Agronomic and Environmental Impacts of Biosolids Application to Bahiagrass Pastures

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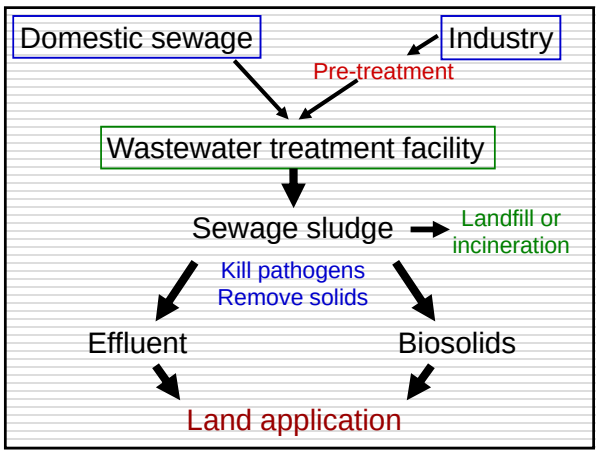
What are "Biosolids"?

- Biosolids are the by-product of the treatment of domestic sewage
- Sewage sludge undergoes pathogen control treatment that meet regulatory requirements
- Sewage sludge that is disposed of by landfill or incineration is NOT considered biosolids



Are all Biosolids Materials the Same?

- Biosolids composition and characteristics vary considerably
- Federal regulation: 40 code of Federal Regulations (CFR) Part 503. Enforced by EPA
- State regulation: Chapter 62-640, FL Administrative Code (FAC) regulations. Regulated by FL-DEP
- Two types of residuals: Class A (AA) or Class B

Are all Biosolids Materials the Same?

Class A and Class B refer to the **pathogen level**.

❖ **Class AA (exceptional quality)**

- contain minute levels of pathogens
- no restrictions (bagged and marketed to the public)

❖ **Class B**

- contain small, but compliant amounts of bacteria
- restrictions for crop harvest, grazing animals (30-d restriction), and public contact

Both materials are required to meet strict pollutant criteria.

Benefits

- Nutrient source (macro and micro)
- Improves soil quality
  - Physical: water holding capacity, aggregation, porosity
  - Chemical: SOM, exchange capacity, retardation of contaminant movement
  - Biological: microbial activity
- Reclamation of disturbed lands
- Carbon sequestration, reduce energy consumption, reduce GHG emissions

Risks

- Odors (sulfur compounds. Nuisance; no data demonstration human toxicological effects)
- Nutrients (N and P)
- Pathogens – human disease
- Contaminants of emerging concern (antibiotic resistant bacteria, pharmaceuticals, personal care products, flame retardants, estrogen compounds, endocrine disruptors, nanoparticles)

No documented scientific evidence suggesting that Part 503 has failed to protect human health
When practiced in accordance with federal regulations, land application of biosolids presents negligible risks to consumers, crop production, and environment

Biosolids "dilemma"

- Nutrients in biosolids are more slowly released and less leachable than when supplied as manures or fertilizers
- Unbalanced N:P ratio in biosolids vs. crop requirements
- Eutrophication: P is limiting nutrient in most water bodies. Concentrations as low as 0.02 mg L^{-1} can cause accelerated eutrophication

Biosolids "dilemma"

- N-based rates provide excess P (Bahiagrass: 80-160 lb N/A; 10-17 lb P/A . N:P ratio of 4-8 N:1 P)
- P-based rates very low (~1-2 T/A)
  - Impractical
  - Uneconomical
  - Require greater land area
  - Require supplemental N

Research Project Goals

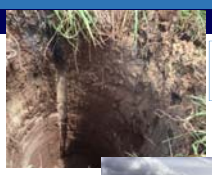
1. Generate and disseminate science-based data based on field experiments,

2. Demonstrate the environmental advantages of using biosolids-P and -N compared to commercial fertilizer,

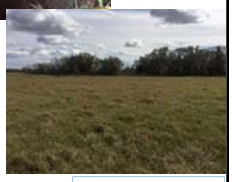
3. Demonstrate the sustainability of the land application of biosolids to pastures in Florida.

Objectives

1. To establish a **long-term, instrumented field trial** designed to evaluate the agronomic benefits of biosolids application on forage production.
2. To evaluate the effects of co-application of biosolids and biochar (also known as "black carbon) on soil chemical (C, N, and P dynamics) and physical properties (water holding capacity, aggregate stability)
3. To monitor N and P losses via leaching and gas emissions



Soil type: Smyrna (sandy, siliceous, hyperthermic Aeric Alaquods)



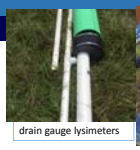
Experimental area: established bahiagrass pasture

Materials and Methods

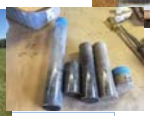
❖ Treatments: 3 Biosolids + commercial fertilizer (N and P) applied either alone or in combination with biochar (1% wt. basis). Biosolids and fertilizer were applied at a rate of 160 lb plant available N/A.

