Sewage Sludge Use on Agricultural Land

Department of Agronomy

Applying municipal sewage sludge to agricultural land has been practiced in the United States for several decades. Most Kansas communities regularly use land application as a sludge disposal method, with benefits for both the wastewater utility and the agricultural producer. However, because of new regulations governing the application of sludge to land, many questions are being asked by farmers, utility managers, government officials, and consultants about this alternative. This publication provides information to help answer questions and evaluate this option.

What is sewage sludge?

Sewage sludge is the biological residual produced during the treatment of sewage wastewater. As the sewage is processed, it goes through a series of processes that reduce the concentration of the easily-decomposable organic materials and pathogenic (disease-causing) organisms. Sludge, more recently being called biosolids, is the solid portion removed from wastewater during the process and might be no more than 1 percent of the wastewater flow. Characteristics of the sludge depend on the wastewater treatment process and sludge treatment.

While sludge properties vary widely depending on process and source, typical liquid sludge may have as much as 5 percent solids (95 percent water). As solids increase, the sludge thickens. Normally a sludge with over 10 percent solids will not flow by gravity through a 6-inch pipe. Sludge becomes a wet semi-solid in the range of 20 to 30 percent solids. It becomes a "dry" solid with solids content above about 30 percent. Sludge with more than about 10 percent solids will usually have gone through some type of intensive dewatering process.

What are the regulations governing sludge application to land?

Sludge is disposed of in many different ways, including landfilling, composting, or even drying and bagging for organic material marketing. However, the most common method of disposal in Kansas is direct land application of bulk liquid sewage sludge.

New federal regulations governing agricultural land application of

Figure 1. Typical Solids Content for Different Sludges

Sludge Type and Treatment	% Solids
Unsettled Aerobic or Anaerobic	1-2%
Settled Aerobic or Anaerobic	1-7
Centrifuge Dewatered	8-40
Vacuum Filter Dewatered	13-45
Filter Press Dewatered	12-52
Sand Drying Dewatered	50-70

Adapted from: "Wastewater Engineering: Treatment, Disposal and Reuse" 3rd edition. McGraw-Hill, Inc., 1991.

municipal sewage sludge were published February 19, 1993 as Section 503 of the Title 40 Code of Federal Regulations, with a compliance date of February 19, 1994. If construction of sludge treatment and handling facilities is required, the compliance date is one year later.

The Kansas Department of Health and Environment has the responsibility of administering the regulations in Kansas. The "503" regulations set standards for pathogens, vector attractions, and pollutants, including nutrients and metals, in sludge that may be applied to agricultural land.

Pathogens. The regulations set specific treatment processes and standards for elimination of disease-causing organisms including certain bacteria, protozoa, viruses, and viable helminth (worm) ova.

Vector Attractions. The regulations list specific standards and treatments to reduce characteristics that attract rodents, flies, mosquitoes or other vectors that may carry infectious diseases.

Metals. The regulations specify ceiling concentrations and loading rates for 10 metals that may be harmful to the environment. They are arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc. In most Kansas sludges these metals seldom present problems. For typical sludge from non-industrialized communities, metal limitations are usually not a problem until more than 1,000 dry tons of sludge have been applied per acre. However, loading rates could exceed specifications if sludge is applied over a long period, or in communities with industries that improperly discharge high concentrations of plating materials such as cadmium, zinc, chromium, and nickel.

Nutrients. To minimize the amount of nitrogen from the sludge that leaches below the crop root zone and possibly to the groundwater, sludge application rate of nitrogen shall not exceed the "agronomic rate," defined as the amount of additional nitrogen needed for crop production.

Are there special site restrictions or required land management practices when applying sludge to agricultural land?

There are some general, land management practices designed to protect the environment.

- Sludge shall not be applied to land if it's likely to adversely affect a threatened or endangered species.
- Sludge shall not be applied to flooded or frozen land so that it will enter a wetland or body of water.
- Sludge shall not be applied within 10 meters (32.8 feet) of a body of water.
- Except when permitted on reclamation sites, sludge shall not be applied at greater than the agronomic rate.

