

Publicly owned treatment works and onsite wastewater systems produce residual products, or biosolids, that can be beneficial resources for forage and grain crop production. In Kansas, approximately 80 percent of publicly owned treatment works apply biosolids to agricultural land. The remainder either landfill or incinerate biosolids. During and after land application, appropriate handling and application practices are important to protect everyone who may come in contact with the biosolids or their products, such as composted biosolids. This publication describes the different types of biosolids and details the regulations and restrictions necessary for their safe use.

What are Biosolids?

Wastewater treatment uses combinations of microbiological, physical, and chemical processes to decompose organic material, reduce pathogens, and separate organic solids and inorganic contaminants from the clarified liquid, or effluent, in the treatment process.

The term “biosolids,” also called “sewage sludge,” refers to matter that is separated from wastewater during treatment. Biosolids from onsite wastewater systems such as septic tanks, aerated systems, lagoons, and certain types of portable toilets are collectively referred to as “septage.” Biosolids may contain a concentration of

solids from 1 percent to as much as 70 percent (99 to 30 percent water) depending on the process used to dewater the sludge. Most biosolids produced in Kansas have a low solids content of 2 to 15 percent and are applied to land as liquid slurry or semi-solid. A solids concentration of approximately 10 percent causes biosolids to be unable to flow by gravity through a 6-inch pipe. Sludge with a solids concentration between 15 to 25 percent is considered “dry” and can be handled using equipment designed for solid manure application (Figure 1). At greater than 25 percent solids, the mixture is a wet, semisolid mass. The less water the sludge contains, the thicker it is and, therefore, cheaper to transport.

Depending on their composition, biosolids can be landfilled, incinerated, composted, and even dried and bagged for sale as a soil amendment (although biosolids may not be used for certified organic production). The Milwaukee



Figure 1. *Biosolids applied on cropland provide valuable plant nutrients and conditions the soil.*

Metropolitan Sewage District has produced and sold their dry sludge under the name “Milorganite” since 1925, for example. In Kansas, land application of bulk biosolids is the most common disposal method and is used at more than 80 percent of wastewater treatment plants.

Composition and Nutrient Value

Biosolids have been extensively used as soil amendment to improve soil productivity and increase crop production. Other common uses include reclamation of mining sites as well as fertilizer for gardens and parks. However, land application of biosolids must be based on current nutrient management recommendations and in accordance with regulatory requirements.

Biosolids contain high amounts of organic matter and plant nutrients, which are beneficial for crop production (Figure 1). Municipal biosolids can supply nitrogen, phosphorus, and small amounts of potassium, all of which are major plant nutrients. The organic matter found in biosolids is a good soil conditioner that helps with microbial activity, water holding capacity, and plant growth. While the composition of biosolids can vary widely, an average ton of dry solids might contain about 80, 200, and 10 pounds of nitrogen, phosphate (P_2O_5), and potash (K_2O) respectively. At 5 percent solids, 5,000 gallons of liquid sludge are needed to make 1 dry ton of biosolids. However, much of the nitrogen may be in an organic form that is not immediately available to plants.

Nitrogen occurs mostly in ammonium or organic forms with only a small fraction being nitrate. The organic form predominates in dry biosolids, while the ammonium content is usually much higher in liquid sludge. Organic nitrogen must be mineralized before crops can use it. Research shows that, depending on the treatment used to produce the sludge, about 10 to 50 percent of the organic nitrogen will be available the first year after application. On the other hand, usually all of the phosphorous and potassium found in biosolids is considered plant-available during the year of application.

Nitrogen volatilization in the form of ammonia may be large at temperatures above 50 degrees Fahrenheit if liquid is spread on the surface without

incorporation. When liquid biosolids are injected directly into the soil, or incorporated promptly after application, most of the ammonium is retained. Nitrate leaching can be significant in sandy soils, often associated with potential groundwater contamination.

Uniform application of biosolids and thorough records of all field applications are essential to be sure that all crop areas are equally treated. Failure to do so may result in “hot spots” of over-application or areas with nitrogen deficiency. Machinery should be carefully monitored to ensure uniform application. Record keeping based on a global positioning system is recommended. Sludge application is usually done by publicly owned treatment works employees or contracted to a third party by the city. The timing and method of application, as well as record keeping, should be planned in advance to ensure the best results.

Regulations for Land Application of Biosolids

The land application of biosolids is governed by EPA 503 regulations (Title 40 of the Code of Federal Regulations, Part 503 (40 CFR 503)) established in 1993. The EPA 503 regulations set limits on pathogens, vector attraction, and toxic pollutants in biosolids. The regulations specify when and where various types of biosolids can be applied. Rules set out in EPA 503 apply to all domestic biosolids generated by wastewater treatment systems, both discharging and nondischarging types.