❖ Why biochar?

- C-rich material that can act as a strong sorbent that can control excess N and P in soil and water
- Non-hazardous residuals
- Low cost
- Improve soil chemical, physical, and biological properties



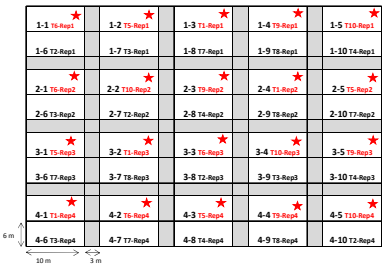
drain gauge lysimeters



Gas chambers

Initial soil characterization

Materials and Methods



Treatment ID	Biosolids/Fertilizer	Biochar
1	Control†	no
2	Control	yes
3	Class AA pellets	no
4	Class A A pellets	yes
5	Class B_Bradenton	no
6	Class B_Bradenton	yes
7	Class B_St Pete	no
8	Class B_St Pete	yes
9	N+P inorg. Fertilizer	no
10	N+P inorg. Fertilizer	yes

†red font indicates water quality and GHG measurements

Initial Soil Characterization

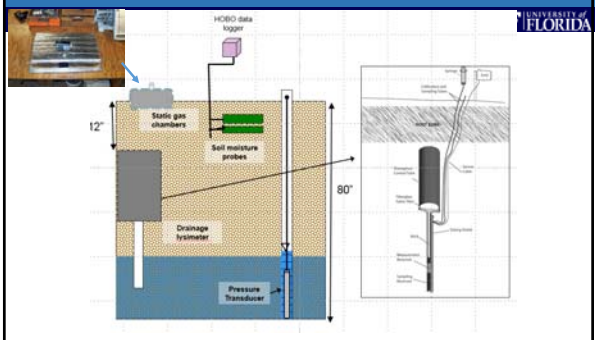
Depth	Bulk density	pH	Total C	Total N	Mehlich-3 extractable						Water extractable P	PSI
					P	K	Ca	Mg	Fe	Al		
cm	g cm^{-3}		____%___		_____ mg kg^{-1}_____							
0-10	1.0	5.0	1.6	0.1	190 (high)	37	110	481	241	1528	3.9	10.1
10-20	1.3	5.6	1.1	0.06	47	12	35	376.	163	1783	0.1	2.2
20-40	1.3	5.8	0.8	0.06	86	8	116	2.5	133	2479	1.0	2.9
40-60	1.7	5.9	0.4	0.01	153	0.1	41	0.2	135	1831	BDL‡	7.0
60-90	1.7	6.1	0.4	0.01	130	0.1	20	0.1	121	1701	BDL	6.4

‡BLD = below the detection limit of 0.01 mg P L^{-1}.

Biosolids and Biochar Characterization

Element	Class AA Pellets Biosolids	Class B Aerobically Digested Biosolids	Class B Anaerobically Digested Biosolids	Biochar
Moisture (%)	8.4	86	84	14
pH	7.7	7.9	8.6	9.9
TN (%)	6.6	4.8	7.6	0.4
TP (%)	1.9 (N:P = 3.5)	3.3 (N:P =1.5)	2.6 (N:P = 3)	0.09
TK (%)	0.1	0.3	0.5	0.6
NH_4^+-N	0.6	1.1	2.7	0.2
NO_3^--N	0.2	0.7	0.9	0.2
S (%)	2.1	1.0	1.0	0.03
B (%)	0.01	0.007	0.006	0.002
Zn (%)	0.09	0.1	0.07	0.002
Mn (%)	0.01	0.007	0.006	0.06
Fe (%)	1.1	4.4	0.4	0.1
Cu (%)	0.03	0.01	0.06	0.001
Ca (%)	2.6	2.7	2. 7	1.0
Mg (%)	0.6	0.6	0.9	0.3
Na (%)	0.3	0.3	0.1	0.07
Al (%)	0.5	0.3	0.3	0.06
Cd (ppm)	1.6	0.6	0.8	0.001
Cr (ppm)	62.1	63.3	23.4	2.6
Pb (ppm)	29.7	14.7	11.8	0.8
Co (ppm)	1.2	3.8	2.5	0.4
Ni (ppm)	45.344	23.746	13.476	0.200

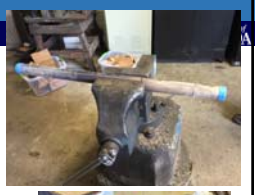
Monitoring Instruments



Response Variables

- Forage were harvested at 6 wk intervals for yield, nutritive value, and tissue N and P determination
- N and P leaching using drain gauge lysimeters
- Water table, soil moisture levels, and drainage volume
- Greenhouse gas emissions using static chambers
- Soil chemical, physical, and biological responses (N, P, C, and water-holding capacity)