There are actually two classes of municipal sewage sludge. "Class A" sludge has been highly treated to nearly eliminate pathogens and vector attractions. There are few restrictions on its use and it is considered safe for human contact. It can even be bagged and sold for use by homeowners and can come in contact with food crops. Food crops are crops grown primarily for use by humans and, in this case, limited to foods that do not undergo significant processing prior to human consumption. Feed crops are grains and forages grown for animal consumption.

"Class B" sludge is what is most often applied to farmland. It may still contain significant amounts of pathogens and vector attractions. While it is generally considered safe for agricultural land application, there are restrictions on contact with crops, animals, and humans.

Specific site restrictions for sludge that is "Class B" with respect to pathogens include:

- Food crops with harvested parts that touch the sewage sludge/soil mixture and are above the land surface shall not be harvested for 14 months after sludge application.
- When the sludge remains on the land surface for four months or longer prior to incorporation, food crops with harvested parts below the surface of the land shall not be harvested for 20 months after application.
- When the sludge remains on the land surface for less than four months prior to incorporation, food crops with harvested parts below the surface of the land shall not be harvested for 38 months after application.
- Food crops, feed crops, and fiber crops shall not be harvested for 30 days after application of sewage sludge.
- Animals shall not be allowed to graze on the land for 30 days after application of sewage sludge.
- Turf grown on land where sludge is applied shall not be harvested for one year after application when the harvested turf is to be placed on either land with a high potential for public exposure or a lawn, unless otherwise specified by the permitting authority (Kansas Department of Health and Environment).
- Public access to land with a high potential for public exposure shall be restricted for one year after sludge application.
- Public access to land with a low potential for public exposure shall be restricted for 30 days after application of sewage sludge.

Only the 30-day restriction is likely to affect the application of sludge to most agricultural land. The public access restriction applies only to the public, not the farmer, his employer, nor the sludge applicator who are assumed to be knowledgeable on

proper handling of sludge. The restrictions should cause few limitations if all sludge application is completed before crops are planted.

How can sludge benefit crops and soils?

Sludge contains organic matter and plant nutrients that make it a beneficial soil amendment for crop production. Municipal sludge can supply appreciable amounts of nitrogen (N) and phosphorus (P), but usually only small amounts of potassium (K). Due to its organic matter content, sludge can be a good soil conditioner, helping promote desirable soil physical properties for microbial activity, water intake, and plant growth.

While composition of individual sludges can vary appreciably, on average, a typical ton of dry sludge 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 will contain a little more than one dry ton of sludge. Sludge should be analyzed regularly to determine its exact nutrient content. Not all of the nutrients in the sludge are immediately available for plant use.

Nitrogen in sludge occurs as ammonium or organic nitrogen, with only a small fraction in the nitrate form. All of the nitrogen in the ammonium form, and nitrate, is immediately available to the plant. Ammonium nitrogen can rapidly volatilize and be lost into the air when liquid sludge is spread on the surface without incorporation, especially if the temperature is above 50°F. If liquid sludge is incorporated into the soil promptly after application or if it is injected directly into the soil, most of the ammonium nitrogen is adsorbed to the clay in the soil. In the soil, ammonium is converted into nitrate that may be removed by the crop, leach downward through the soil with percolating water, or be lost to denitrification.

Organic nitrogen in sludge must be mineralized before it can be assimilated by crops. Research shows that from 10 to 50 percent of the organic nitrogen will become available the first year after application, depending on the type of treatment used in producing the sludge. Liquid sludge will have a higher proportion of ammonium nitrogen while organic nitrogen will predominate once sludge is dried. All phosphorus and potassium in sludge is considered available to plants.

Uniformity of application is extremely important. Careful records of application should be kept to be certain all areas of a field 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 be sure it provides uniform application.

How is "agronomic rate" determined?

The federal regulations do not specify how the "agronomic rate" is to be calculated. However, the Kansas Department of Health and Environment, working closely with soil scientists, has developed a worksheet for calculating the agronomic rate for the land application of sewage sludge. Obtain the most current version from KDHE Bureau of Water at the address at the end of this publication. It includes the following steps.

