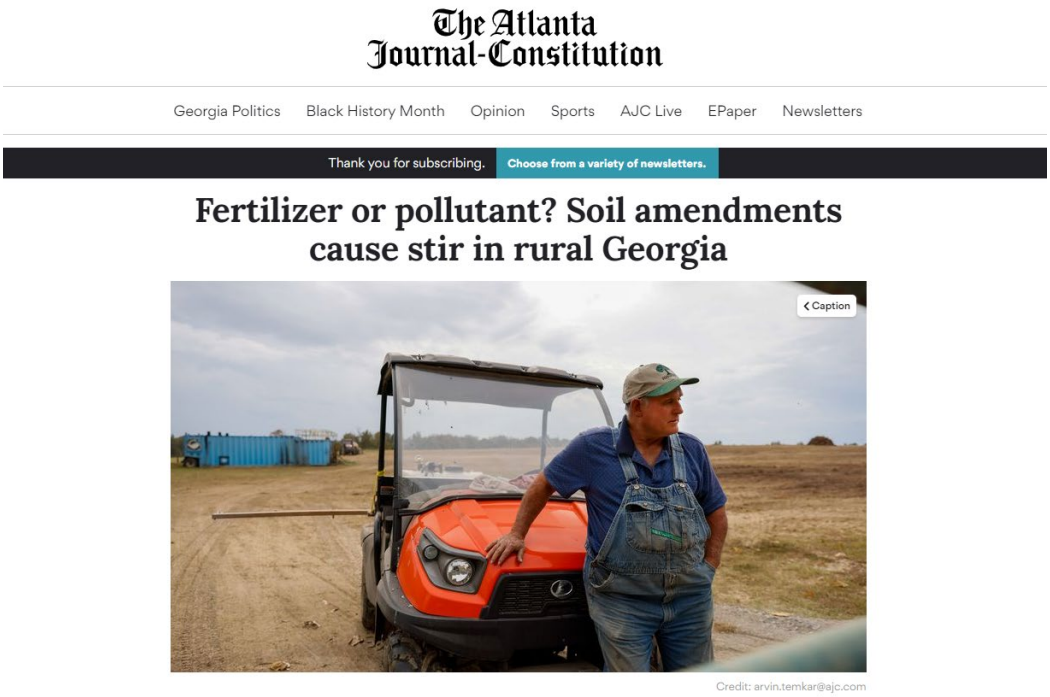
The Science of Soil Amendments

Introduction

In Georgia, soil amendments are defined as additives that alter the physical properties of the soil, such as soil texture. These additives can be used to reduce erosion, improve water retention, change soil pH, enhance nutrient holding, and/or re-establish microbial communities. All these uses are vital for soil remediation and revitalization. [1] Soil amendments do not enhance the nutrient value of soil. They are not fertilizer. [2]

Unfortunately, soil amendment regulations are incomplete and unenforced. The Georgia Department of Agriculture Soil Amendment program is being abused to enable quasi-legal to straight-up illegal dumping of untreated industrial waste streams including waste from slaughterhouses, fat-traps, wood-ash, and humans. [3]



The science is clear that properly treated and properly applied soil amendments are beneficial for changing the physical properties of soil. [1] The science is also clear that without proper treatment and regulation, industrial by-product (IBP) and wastewater treatment plant (WWTP) sludge can harm the land and the citizens of Georgia. IBPs include material from industries (like restaurants, kitchen, food processing, and slaughterhouses) that is derived from living matter. WWTP sludge is semi-solid material recovered from sewage.

Questions? Please contact: Gordon Rogers, gordon@flintriverkeeper.org or
Tonya Bonitaibus, riverkeeper@savannahriverkeeper.org

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Untreated and improperly treated IBPs and WWTP sludge contain toxic pathogens such as Salmonella, other bacteria, viruses, prions (mad cow disease), and heavy metals, which are a human health risk. [4] [5] [6] They may contain high loads of antibiotics, which can lead to increased antibiotic resistance in humans and livestock. [4] An emerging worry is PFAS concentrations, which are not remediated by current treatment techniques. [7]

The Georgia Department of Agriculture already regulates soil amendments. [3] All amendments must be licensed and labeled. IBP-derived amendments must provide information about the industry of origin, production process, and suitable application rates. WWTP sludge amendments must be Class A sewage sludge and contain information on facility(ies) of origin and suitable application rates.

