Nutrient and Heavy Metal Contents of Hog Manure – Effects on Soil Quality and Productivity

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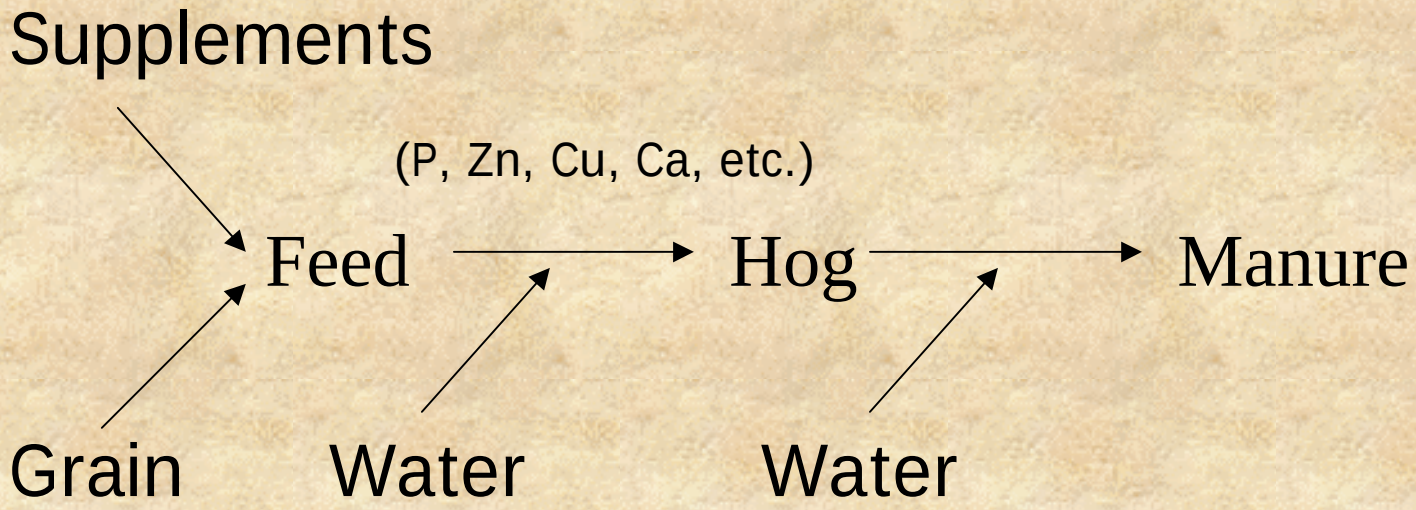
Application of Hog Manure to Land

– Is an economical means of utilization.

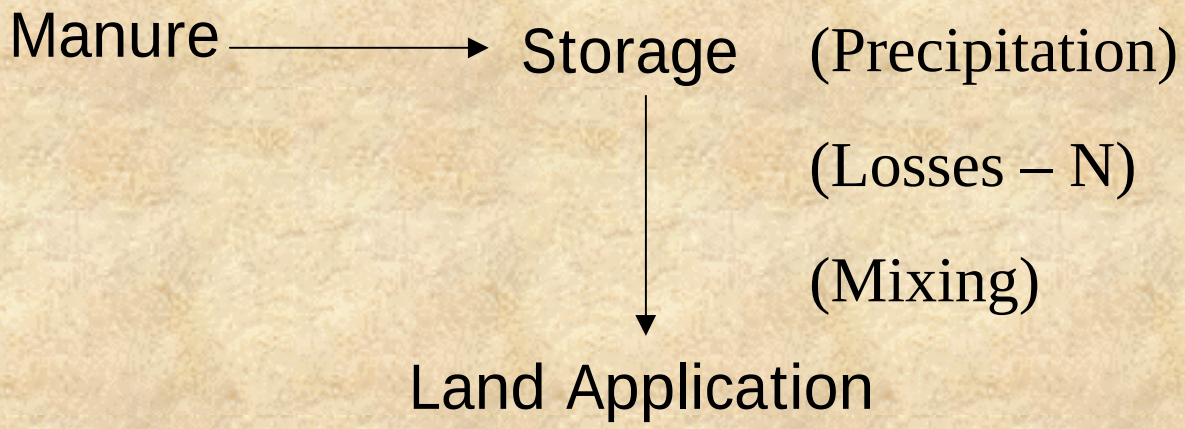
– Provides nutrients for crop growth.

  - Less commercial fertilizer.
  - More stable Agro-Eco system.

– Can increase soil quality and productivity of most soils provided loadings are maintained at levels equal to crop removal and/or below levels known to reduce soil quality.



Composition of manure varies based on feed type, water source, etc.



Composition of manure and therefore the loadings of various constituents will vary with all of the above.

Study

– Exploratory study to determine the concentration of various constituents of hog manure.

– Using the composition data, calculate the loadings of various constituents when manures are added at a rate of 70 kg N/ha. (i.e. Calculate amounts (kg/ha) of other nutrients, heavy metals added.

