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## Updates on Biosolids Research

### On a Webinar April 9, 2024

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**Maria L. Silveira**  
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Range Cattle REC

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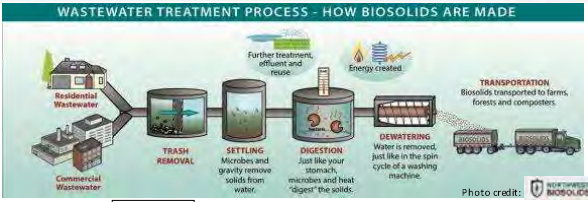
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## Biosolids vs Sewage Sludge

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**WASTEWATER TREATMENT PROCESS - HOW BIOSOLIDS ARE MADE**



The diagram shows the following steps: Residential and Commercial Wastewater enter a treatment plant. **TRASH REMOVAL** occurs first. **SCREENING** follows, including Primary (gravity sedimentation and flotation) and Secondary (Biological process). **SETTLING** occurs where microbes and gravity remove solids. **DIGESTION** follows, where microbes and heat "digest" the solids, creating energy. **DEWATERING** is the final step where water is removed, like in a washing machine. The resulting **BIOSOLIDS** are then transported to farms, forests, and composters. Further treatment, effluent, and reuse are also shown.

Photo credit: NORTHWEST BIOSOLIDS

- ~99% of the wastewater stream that enters a treatment plant is discharged as effluent
- Biosolids refers to sewage sludge that has undergone sufficient treatment for stabilization and pathogen reduction, and that is of sufficiently high quality to be land applied

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## The Stickney Water Reclamation Plant in Chicago, IL\*

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\*One of the largest wastewater treatment facilities in the world. It serves over 2.3 million people and cleans an average of 700 million gallons of wastewater per day.

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## The Stickney Water Reclamation Plant in Chicago, IL

NUTRIENT RECOVERY FACILITY

If you flush a toilet in Northlake, it takes about 8 hours to get to Stickney WRP (in dry weather) and 8-12 hours to go through the treatment process before it is released as clean water to the Chicago Sanitary and Ship Canal.

Source: Metropolitan Water Reclamation District of Greater Chicago, Inc.

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## Biosolids in Florida

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- Each person in the US generates ~0.16 pounds (dry weight basis) of sewage sludge per day
- FL population of 21.5 million (70% serviced by centralized sewerage systems) = 400,000 tons of biosolids (dry weight basis) per year
- Class B: Treatment significantly reduce pathogens. Minimum quality for beneficial use. Site restrictions are required to minimize potential exposure
- Class AA – Treatment eliminates pathogens. Highest quality for beneficial use
- **Federal** (Title 40 CFR Part 503 (Standards for the Use and Disposal of Sewage Sludge), **State** (Chapter 62-640, Florida Administrative Code), and **local ordinances**

Source: University of Florida, UF/IFAS, 2022

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## Use and Disposal of Biosolids

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**Class AA Biosolids Products Distributed and Marketed in Florida**  
178,511 Dry Tons

Landfilling (27%)	48,288 Dry Tons
Other (2%)	3,570 Dry Tons
Land Application (71%)	126,653 Dry Tons

FLDEP, 2013

**Biosolids Use & Disposal from 2022 Biosolids Annual Reports**

Land Application (71%)	252,000 Dry Tons
Landfilling (27%)	91,000 Dry Tons
Other (2%)	6,000 Dry Tons

EPA, 2022 (data from facilities that serve 10,000 people or more)

Source: University of Florida, UF/IFAS, 2022

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## What is in biosolids?



Major element	Mean	95 <sup>th</sup> percentile
Nitrogen	4.8	7.7
Phosphorus	2.2	3.9
Potassium	0.1	0.6
Calcium	3.1	15
Magnesium	0.3	0.6

- 50-70% organic material

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## What is in biosolids?



Parameter	Ceiling Concentration Limit (mg/kg dry weight basis)	Class AA Parameter Concentration Limit* Monthly Average (mg/kg dry weight basis)	2013 Class AA Average (mg/kg dry weight basis)	2013 Class B Average (mg/kg dry weight basis)	2013 Overall Average (mg/kg dry weight basis)
Arsenic (As)	75	41	4.21	5.68	4.80
Cadmium (Cd)	85	39	2.10	2.94	2.44
Copper (Cu)	4300	1500	346.65	429.76	380.00
Lead (Pb)	840	300	18.89	25.31	21.47
Mercury (Hg)	57	17	0.68	0.93	0.78
Molybdenum (Mo)	75	- *	9.84	14.37	12.38
Nickel (Ni)	420	420	19.28	20.82	19.90
Selenium (Se)	100	100	9.15	9.15	9.15
Zinc (Zn)	7500	2800	676.14	853.16	747.32

FLDEP, 2013

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## What is in biosolids?