These regulations are a good start to protecting our land and our health. Strengthening enforcement of regulations and transparency of reporting is needed to ensure that soil amendments are:

- Utilized by farms for agriculture purposes, and
- Safe for humans and the environment.

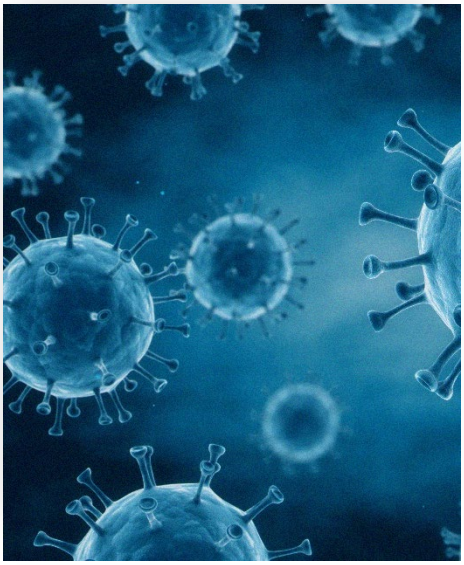
To ensure the above, it is key that the contents, location, and amount of all soil amendments applied in Georgia are known to maintain transparency for farmers and the larger community.

The Dangers of Untreated Industrial By-Products

Slaughterhouse IBPs are highly unstable and ripe for unhygienic conditions. [9] The high water content and the high fat content combine to produce waste that can contain microbes and pathogens that can spiral out of control. [5]

Untreated slaughterhouse waste typically contains an abundance of nutrients, possible pathogens, and antibiotics. [10] Nutrient-abundant runoff from land application of untreated waste into streams and rivers causes algae blooms, temperature changes, and oxygen depletion, all of which harm the existing aquatic life. [4] Pathogens include Salmonella, which are a human health risk. [4] And high loads of antibiotics can lead to increased antibiotic resistance in humans and livestock.

WWTP sludge "contains toxic and less toxic pollutants, organic matter, pathogenic microorganisms, inorganic substances, and heavy metals (cadmium, chromium, copper, lead, mercury, nickel, zinc, platinum and platinum group metals (PGMs), silver, etc.)." [6]



Human exposure to excess amounts of heavy metals has been shown to have various detrimental effects on different body systems including gastrointestinal, kidney, immune system, and nervous system disorders, skin problems, circulatory damage, birth defects, and cancer. When exposed to more than one heavy metal toxin, the effects are cumulative, increasing the damage. [11]

Contaminants in Untreated IBP-Derived Soil Amendments

Untreated IBP-derived soil amendments may include contaminants which can pose a risk to both human and environmental health. These possible contaminants should be considered when suggesting testing protocols and requirements.

- Pathogens: [5]
  - Salmonella
  - Botulism, tetanus
  - Brucellosis
  - Anthrax
  - M. Bovis (Beef Tuberculosis)
  - Erysipelothrix rhusiopathiae
  - BSE (mad cow)
  - Foot-and-mouth
- Heavy Metals: [6]
  - Cadmium
  - Chromium
  - Copper
  - Lead
  - Mercury
  - Nickel
  - Zinc
  - Platinum and platinum group metals
  - Silver

Emerging PFAS Concerns for IBP-Derived Soil Amendments

An emerging concern for all types of waste is per- and polyfluoroalkyl substances, known as PFAS, concentration. [12] PFAS have been linked to a host of human health problems including obesity, liver disease, blood pressure problems, and cancer. [12] “Without appropriate mitigation methods, human exposure could occur from wastewater through de facto and planned potable reuse, or through bioaccumulation into food or leaching into groundwater from biosolid application sites.” [16]

PFAS concentration in an individual application will vary greatly depending on the source. Current treatment strategies employed at WWTPs and IBP treatment plants (anaerobic digestion and composting) are ineffective. [7]

To reduce PFAS overall they should be phased out of new products and remediation technologies should be implemented in WWTP and IBP treatment plants. [17] In the meantime, to reduce the spread of PFAS back into the environment, soil amendments should be tested for PFAS concentration and permits should be issued only for those with an acceptable level of PFAS. Landfill disposal of the rest is environmentally unsustainable, but an unfortunate necessity until remediation treatment technology is utilized. [18]

The Benefits of Properly Treated Soil Amendments

Soil amendments are a key part of a circular economy where waste is utilized to improve soil health and reduce environmental impacts. [12]

“The addition of amendments restores soil quality by balancing pH, adding organic matter, increasing water holding capacity, re-establishing microbial communities, and alleviating compaction. As such, the use of soil amendments enables site remediation, revegetation and revitalization, and reuse.” – EPA [1]

This memo references peer-reviewed research, which discusses how to treat IBPs and WWTP sludge so that it can be used. It is important to note that no study looked at spreading untreated material due to the overwhelming negative effects that have been outlined herein. It would be ethically unviable.