Drain gauge lysimeters



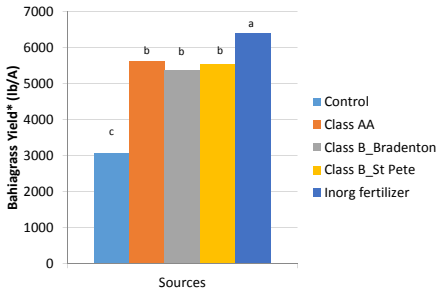

Drain gauge lysimeters


video

Biosolids and biochar application


Biosolids and biochar application

Preliminary Results



Data refer to 2 harvest events (June 22 and Aug. 17) in 2017.

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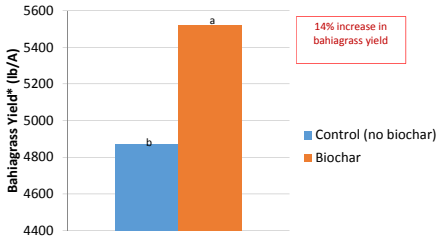

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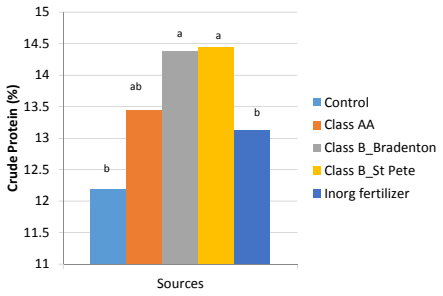

Data refer to 1 harvest event (June 22) in 2017.

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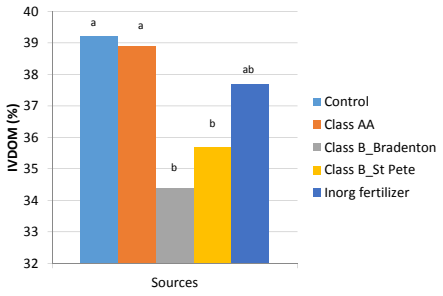

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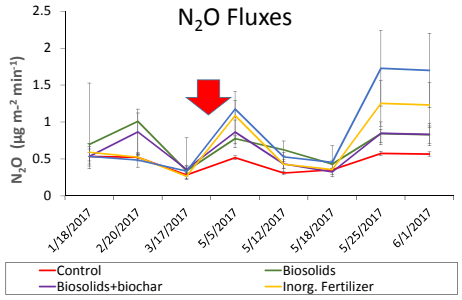

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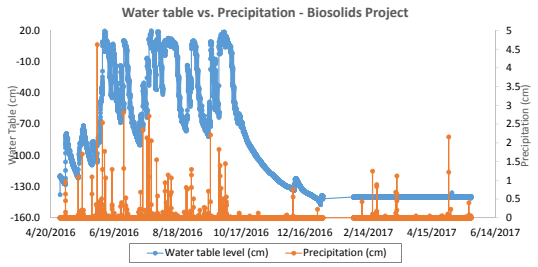
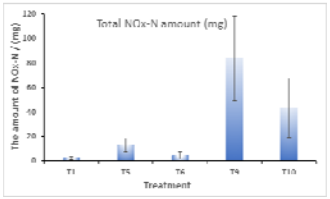


Preliminary Results

Treatment	Sampling Date				
	9/8/2016	9/17/2016	9/30/2016	3/14/2017	5/5/2017
	Leachate NO_3-N (mg)				
Control	0.1±0.04	0.2±0.07	0.3±0.2 b	0.2±0.07	0.1±0.05
Biosolids	0.2±0.1	0.2±0.05	0.3±0.2 b	0.1±0.06	0.05±0.03
Biosolids + biochar	0.2±0.04	0.2±0.03	0.9±0.8 b	0.3±0.08	0.05±0.04
Inorg. Fertilizer	0.3±0.2	11±10	66±18 a	12±4.9	1.1±0.8
Inorg. Fertilizer + Biochar	0.3±0.1	0.3±0.1	42±24 a	7.2±5.9	0.1±0.05
P value	*0.6*	*0.3*	*0.007*	*0.09*	*0.5*
Significance	NS	NS	*	NS	NS

Preliminary Results



T1: Control T5:Class B_Bradenton biosolids T6: Class B_Bradenton biosolids+Biochar
T9:NH4NO3+Phosphate T10: NH4NO3+Phosphate+Biochar

Additional Studies

1. Laboratory characterization
   - Comparative bioavailability and leachability to fertilizer-N
2. Greenhouse studies
   - Impacts of biosolids + biochar on bahiagrass responses
3. Simulated rainfall studies
   - Amendment and management effects
4. Trace organics
   - **Ciprofloxacin and azithromycin**

THANK YOU!

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