In Kansas, the Department of Health and Environment (KDHE) administers the regulations of EPA 503 for municipal biosolids through its permitting of publicly owned treatment works. The KDHE Bureau of Water, Technical Services Section, makes available a set of “Land Application Forms for Kansas Domestic Wastewater Treatment Facilities” on their Web site to ensure that any biosolids generated are treated, reported, and applied according to EPA 503 rules. Individual counties are responsible for overseeing onsite wastewater systems and conducting septage disposal according to EPA 503 rules. A packet called *Land Application of Septage* is available from the local environmental planning office or county sanitarian and the KDHE Web site at www.kdhe.gov.

kdheks.gov/nps/lepp/Kansas_EPA_503_Land_Application_of_Septage.pdf.

In general, the EPA 503 regulations make few demands on landowners and operators who agree to have biosolids applied on their land. All of the responsibility for testing, recordkeeping, and reporting, as well as the legal liability for damage during application, lie with the permit holder or septage hauler.

Some specific features of the EPA 503 regulations that affect biosolids' suitability for crop production are:

- **Pathogens.** Specific treatment processes and standards are required for eliminating disease-causing organisms, including bacteria, protozoa, viruses, and viable worm ova. Two classes of biosolids are defined based on pathogens. **Class A biosolids** must be essentially pathogen-free and are, therefore, considered safe for human contact. They are allowed to come into contact with crops that are consumed by humans with little or no processing, such as fruits and vegetables. Class A biosolids can even be bagged or sold in bulk to homeowners to be used as residential soil amendments. **Class B biosolids** meet a lower standard of pathogen reduction and have more restrictions in their use (see information below). Field crops used for animal feed or fiber, however, may safely receive Class B biosolids. Most biosolids produced in Kansas are handled as Class B.

Pathogens from biosolids do not pose a significant threat to humans for several reasons. When sludge is stabilized, either through the addition of lime or through composting, most pathogens are destroyed. Soil is also a hostile environment for many human pathogens because they thrive in a warm, moist, environment (such as the human body). Soil is subject to wet-and-dry and hot-and-cold cycles and does not allow most pathogens to survive. Also, most biosolids are incorporated into the soil through tillage, further decreasing the risk of direct human contact.

- **Vector Attractions.** Specific standards and treatments are required to reduce the tendency of biosolids to attract rodents, flies,

mosquitoes, or other vectors that may carry diseases. Class A biosolids must incorporate multiple factors that reduce vector attraction to a minimum, such as reducing the volatile solids by digestion at high temperature, or by raising the pH to greater than 12 for a certain length of time, or by incorporation (injecting or tilling the biosolids beneath the soil surface). Class B biosolids have less stringent requirements for treatment because they are often used in less populated areas.

- **Metals.** EPA 503 regulations specify maximum concentrations and loading rates for nine metals known to accumulate in soil or damage the environment. These metals are arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. In Kansas biosolids, these metals are rarely found in concentrations that restrict land application. Most nonindustrialized communities have minimum record keeping requirements because biosolids do not reach dangerous metal concentrations even after a total application of 1,000 tons per acre. Communities with plating industries that use cadmium, zinc, or nickel may produce biosolids with a higher concentration of these metals, triggering a limit on the total amount of biosolids that can be applied to any given location. Additional record keeping and testing requirements are the responsibility of the waste generator, not the landowner.
- **Nutrients.** The EPA 503 rules require that biosolids be applied at an "agronomic rate" based on the nitrogen requirements of the crop to be produced. Following an agronomic rate minimizes the chance that nitrogen will leach below the root zone into groundwater. Soil tests of 0 to 6 inches for phosphorus, potassium, and pH; and 0 to 24 inches for nitrate, are required for all fields. Municipal sludge can be applied at a rate determined by nitrogen availability and crop uptake using KDHE form LA-ANR, or at a fixed rate of no more than 2 dry tons of biosolids per acre as described in KDHE form LA-ANR/EZ.

Regulations require that annual reports be submitted to KDHE by February 28 of the

following year. Be sure to use the latest forms from KDHE in *Domestic Sewage Sludge Re-use and Disposal Regulations*. For septage, application rate is based on K-State's current fertilizer recommendations for nitrogen, described in *Soil Test Interpretations and Fertilizer Recommendations*, MF-2586 with nitrogen assumed to be 0.0026 pounds per gallon.

Environmental and Health Considerations

The EPA 503 rules are designed to ensure the best public health protection against pathogens, heavy metals, and nitrate in groundwater. Additional precautions may be needed to ensure employee safety when biosolids are handled and applied, to prevent degradation of cropland, and to keep biosolids from becoming a public nuisance.