Proper Treatment to Produce a Beneficial Soil Amendment

Slaughterhouse IBPs used to be disposed of as animal feed or other food by-products. [9] But the risk of pathogens and prion diseases (mad cow) have limited the profitability as feedstock usage. [13] Instead, non-food uses are becoming more popular. Studies have shown that anaerobic digestion combined with pasteurization is an effective method to properly process IBPs. [5] It creates two things: 1) biogas + methane and 2) nutrient rich digestate. These are mutually beneficial, as the methane can be used to pasteurize the digestate, which can then become bedding for livestock, flowerpots, soil amendments, and fertilizers. [14]

Proper disposal of the biosolids from WWTPs is done via landfilling, incineration, or land application. [15] Landfilling is inexpensive, but to prevent environmental exposure it must occur in properly maintained and lined landfills. Landfilled waste also emits methane, a potent greenhouse gas. Incineration reduces the volume of waste via burning. The incinerated ash then goes to a landfill or can become construction material. However, incineration is expensive and requires appropriate scrubbing to prevent the release of harmful air pollution, such as CO2.

Land application of biosolids can restore soil health and are a slow-release form of nutrients, both of which are economically valuable to farmers and reduce harmful nutrient runoff. It must be properly treated to remove pathogens and heavy metals. In this case, anerobic digestion combined with pasteurization is a viable treatment alternative.

Policy Examples

Illinois, New Mexico, and Hawaii have policies that define the characteristics of a beneficial soil amendment. [19] [20] [21] Generally, these policies aim to restore or otherwise improve the soil's rates of erosion, water retention, maintenance of its root systems, organic matter, and ultimately care for the "health, yield, and profitability of soils throughout the state."

The State of Minnesota requires that an IBP be tested for: [22]

- Chloride
- Nitrogen, Ammonia
- Nitrogen, Kjeldahl
- pH, Sludge
- Phosphorus
- Sodium
- Solids, Total
- Solids, Total Volatile
- Oil and grease, Total Recoverable
- And any pollutants that have a reasonable likelihood of being present - based on where the IBP came from. [22]

Georgia's Current Regulations and Suggested Changes

The Georgia Department of Agriculture currently issues licenses for soil amendments.

According to current code, soil amendments must: [3]

- Include a label with the following:
  - The product name;
  - A statement of product benefit;
  - The concentration of active and inert ingredients;
  - Recommended directions for use;
  - The net weight or volume; and
  - The name and address of the registrant.

If the amendment is derived from an industrial by-product, the following supplemental information must be provided: [3] [8]

- Information about the industry that produces the by-product.
- Contents of the amendment and process by which it is produced.
- Intended use of amendment and suitable rates / frequency of application to a site.
- A representative analysis of the soil amendment.

Georgia regulations also mandate how IBP-derived soil amendments must be applied:

- Nutrient Management Plans must specify that IBP-derived soil amendments with greater than or equal to 85% moisture content be applied via subsurface injection.
- Nutrient Management Plans must specify that IBP-derived soil amendments with less than 85% moisture content be applied by topical application followed by incorporation into the soil within 6 hours of application.

If the amendment is derived from sewage sludge (biosolids), only "Class A Sewage Sludge" can be used, and supplemental information must be provided: [3]

  - Facility(ies) that the sludge came from.
  - Intended use of amendment and suitable rates / frequency of application to a site.
  - A representative analysis of the sludge.

By listing the contents of the amendment, the source of the amendment, and the intended use, farmers can ensure that they are applying something useful to their land – and their neighbors can feel confident they are not being exposed to anything harmful. However, given that IBP- and WWTP-derived amendments can contain a host of ingredients that are harmful to human and environmental health, a recommended addition to the current regulation would be testing for and listing of concentrations of processing chemicals, PFAS, heavy metals, and toxins.

