Biosolids processing effect on sulfur plant availability

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Background

- Understanding the sulfur (S) nutritive value of biosolids produced by various processing methods is important for growers who apply biosolids to crop production fields
- Plants use the sulfate form of S, which is released at varying rates and amounts

Background

- Sulfate release driven by both biological and chemical processes, difficult to predict for organic amendments like biosolids
- Sulfate release likely varies across biosolids types, including
  - Anaerobically digested biosolids
  - Aerobically digested biosolids
  - Lagoon treated biosolids
  - Composted biosolids
  - Specialty processes, like sawdust blending, alkaline stabilization, and dual digestion (anaerobic + aerobic)

- Our project goals were to determine how processing method and biosolids properties influence S availability and S fertilizer value

Description of processing methods and EPA Class for the 14 biosolids materials used in this study.

Biosolids type	Class	Biosolids processing method description
Aerobic1	B	Aerobic digestion, belt filter press
Aerobic2	B	Oxidation ditch, aerobic storage, belt filter press
DualDigest	A	Aerobic digestion followed with temperature phased anaerobic digestion, screw press
Anaerobic1	B	Anaerobic digestion, centrifuge
Anaerobic2	B	Anaerobic digestion, centrifuge
Anaerobic3	A	Anaerobic digestion, centrifuge, direct dry, pelletized
Anaerobic4	B	Anaerobic digestion, centrifuge
Anaerobic5	B	Anaerobic digestion, centrifuge
Sawdust Blend	B	Blend of 50% dual digestion biosolids, 25% sawdust, and 25% screened sand
Compost1	A	Clarifier sewage sludge mixed with wood residue, yard waste, composted for 10-12 weeks
Compost2	A	Aerobically digested biosolids mixed with yard waste and septage, composted for 12 weeks
Lagoon1	B	Centrifuged lagoon slurry, ~2 years since last lagoon cleaning
Lagoon2	B	Centrifuged lagoon slurry, ~2 years since last lagoon cleaning
Alkaline	A	Primary and secondary clarifiers, centrifuge, lime pasteurization

Methods

- Biosolids were air-dried, ground, and added to Walla Walla silt loam soil at a rate of 100 mg S/kg soil
  - Equivalent to roughly 200 lb S/acre

Methods

- The treated soils were incubated in ziplock bags at room temperature (~72 degrees F)
- Soils extracted for sulfate-S on days 1, 13, 29, 44, and 83 of the incubation

Plant-available sulfate-S release from biosolids at 12 weeks following incorporation into a Walla Walla silt loam soil. Source: Moore et al. 2022

Biosolids Stabilization		Biosolids analysis					Plant-available S[b]	
	No. of facilities	Moisture	Organic C[a]	Total S	C:S ratio		Range	Avg
		----------%----------					% of total S	lb/dry ton
Aerobic	2	86	39	1.0	44		11-19	3
Anaerobic	5	77*	37	1.1	35		27-37	6
Compost	2	55	32	0.4	89		3-6	0.3
Lagoon	2	77	22	1.6	14		26-46	11
Lime	1	61	25	0.5	48		52	5
Sawdust blended	1	41	20	0.4	56		37	3
Dual digestion	1	69	34	1.4	23		31	9

*Excludes the dried and pelletized anaerobic biosolids material, which had a moisture of only 3%.

Moore, A., E. Smith, A. Bary, and D. Sullivan. 2022. Biosolids processing effect on sulfur availability. Soil Science Society of America Journal. Accepted with minor revisions.

Can we predict S release based on biosolids properties?

- Conducted stepwise regression analysis, determining if biosolids properties could be used to estimate S availability

- **k** = 0.94 - (0.025 * **C:S**) + (0.041 * **Ca**), $r^2 = 0.88$
  - **k** = S release rate (mg/kg/week)
  - **Ca** = biosolids total Ca concentration (%)
  - **C:S** = biosolids organic C:total S

- **PAS** = -71.27 + (13.10 * **pH**) + (0.0051 * **SO_4-S**), $r^2 = 0.75$
  - **PAS** = plant available S % from biosolids total S pool
  - **SO_4-S** = biosolids sulfate-S concentration (mg kg^{-1})
  - **pH** = 1:5 biosolids pH

Can we predict S release based on biosolids properties?

- Sulfur mineralization of organic S compounds is known to be influenced by organic C:total S
- Ca and pH effects may be related to gypsum ($CaSO_4$) dissolution and oxidation of hydrogen sulfide compounds.
- The correlations discussed here may need to be further investigated and verified on additional soil types

Summary

- Biosolids processes that we evaluated did have a significant effect on S availability, and should be accounted for when providing S availability estimates to producers
- Growers can use these S availability estimates by processing to better understand if crop S needs can be met by their biosolids application

Thank you!

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