- Misconceptions over high levels of trace elements, potentially harmful pathogens and other pollutants such as microplastics, pharmaceuticals, per and polyfluoroalkyl substances (PFAS)
- Most contaminants in biosolids occur naturally in soil, water and air and the amounts added via land application are small compared to the background levels

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# Risk Assessment

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- Risk assessment is a scientific process that considers two primary factors: 1) exposure (i.e., how much contact a person or ecological receptor, such as plants or fish, has with the contaminant); and 2) the toxicity of the pollutant.
- 40 CFR Part 503 was developed based on the results of risk assessments to identify what, if any, risks were associated with the use or disposal of biosolids via land application, surface disposal, or incineration.
- Worst-case protection - standards and practices protect a person, animal, or plant that is highly and chronically (continuously) exposed to biosolids pollutants.

Source: US EPA and Westview Books, 2003. Page 26/29

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# Risk Assessment

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The infographic compares risk levels for different biosolids applications. It includes a table of application types and their associated risks, and a central diagram illustrating the relative risk of various scenarios.

**WHAT'S THE RISK?**  
 It would take many thousands of working or playing around biosolids or compost made with biosolids to equal everyday exposure to many common products.

Category	Application	Relative Risk
Residential	Lawns	Very Low
	Landfills	Very Low
Industrial/Commercial	Construction Sites	Low
	Landfills	Low
	Construction Sites	Low
Agriculture	Crop Land	Very Low
	Landfills	Very Low

Source: Northwest Biosolids, 2021. Biosolids: understanding the risk

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# What does science tell us about biosolids?

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- Benefits of biosolids as a useful soil amendment well documented by peer-reviewed research
- No peer reviewed scientific evidence of harm or disease from land application
- Biosolids research in FL - Maria Silveira, George O'Connor, Lynn Sollenberger, Yuncong Li, Tom Obreza, Jonathan Judy, ...
- Keywords "Biosolids" and "Florida" and "Pasture" or "bahiagrass"

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## What does science tell us about biosolids?

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## Multi-state project "W4170 Beneficial Use of Residuals to Improve Soil Health and Protect Public, and Ecosystem Health"

- Established in early 1970's, 50+ scientists (**diverse expertise with national and international recognition**) from 30 states with extensive history on biosolids research
- USEPA Office of Water, Office of Research and Development, USDAARS
- Biosolids Regional Groups (NW, NEBRA, CASA, MWRD, Mid Atlantic)
- Other biosolids stakeholders, industry representatives
- More than a 48-year history of biosolids research used to support the regulatory community for promulgation of Part 503 (Title 40 CFR Part 503 – Standards for the Use or Disposal of Biosolids) and other science-based state and federal guidelines and regulations

2023 Annual Meeting

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## National Academy Review, 1996 and 2002

**1996**

- When practiced in accordance with existing federal guidelines and regulations, land application of biosolids presents negligible risk to consumers, crop production and environment
- Part 503 adequate to protect human health and the environment

**2002**

- No documented scientific evidence that Part 503 has failed to protect human health
- A casual association between biosolids exposure and adverse health outcomes has not been documented
- There are no scientifically documented outbreaks or excess illnesses that have occurred from microorganisms in treated biosolids

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# Office of Inspector General (OIG) Report No. 19-P-0002 \*



- The OIG report alleged that "...[EPA] lacked the data or risk assessment tools needed to make a determination on the safety of 352 pollutants found in biosolids...[including] 61 designated as acutely hazardous, hazardous or priority pollutants in other programs."
- Comprehensive review of literature by the Research Committee W4170
- W4170 report showed extensive data and risk assessment, some conducted by USEPA, exist for the pollutants listed by OIG. Sufficient data and research are available to conclude that current biosolids regulations are protective of human health and the environment.
- The report concluded that OIG statement was "inaccurate and alarmist", however, it also pointed out several chemicals, including persistent pharmaceuticals, require further study.

<https://nimss.org/system/ProjectAttachment/files/000/000/502/original/W4170%20Response%20to%20OIG%20Report%20July%202023%202020%20final.pdf>

\*EPA unable to assess the impacts of unregulated pollutants in land-applied biosolids on human health and the environment

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# Why obstacles still exist?



- Odor issues
  - Nuisances but no data that show biosolids odors cause human toxicological effects
  - Most odors caused by sulfur compounds and ammonia that only cause toxicological effects at concentrations > detected as odors
  - Additional information:  
[https://faculty.washington.edu/slb/docs/basics/Biosolids\\_an\\_d\\_odor.pdf](https://faculty.washington.edu/slb/docs/basics/Biosolids_an_d_odor.pdf)
- Misinformation/"yuck" factor
- Past mismanagement
- Scientific uncertainty – e.g. PFAS contamination in dairy farm in Michigan

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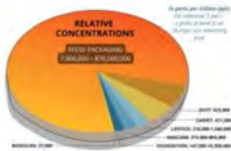
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# Putting things in perspective



Source: CASA




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### Future Direction in Biosolids Research in Florida