Soil Amendment Terms and Definitions

Soil Amendment

Any product or substance added to the soil, via active tillage into the soil, with the purpose of enhancing the soil to make it better suited for growing. Key components are:

- The amendment is tilled into the soil and/or injected below the surface to ensure absorption and prevent runoff.
- The amendment enhances the physical properties of soil itself by restoring pH levels, changing water holding capacity, and/or adding material that restores overall soil health. [1]
- An amendment is not "fertilizer" which does not change the soil itself. Fertilizers are for plant use only and do nothing to the soil itself. Soil amendments make the land more able to sustain plant life. [23]

Industrial By-Product

Any material that originates from industry (food processing, slaughterhouse, restaurant) that consists of material derived from living matter (animals or plants).

Wastewater Treatment Plant (WWTP) Sludge

A watery mixture of solids that is left over after wastewater is treated and the clean water released back into the environment. [15]

Biosolid

An industry term referring to WWTP sludge that has been treated and can be applied safely to the land. [15]

Organic Materials

While "organic" is often used to imply a specific set of farming and production practices, in this case organic refers to any material derived from living organisms (plants or animals).

Fats, Oils, and Greases (FOGs)

FOGs should not go to landfills or sewer systems as they can cause clogs and other problems. Instead, FOGS should be processed via 3 pathways:

1. Rendering - turning into animal food, cosmetics, soap, etc. Many companies provide free pickup for this type of waste.
2. Biodiesel.
3. Anaerobic digestion. [24]

Anerobic Digestion (AD)

AD is one method of treating organic materials that come from IBP or WWTP sludge. [14] [24] The material is placed in an oxygen free environment and microorganisms break it down to produce: Biogas (methane and carbon dioxide – which can become natural gas), or Digestate – this end-product is nutrient rich. It has a solid and liquid component. When properly treated it can become: bedding for livestock, flowerpots, soil amendments, fertilizers.

Pasteurization

Sterilization of a product, often through heating to high temperatures, to make it safe for use.

Per- and polyfluoroalkyl substances (PFAS)

Per- and polyfluoroalkyl substances (PFAS) are class of chemicals used since the 1950s to make products resistant to heat, oil, stains, grease, and water. [25] PFAS are widely used as coatings are on a variety of products, including furniture, food packaging, and electrical wire insulation. [26]

References

[1] US Environmental Protection Agency, "The Use of Soil Amendments for Remediation, Revitalization, and Reuse," [Online]. Available: https://www.epa.gov/biosolids/use-soil-amendments-remediation-revitalization-and-reuse. [Accessed 16 Dec 2022].

[2] S. L. Capitaine and C. Carlson, "Soil Amendments And Conditioners Vital In Soil Restoration," [Online]. Available: https://feeco.com/soil-amendments-and-conditioners-vital-in-soil-restoration/. [Accessed 22 Jan 2023].

[3] GA Dept of Agriculture, "Soil Amendments," 22 Jan 2023. [Online]. Available: https://agr.georgia.gov/soil-amendments.

[4] M. M. K. A. G. L. H. M. A. E. L. V. B. R. P. Mauricio Barrera, "Photolytic treatment of organic constituents and bacterial pathogens in secondary effluent of synthetic slaughterhouse wastewater," Chemical Engineering Research and Design, vol. 90, no. 9, pp. 1335-1350, 2012.

[5] I. H. Franke-Whittle IH, "Treatment alternatives of slaughterhouse wastes, and their effect on the inactivation of different pathogens: a review.," Crit Rev Microbiol., vol. 39, no. 2, pp. 139-51, May 2013.

[6] A. C. K. K. A. Grobelak, "General considerations on sludge disposal, industrial and municipal sludge," in Industrial and Municipal Sludge, 2019, pp. 135-153.

[7] S. T. W. D. S. S. A. G. K. E. P. J. Crone BC, "Occurrence of Per- and Polyfluoroalkyl Substances (PFAS) in Source Water and Their Treatment in Drinking Water.," Crit Rev Environ Sci Technol., vol. 49, no. 24, pp. 2359-2396, Jun 2019.

[8] Georgia Secretary of State, "Rules and Regulations of the State of Georgia. Chapter 40-31. Soil Amendments," [Online]. Available: https://rules.sos.ga.gov/GAC/40-31.