Class B biosolids and raw septage are digested in order to reduce pathogens in the wastewater treatment process; however, both may still contain human pathogens. People who handle Class B biosolids and raw septage must take care to avoid inhaling or ingesting particles around application areas. As mentioned previously, Class A biosolids are safe for human contact. Everyone who has direct contact with these materials should be trained to protect themselves from exposure and what actions to take in case of exposure. Immunizations are recommended for employees likely to be exposed to diseases for which they have insufficient immunity.

Application of biosolids often involves the use of heavy vehicles to distribute material in the field. Timing of applications should consider soil moisture to minimize compaction (Figure



Figure 2. *Avoid land application of biosolids when the ground is wet, otherwise, compaction and tracking will occur.*

2). Compaction of wet soil often negates any improvement in soil condition provided by the organic matter. Also, all-weather access roads are important for transporting sludge to the field. These roads must be able to withstand the traffic load required for hauling. Transportation of sludge through residential areas may result in complaints about odor and traffic, so it is especially important to avoid any spillage or leakage onto or along public roadways.

Over-application of nitrogen and phosphorus rich biosolids also can generate negative effects on water quality. Phosphorus movement with runoff water and erosion from land treated with biosolids can contribute to eutrophication of water bodies. Risk of phosphorus loss from a field is evaluated through the Phosphorus Index. The purpose of the Phosphorus Index is to provide a tool to assess different management practices for potential risk of phosphorus movement to water bodies.

This index considers field parameters such as erosion rate, runoff, level of soil test phosphorus, and phosphorus application rates (from fertilizer and organic sources). Producers should evaluate fields for these parameters and determine the need for soil and water conservation practices,

often referred to as “best management practices,” before biosolids application. For more information, consult the K-State Research and Extension publication, *Best Management Practices for Phosphorus*. For more information on the Phosphorus Index refer to the NRCS publication, *A Phosphorus Assessment Tool*.

The not-in-my backyard syndrome strongly applies to the application of biosolids near residential areas. Typically, homeowners do not want biosolids applied near their homes because they perceive biosolids as potentially dangerous, undesirable, and degrading to property values. This attitude is often based on mistaken perception, but, unfortunately, it is fueled by examples of poor management that have occurred in the past. Certainly, odor control is an important consideration when applying near residences.

Anaerobically treated sludge will produce offensive odors if it is applied to the surface during warm, moist weather. This type of biosolid should be injected under the soil surface, incorporated into the soil immediately after application, or a wide buffer (at least 500 feet) should be maintained between the application area and residences or public areas. Operators should pay attention to wind direction and weather conditions when making applications. Temperature inversions, accompanied by light winds in the morning or evening, result in the strongest odors.

Aerobic sludge should produce little odor, so a 100-foot buffer around residences is usually sufficient. Injection or incorporation of sludge into the soil is recommended because it reduces the potential for off-site transport by wind or water.

Site Restrictions and Required Management Practices

The EPA 503 management practice rules that must be followed with land-applied biosolids are:

- Biosolids shall not be applied if an adverse effect on threatened or endangered species is likely.
- Biosolids shall not be applied to flooded or frozen land when solids have a possibility of entering a wetland or body of water.
- Biosolids shall not be applied closer than 33 feet (10 meters) to any body of water.

- Except for permitted reclamation sites, biosolids shall not be applied higher than the agronomic rate.

Class B biosolids are subject to these additional restrictions:

- Food crops, feed crops, and fiber crops whose edible parts do not touch the land surface (such as peaches, apples, corn, wheat, soybean, etc.) shall not be harvested for 30 days after application of biosolids.
- Food crops with harvested parts that are above the land surface and may contact the biosolids/soil mixture (such as melons, tomatoes, lettuce, etc.) shall not be harvested for at least 14 months after application.
- Food crops with harvested parts that are below the land surface (such as potatoes, yams, beets, carrots, etc.), shall not be harvested for at least 38 months after application if the biosolids remain on the land surface less than 4 months before incorporation. Harvest time is reduced to at least 20 months if the biosolids remain on the surface for more than 4 months before incorporation.
- Animals shall not be allowed to graze on the land for 30 days after application of biosolids.
- Unless authorized by KDHE, turf grown where biosolids are applied shall not be harvested for at least 1 year after application if it will be used on a site with a high potential for human exposure.
- When human exposure is likely, public access to the site shall be restricted for 1 year after biosolids application.
- When human exposure is unlikely, public access to the site shall be restricted for 30 days after application of biosolids. This restriction does not apply to the owner, operator, or employees, all of whom should be aware of the risks involved and application precautions needed.