- Long-term, field studies are critical for better understanding the benefits and risks associated with land application of biosolids

“Data gaps exist where actual biosolids, with realistic concentrations of the chemical of concern, are land applied. Field-realistic land application of biosolids research should be used to provide data by USEPA to conduct its risk assessment and promulgate regulation of these and future chemicals of concern. ”

- Environmental footprint

N. Saha, Soil and Water Resour. Educ. 69:59-62 (2023)

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### Biosolids Field Trial at the UF/IFAS Range Cattle REC, Ona




3 PhD students trained, multiple outreach activities, presentations at scientific meetings and peer-reviewed articles

Experimentalsite funded by Florida Cattle Enhancement Board

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### Published peer-reviewed articles



1. Vieira, L.O., **Silveira, M.L.**, Kohmann, M.M., Sollenberger, L.E., Sanchez, J.M.D., Cardoso, and A.S., and Ricken E.C 2024. Agronomic impacts of new regulations governing land application of class B biosolids in Florida. *Agronomy Journal*. DOI: 10.1002/agj.2.21510.
2. Vieira, L.O., **Silveira, M.L.**, Kohmann, M.M., Sales, C.A.R., Sollenberger, L.E., Bhadha, J.H., Strauss, S.L., Moriel, P. 2023. Water table effect on phosphorus solubility in biosolids-amended soils. *Soil Science Society of America Journal* <https://doi.org/10.1002/saj2.20568>.
3. Lu, Y., **Silveira, M.L.**, Vendramini, J.M.B., and Li, Y. 2023. Biochar impacts on soil nitrogen and carbon dynamics in a Spodosol amended with biosolids and inorganic fertilizer. *Journal of Environmental Quality*, <https://doi.org/10.1002/jeq2.20504>
4. Lu, Y., **Silveira, M.L.**, O’Connor, G.A., Vendramini, and Li, Y.C. 2022. Biochar type and application methods affected nitrogen and phosphorus leaching from a sandy soil amended with inorganic fertilizers and biosolids. *AgroSystems, Geosciences & Environment*, DOI: 10.1002/agg2.20236).
5. Lu, Y., **Silveira, M.L.**, O’Connor, G.A., Vendramini, J.M.B., Erickson, J.E., and Li, Y.C. 2021. Assessing the impacts of biochar and fertilizer management strategies on N and P balances in subtropical pastures. *Geoderma* 394 [doi.org/10.1016/j.geoderma.2021.115038](https://doi.org/10.1016/j.geoderma.2021.115038)
6. Lu, Y., **Silveira, M.L.**, Cavigelli, M., O’Connor, G.A., Vendramini, J.M.B., Erickson, J.E., and Li, Y.C. 2020. Biochar impacts on nutrient dynamics in subtropical grassland soil: 2. Greenhouse gas emissions. *Journal of Environmental Quality* 49:1421-1434. DOI: 10.1002/jeq2.20141.

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Published peer-reviewed articles – cont.



- 7. Lu, Y., **Silveira, M.L.**, O'Connor, G.A., Vendramini, J.M.B., Erickson, J.E., Li, Y.C., and Cavigelli, M. 2020. Biochar impacts on nutrient dynamics in subtropical grassland soil: 1. Nitrogen and phosphorus leaching. *Journal of Environmental Quality* 49:1408-1420. DOI: 10.1002/jeq2.20139.
- 8. Lu, Y., **Silveira, M.L.**, Vendramini, J.M.B., Erickson, J.E., Li, Y. 2020. Biosolids and biochar application effects on bahiagrass herbage accumulation and nutritive value. *Agronomy Journal* 112, 1330-1345.
- 9. **Silveira, M.L.**, O'Connor, G.A., Lu, Y., Erickson, J.E., Brandani, C., Kohmann, M.M. 2019. Runoff and leachate P and N losses from grass-vegetated soil boxes amended with biosolids- and fertilizer. *Journal of Environmental Quality* 48:1498-1506.



Dr. Yanyan Lu (2016-2020)



Dr. Leandro Vieira (2019-2023)



Nikitha Kovvuri (2023-present)

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Take-home message



- ❑ Field, greenhouse, and laboratory studies conducted in Ona demonstrated that biosolids have considerable fertilizer value and can be a sustainable alternative to commercial inorganic fertilizer
- ❑ Application of biosolids resulted in significant lower risks of N and P losses than inorganic fertilizer
- ❑ Commercial cow-calf operation with a previous history of biosolids application: data demonstrated despite elevated soil P levels, Al and Fe added with biosolids reduced P solubility by as much as 55% compared with the control (no biosolids)

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Biosolids disposal options/technologies



The Metropolitan Water Reclamation District of Greater Chicago's nutrient recovery facility has 3 mega-sized reactors that can recover more than 85% of the P and up to 15 % of the N from the wastewater cleaned by the plant.

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### Biosolids disposal options/technologies

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Revolving Algal Biofilm system (RAB)

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THANK YOU!  
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