– Using existing information assess the effects of these loadings on soil quality.

Methods

– Hog manures obtained in fall (during clean-out of storage facilities) of 1998 and 1999.

– 145 samples:

- 38 different locations or types of barns.
- Top, middle, or bottom one-third of storage.
- 92 samples from feeder barns.
  - 37 from sow barns
  - 11 from nursery barns
  - 5 from farrow to finish

– Additive used in feed were recorded.

Table 1. Feed Additives for Various Barn Types

Feed Additives	Feeder Barn	Sow Barn	Nursery Barn	Farrow to Finish
Protein	medium	med. to low	high	** medium (1999)
Copper	high	low (1998) med. to low (1999)	high	** medium (1999)
Zinc	low (1998) med. to low (1999)	medium	high (1998) med. to high (1999)	** medium (1999)

Analysis Conducted

– % of Moisture (% of Solids)

– Total N, Inorganic N (Organic by Difference)

– Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Cl, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, Se, Si, Ag, Sr, Na, Ti, Th, V, Sn, Zn

– Conducted correlations among manure constituents.

Results

% of Solids

- Averaged 3.5%
- Closely correlated with total P and many minor elements and/or heavy metals.

Total Nitrogen

Table 2. Total N (kg/1000L) in Hog Manure

Frequency Distribution (kg/1000L)					
Range	0-1	1-2	2-3	3-4	>4
No. of Samples	5	45	36	26	33

Maximum	Minimum	Mean	Std. Dev.
6.50	0.60	2.89	1.38

2.89 kg/1000L = 28.95 lb/1000 gal.

Nitrogen

– Varied greatly within and with type of barn (feeder barns highest.)

– Total N Increased with depth of manure in storage facility (ammonium N reasonably constant with depth.)

– Need to analyze all manures and as storage facility is emptied to obtain data on N content for loading rate.

Total Phosphorus

Table 3. Total P (kg/1000L) in Hog Manure

Frequency Distribution (kg/1000L)					
Range	0.0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	>2.0
No. of Samples	76	17	15	13	24

Maximum	Minimum	Mean	Std. Dev.
5.51	0.03	0.92	0.97

Table 4. Ratio of Total Nitrogen to Total Phosphorus in Hog Manure Samples

Frequency Distribution					
Range	<4	4-8	8-12	12-16	>16
No. of Samples	64	26	22	14	19

Maximum	Minimum	Median	Mean*
32.00	0.89	5.00	3.14

*Calculated from overall average concentrations of N and P, not from ratio of individual samples.

Nitrogen to Phosphorus Ratios

– Mean of 3.14 (45% of samples had N to P ratios of less than 4 to 1 and about 38% of samples had ratios greater than 8 to 1.

– Better mixing of some manures.

– But mean N to P ratio was 3.14 to 1. Therefore, P will tend to accumulate in soils if loading rates of manure are based on N rate.

Two Strategies to Reduce P Accumulation in Soils

- Mix manures well and add at rates consistent with crop removal of P.
- Separation of solids from liquids, and use of solids as a P fertilizer. e.g: on alfalfa, prior to establishment at rates of 50 to 70 kg P/ha.

Table 5. Nitrogen and Phosphorus Contents for Different Depths

Sample Depth	Dry Matter %	Total N (kg/1000L)	Total P	N to P Ratio
Top (n=62)	2.3	2.59	0.61	4.2
Middle (n=30)	3.7	2.79	0.88	3.2
Bottom (n=53)	4.6	3.27	1.31	2.5

Table 6. Total Phosphorus (kg/ha) Loadings Based on the Application of Hog Manure at a Rate of 70 kg Available Nitrogen Per Hectare

Frequency Distribution					
Range	<10	10-25	25-40	40-55	>55
No. of Samples	53	33	25	18	15

Maximum	Minimum	Mean¤	Median
112.0	2.28	27.5	16.0

¤Means were calculated from average concentrations and are not means of individual samples.

Table 7. Electrical Conductivity (dS/m) of Hog Manure Samples

Frequency Distribution					
Range	0-8	8-12	12-16	16-24	>24
No. of Samples	0	28	44	69	4

Maximum	Minimum	Mean	Std. Dev.
27.5	8.7	16.0	4.1

Table 8. Sodium Adsorption Ratio in Hog Manure Samples

Frequency Distribution					
Range	0-3	3-6	6-9	9-12	>12
No. of Samples	47	55	26	9	8

Maximum	Minimum	Mean	Std. Dev.
17.8	0.6	5.1	3.5

Concentration, Loadings of Major, Minor, and Rare Elements

– Table 9 of the paper lists the maximum, minimum, and mean concentration of the 32 elements studied.

