -N
		-------------lb/acre-------------			-------------lb/acre-------------			-------------lb/acre-------------			-------------lb/acre-------------		
Coarse Textured Soil													
Control	None	3.4	6.0	9.3	14.3	0.0	14.3	6.3	10.1	16.4	8.2	5.9	14.1
Beef	Bedded	17.6	1.1	18.7	16.2	0.0	16.2	11.0	8.9	19.9	12.3	9.0	21.2
	Deep Pit, Liquid	75.6	0.0	75.6	129.8	0.0	129.8	42.2	18.7	60.9	48.0	10.9	58.9
Dairy	Separated, Liquid	55.3	0.0	55.3	48.4	0.0	48.4	60.8	8.0	68.8	44.9	9.8	54.6
	Raw, Liquid	32.1	0.0	32.1	62.0	0.0	62.0	59.2	1.8	61.0	28.1	20.5	48.6
Swine	Finisher, Liquid	65.6	0.5	66.2	82.6	0.0	82.6	81.9	10.3	92.2	45.3	19.6	64.8
	Sow, Liquid	102.5	0.0	102.5	139.5	0.0	139.5	103.7	20.4	124.2	73.8	48.7	122.5
Poultry	Turkey Litter, Solid	41.1	1.0	42.2	49.0	0.0	49.0	38.5	16.0	54.5	18.1	14.3	32.4
	Chicken Layer, Solid	90.8	5.6	96.5	108.1	0.0	108.1	116.5	12.3	128.9	38.5	32.1	70.7
Medium Textured Soil													
Control	None	6.3	44.9	51.2	13.2	59.8	73.1	12.4	60.8	73.2	11.7	45.1	56.9
Beef	Bedded Pack, Solid	4.3	50.8	55.2	17.9	79.1	97.0	13.7	88.1	101.9	9.8	12.7	22.5
	Deep Pit, Liquid	15.5	112.6	128.1	11.7	91.6	103.3	8.7	85.2	93.9	9.0	43.6	52.6
Dairy	Separated, Liquid	6.2	101.7	108.0	14.4	87.9	102.2	6.9	101.3	108.3	7.9	55.6	63.5
	Raw, Liquid	2.5	68.4	71.0	16.9	71.5	88.4	6.3	41.5	47.8	8.3	20.6	29.0
Swine	Finisher, Liquid	54.0	100.6	154.6	25.3	122.7	148.1	7.6	0.0	7.6	7.5	88.9	96.4
	Sow, Liquid	25.1	123.8	148.8	27.2	152.1	179.2	5.9	0.0	5.9	8.5	141.2	149.7
Poultry	Turkey Litter, Solid	0.0	95.5	95.5	5.6	104.1	109.7	3.3	105.2	108.5	11.3	47.3	58.5
	Chicken Layer, Solid	2.0	99.9	102.0	28.8	141.2	170.1	4.3	0.0	4.3	8.6	52.9	61.6
Fine Textured Soil													
Control	None	0.0	7.2	7.2	7.2	28.4	35.6	8.9	18.0	26.8	12.7	13.1	25.8
Beef	Bedded Pack, Solid	0.0	15.3	15.3	8.5	23.0	31.5	5.5	7.3	12.8	9.8	8.1	17.9
	Deep Pit, Liquid	5.0	78.8	83.8	31.4	24.7	56.1	13.7	50.3	64.0	15.4	16.3	31.7
Dairy	Separated, Liquid	1.4	50.7	52.1	26.0	22.8	48.8	12.3	34.9	47.2	14.3	29.5	43.8
	Raw, Liquid	9.3	1.0	10.4	18.3	41.9	60.2	13.4	29.2	42.7	14.2	12.3	26.5
Swine	Finisher, Liquid	18.4	1.7	20.1	62.2	30.3	92.5	15.9	126.6	142.5	16.5	13.8	30.3
	Sow, Liquid	12.2	4.5	16.7	65.6	44.9	110.5	40.7	136.9	177.5	24.1	101.8	126.0
Poultry	Turkey Litter, Solid	9.6	3.9	13.6	18.0	53.5	71.5	13.4	68.7	82.1	14.2	10.2	24.4
	Chicken Layer, Solid	15.1	2.1	17.2	83.7	19.4	103.0	22.6	102.0	124.6	13.4	16.4	29.8

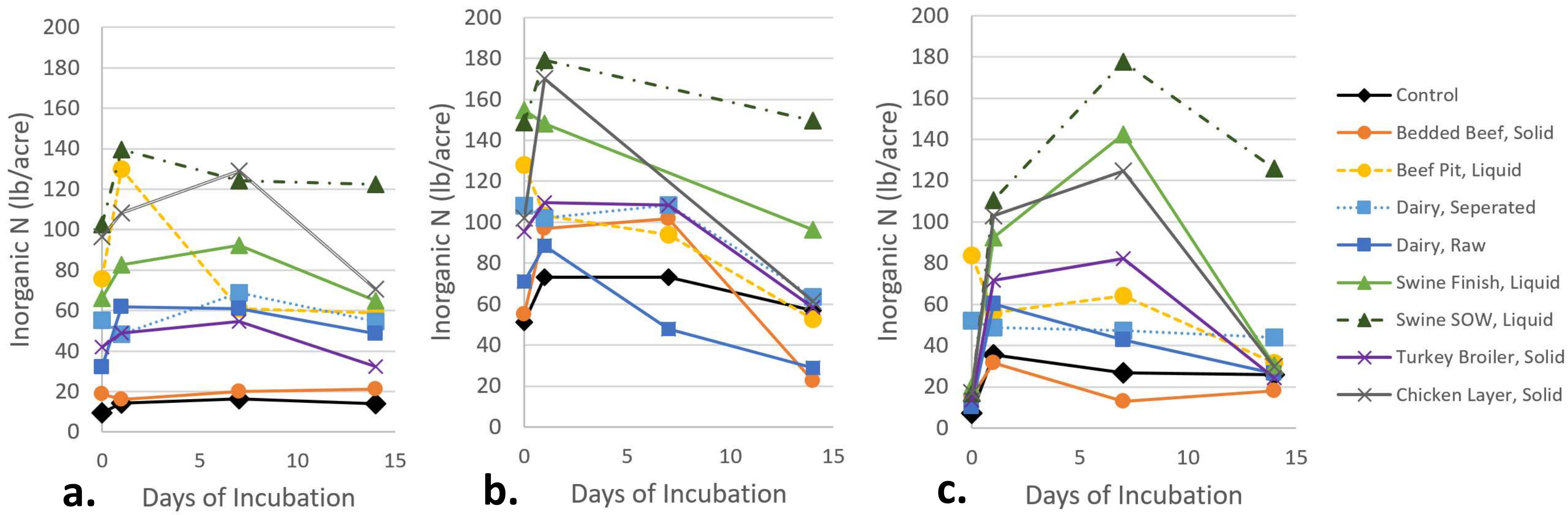

Figure 1. The amount of inorganic-N (the sum of ammonium-N + nitrate-N) in soil mixed with various manure types in: a. coarse textured soil from Becker, MN; b. medium textured soil from Rochester, MN; and c. fine textured soil from Morris, MN.