Requirements for Septage Application

Because separate analysis and extensive reporting for each truckload of septage is impractical, EPA 503 rules for septage haulers are simpler

than those required for publically owned treatment works. While septage can be disposed of at a permitted landfill or incinerator, it is usually discharged to a publically owned treatment works (the preferred solution) or land applied. When discharged into a municipal system, the septage hauler only needs to keep records of the source of the waste and the volume. The treatment plant is responsible for all testing, treating, and disposal.

Land application is suitable only for sites with a low potential for human contact (such as farmland). The process of land application must include one of three approved methods to reduce the risk from pathogens and vectors. Septage can be injected below the surface, incorporated immediately after application, or treated with lime to raise the pH above 12 for at least 30 minutes before application. All requirements and practices previously described for class B biosolids also apply to septage. The 30-day restriction for grazing and public entry can be waived if the lime treatment method is used. Although testing of the septage is not required (except pH for the lime treatment method), the hauler must calculate the agronomic rate based on crop nutrient requirements and the assumed nitrogen availability of 0.0026 pounds per gallon. Records of calculations, application rates, and soil tests must be kept for 5 years, along with a signed affidavit for each application affirming that all management and site requirements were met.

KDHE Procedure for Agronomic Nitrogen Rate

KDHE form LA-ANR was developed in cooperation with Kansas State University soil scientists. It provides a uniform system for estimating crop nitrogen requirements and biosolids application rates across Kansas. As of June 2008, the KDHE specified method for determining agronomic rate was as follows:

Step 1. Record the amount of each nitrogen form (ammonium, nitrate, and organic) in the sludge based on laboratory analysis. These amounts are expressed as pounds nitrogen per dry ton sludge.

Step 2. Estimate the amount of ammonium nitrogen in the sludge that will remain in the soil after volatilization losses during application.

Step 3. Calculate the amount of organic nitrogen that will become available for plant use during the current year based on the process used to produce the sludge and the organic nitrogen concentration.

Step 4. Using the results from Steps 1 through 3, calculate the total available nitrogen per dry ton sludge.

Step 5. Calculate the amount of nitrogen that will be available from other sources in the soil. This includes a credit for the residual nitrate nitrogen in a 0- to 24-inch soil profile (based on a soil test), a credit for nitrogen mineralized from a previous legume crop, and a credit for nitrogen mineralized from previous biosolids applications. The mineralization credit for biosolids is assumed to be half the previous year's organic nitrogen availability.

Step 6. Determine the crop nitrogen requirement based on the type of crop, crop yield, and soil factors.

Step 7. Subtract the soil profile nitrogen plus credits (Step 5) from the crop requirement (Step 6) to find the amount of additional nitrogen needed.

Step 8. Calculate the agronomic loading rate for sludge (step 7 divided by step 4) to ensure that sufficient nitrogen is available for crop production. Multiply by 1.2 to find the "approved loading rate," the highest rate that can be legally applied.

Step 9. Convert loading rate to volume, gallons, or cubic feet of biosolids to be applied based on the approved loading rate.

Step 10. Record the levels of phosphorus, potassium, and pH levels as found in the soil test at 0 to 6 inches, and the soil nitrate concentration at 6 to 24 inches. These values can be used to diagnose additional fertility or environmental concerns at the site.

Contact Information

Sludge and septage biosolids are available to a wide variety of producers as a low-cost source of plant nutrients and organic matter. However, the costs associated with transporting and spreading this material is not trivial. To find out what

resources are available in your area, contact the KDHE for a list of publicly owned treatment works, or directly contact the publicly owned treatment works in cities near you. Each treatment plant should be able to tell you what type of biosolids are produced at that location and what arrangements can be made for applying it to your crops. Since the alternative to land application of biosolids is often landfill disposal, treatment plants are often eager to assist you. Septage haulers are often easier to find since they may advertise their services. To be sure haulers are licensed and reputable, check with local authorities such as the local sanitarian (usually located in either the county environmental, health department, or planning and zoning office).

For more information concerning biosolids, contact:

Kansas Department of Health and Environment,
Bureau of Water
Curtis State Office Building, 1000 SW Jackson,
Suite 420
Topeka, KS 66612
785-296-5520

References

- A Plain English Guide to the EPA Part 503 Biosolids Rule: www.epa.gov/owm/mtb/biosolids/503pe/503pe_2.pdf
- Domestic Sewage Sludge Re-Use and Disposal Regulations. Kansas Department of Health and Environment Bureau of Water, Includes form LA-ANR. www.kdheks.gov/water/download/Sludge_Packet.pdf
- Best Management Practices for Phosphorus. K-State Research and Extension. Publication MF-2321. www.oznet.ksu.edu/library/crpsl2/mf2321.pdf
- The Phosphorus Index. A Phosphorus Assessment Tool. Technical Note. United States Department of Agriculture Natural Resources Conservation Service. www.nrcs.usda.gov/technical/ECS/nutrient/pindex.html

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