– K, Ca, Cl - Most Abundant

– Mg, Na, S - Moderate Concentration

– Fe, Al, Si - Soil Structural Elements

– Cu, Zn, Mn, Ti, Sr, B, Ba - Detectable Levels

– V, Ni, Mo, Cr, Li, Sn, Se - Very Low Concentration (0.2 to 0.5 mg/L)

– Pb, As, Sb, Co, Bi, Cd, Th, Be, Ag (many samples had levels below detection levels)

- Concentrations extremely variable:
  - Zn, 1.18 to 541 mg/L, average = 58
  - Cd, <0.005 to 0.198 mg/L, average = 0.044
- Concentration increased with depth in storage facility.
- Concentration of metals such as Cu, Zn, related to inputs of these metals in feed.
- Concentration of metals such as Cd, Pb, Ni, etc. Highly correlated with elements such as Cu and Zn. (Therefore most likely present as contaminants in the mineral supplements.)

Loadings of Metals

– Listed for each element in Table 10, calculated at rate of manure = 70 kg N/ha (available).

– Highest for manures from sow and nursery barns (metals – highest from nursery barns.)

– Loadings reflected concentration of metal and therefore extremely variable.

Loadings of Metals

K - 4.3 to 122 kg/ha

Na - 5 to 62 kg/ha

Ca - 2 to 200 kg/ha

Mg - 0.3 to 75 kg/ha

Cu - 0.04 to 4.4 kg/ha

Mn – 0.017 to 2.8 kg/ha

Zn – 0.04 to 14.2 kg/ha

Loadings of Metals

Al, Si, S, Fe

- Trace to 25 kg/ha

Sb, As, Be, Bi, Cd, Co, Pb, Ag, Th

- Trace to 10 g/ha

Ba, B, Cr, Li, Mo, Ni, Se, Sr, Ti, V, Sn

- Trace to 300 g/ha

Assessment of Loadings

- CCME and Ontario Ministries of Environment and Agriculture, Food and Rural Affairs.
- Alberta guidelines for use of biosolids on agricultural land.
- Crop removal versus amounts added to soil.

Sodium – Loadings Varied From 5 to 67 kg/ha

*Suggested annual sodium addition to Ontario soils * (Table from Ontario Ministries, 1996)*

Soil Texture	Annual Maximum Sodium Addition (kg/ha)
Sands, Sandy loams	200
Organic soils, Loams, Clay loams, and Clays	500

Sodium

– 5% of C.E.C.

– 115 to 1150 kg/ha (lifetime) for sandy and loams – clays.

– Calculations show that it would be prudent to limit sodium applications to soils of medium texture. (Low C.E.C.) (Grey wooded and luvisolic) (Monitor)

Potassium

– Loadings varied from 4 to 122 kg/ha. (mean of 48 kg K/ha)

– High levels of K in forage increases the incidence of milk fever and grass tetany in cows.

– Therefore need to manage crop rotations and manure applications to maintain K levels in forage at acceptable levels.

CCME and Ontario Guidelines

CCME Upper Limit for Agriculture – Soil mean (median) of Manitoba soils = Difference

Calculated number of applications = Difference for highest concentration, lowest concentration, and median concentration

Element	No. of Applications		
	Max.	Min.	Median
Antimony	8,900	124,000	344,000
Arsenic	1,000	15,000	4,000
Barium	1,800	168,000	21,000
Beryllium	3,900	124,000	31,000
Cadmium	400	25,000	3,000
Chromium	600	120,000	6,500
Cobalt	4,000	460,000	50,000
Copper	20	2500	160

Element	No. of Applications		
	Max.	Min.	Median
Lead	5,800	324,000	57,000
Molybdenum	70	11,000	500
Nickel	1,000	42,000	7,000
Selenium	136	3,000	600
Silver	46,000	520,000	170,000
Thallium	5000	5,000	1,700
Vanadium	1,000	407,000	17,000
Tin	36	5,000	600
Zinc	19	6,400	320

Alberta Guidelines - Biosolids

Element	Loams – Clay	Sandy
	(High pH)	(Lower pH)
Boron	50 – 900	25 – 450
Cadmium	240 – 15,000	125 – 8,000
Chromium	1,200 – 260,000	800 – 170,000
Copper	45 – 6,000	20 – 3,000
Lead	5,500 – 300,000	2,700 – 150,000
Nickel	425 – 18,000	200 – 9,000
Zinc	21 – 7,000	11 – 3,600

Removal by Crops Versus Amounts Added

– Removal of Ca, S, Mg, B close to median of addition

– Removal much less than added for many elements. (Particularly P, Zn, Cu)

Summary and Recommendations

– Hog manures were extremely variable in composition (ration, storage type, etc.) Need frequent analysis for N and P.

– Producers should obtain analysis of a few samples for a large number of constituents to calculate loadings.

– Assess effects of loadings on a site specific basis.

- Soil type (texture, pH)
- Cropping system (alfalfa – grass versus cereal grain)
- Surficial geology (risk of runoff, leaching, etc.)

Summary and Recommendations

– Manures, exceptionally high in particular constituents (Cu, Zn, P, B) will require special management practices for long-term sustainability.

Acknowledgements

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