[9] S. K. R. K. B. A. Jayathilakan K, "Utilization of byproducts and waste materials from meat, poultry and fish processing industries: a review.," J Food Sci Technol., vol. 49, no. 3, pp. 278-293, Jun 2012.

[10] M. Musa and S. Idrus, "Physical and Biological Treatment Technologies of Slaughterhouse Wastewater: A Review.," Sustainability, vol. 13, no. 9, p. 4656, Apr 2021.

[11] M. N. K. T. Z. K. M. S. M. Balali-Mood, "Toxic Mechanisms of Five Heavy Metals: Mercury, Lead, Chromium, Cadmium, and Arsenic," Front. Pharmacol., 13 Apr 2021.

[12] K. V. M. E. P. S. S. D. D. B. D. D. N. M. Jha G, "Per- and Polyfluoroalkyl Substances (PFAS) in Integrated Crop-Livestock Systems: Environmental Exposure and Human Health Risks.," Int J Environ Res Public Health., vol. 18, no. 23, p. 12550, 28 Nov 2021.

[13] C. M. B. D. Adhikari BB, "Utilization of Slaughterhouse Waste in Value-Added Applications: Recent Advances in the Development of Wood Adhesives," Polymers (Basel), vol. 10, no. 2, p. 176, 11 Feb 2018.

[14] US Environmental Protection Agency, "Basic Information about Anaerobic Digestion (AD)," [Online]. Available: https://www.epa.gov/anaerobic-digestion/basic-information-about-anaerobic-digestion-ad. [Accessed 16 Dec 2022].

[15] PennState Extension, "What Is Sewage Sludge and What Can Be Done with It?," [Online]. Available: https://extension.psu.edu/what-is-sewage-sludge-and-what-can-be-done-with-it. [Accessed 16 Dec 2022].

[16] S. M. D. J. G. C. B. J. H. C. E. S. a. E. R. V. D. Kyle A. Thompson, "Poly- and Perfluoroalkyl Substances in Municipal Wastewater Treatment Plants in the United States: Seasonal Patterns and Meta-Analysis of Long-Term Trends and Average Concentrations," ACS ES&T Water, vol. 2, no. 5, pp. 690-700, 21 Apr 2022.

[17] US Environmental Protection Agency, "Reducing PFAS in Drinking Water with Treatment Technologies," [Online]. Available: https://www.epa.gov/sciencematters/reducing-pfas-drinking-water-treatment-technologies. [Accessed 16 Dec 2022].

[18] K. Jansen, "'Forever chemicals' no more? These technologies aim to destroy PFAS in water," [Online]. Available: https://cen.acs.org/environment/persistent-pollutants/Forever-chemicals-technologies-aim-destroy/97/i12. [Accessed 16 Dec 2022].

[19] Illinois General Assembly. 101st General Assembly., "Bill Status of HB2737," 2019.

[20] New Mexica Department of Agriculture, "Healthy Soil Program based on 2019 Healthy Soil Act".

[21] Hawaii House of Representatives. 31st Legislature. 2021, "HB 861. Relating to Composting".

[22] Minnesota Pollution Control Agency, "Land application of industrial by-products," [Online]. Available: https://www.pca.state.mn.us/business-with-us/land-application-of-industrial-by-products. [Accessed Dec 2022].

[23] Georgia Dept of Agriculture, "GEORGIA FERTILIZER ACT OF 1997 AND RULES AND REGULATIONS," [Online]. Available: http://agr.georgia.gov/Data/Sites/1/media/ag_plantindustry/seed_fertilizer_feed/files/fertilizer/GA_Fertilizer_Act_of_1997_with_Rule_and_Regs.pdf.

[24] US Environmental Protection Agency, "Industrial Uses for Wasted Food," [Online]. Available: https://www.epa.gov/sustainable-management-food/industrial-uses-wasted-food. [Accessed Dec 2022].

[25] Centers for Disease Control and Prevention, "Per- and Polyfluorinated Substances (PFAS) Factsheet," [Online]. Available: https://www.cdc.gov/biomonitoring/PFAS_FactSheet.html. [Accessed Dec 2022].

[26] Science for Georgia, "WHAT ARE PFAS (FOREVER CHEMICALS)?," [Online]. Available: https://sciencelookup.org/knowledge-base1/what-are-pfas-forever-chemicals/. [Accessed Dec 2022].

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