Step 1. Determine the amount of each form of nitrogen (ammonium, nitrate, and organic) in the sludge based on laboratory analysis.

Step 2. Estimate the amount of the sludge ammonium nitrogen that will be retained in the soil, taking into account different volatilization losses based on the method of application.

Step 3. Calculate the amount of organic nitrogen in the sludge that will become available through mineralization for plant use during the current year. The mineralization rate varies with the type of process used in producing the sludge.

Step 4. Calculate the total available nitrogen for the year from the sludge.

Step 5. Determine residual available nitrogen in the soil, from soil tests, and nitrogen credits from previous legume crops. Further adjustment is made by taking into account the amount of organic nitrogen that will become available due to mineralization of previously applied sludge. It assumes that the organic nitrogen mineralization rate for the second and third years will be about half the first-year rate.

Step 6. Determine the crop nitrogen requirement, varying with type of crop, crop yield, and soil factors.

Step 7. Subtract the existing nitrogen (credits) from the requirement to determine the amount of additional nitrogen needed for production.

Step 8. Calculate the agronomic loading rate of sludge based on nitrogen content of sludge and additional nitrogen needed. This also obtains an "approved loading rate" that uses a multiplier to increase the certainty that there will be sufficient nitrogen for optimum crop production.

Step 9. Convert the loading rate to actual gallons or cubic feet of sludge that can be applied without exceeding the agronomic rate.

Step 10. Indicates soil analysis results for phosphorus, potassium and pH as determined by soil tests. Soil tests for N, P, K and pH are required annually, just before sludge application.

Can sludge be harmful?

While plant nutrients and organic matter are essential to plants, application of excessive rates of nitrogen and phosphorus, could contaminate surface and groundwater or interfere with good crop growth when applied above the "agronomic rate." Sludges also may contain metals and some other constituents that can be harmful to humans if total accumulated application is not managed properly. At the

least, sludge application can create a nuisance

Sludge is a waste organic product and often is considered by the public as undesirable. This attitude is based on perception and awareness of examples of poor management of some systems. The not-in-my-backyard (NIMBY) syndrome applies. That is, the public perceives sludge as an undesirable product and does not want it anywhere nearby.

Certainly, some sludge does smell bad. Anaerobically digested sludge is likely to smell when surface applied in warm and moist weather. Sludge should be injected or incorporated soon after application, or a wide buffer area, at least 500 feet, should be maintained away from residences and public access areas. Applicators should be aware of wind direction and weather conditions. Aerobically digested sludge will produce a minimum of odor, even when surface applied, and a 100-foot buffer should be sufficient. Injection or incorporation of sludge also will reduce the potential for erosion of the sludge by wind or water.

All-weather access roads are important for transporting sludge to the field. The roadways must be able to withstand the increased traffic load. It should be recognized that transport of sludge through residential areas may result in complaints about odor and traffic. It is especially important to avoid and spillage or leakage onto public roadways

"Class B" sewage sludge is likely to contain massive quantities of bacteria and other organisms, including pathogens that are harmful to humans. People who have direct contact with it should be aware of the potential dangers. Employees should be provided appropriate immunizations and be trained about dangers, how to protect themselves, and actions to take if exposed.

Who is responsible for all of the analysis, recordkeeping, monitoring and reporting?

Application, management practices, monitoring, recordkeeping, and reporting are generally the responsibility of the entity (or person) preparing (generating) the sludge. That includes analysis of the constituents of the sludge. It also is their responsibility to be sure that application does not exceed cumulative pollutant loading rates. Farm operator(s) and/or landowner(s) do not normally have those responsibilities unless they contract to manage and operate the application operation.

Testing sludge for metals, pathogens and vectors must be done at a laboratory approved by the Kansas Department of Health and Environment using methods approved in 40 CFR Part 136. KDHE makes a list of these laboratories available to sludge producers.

KDHE recommends that entities or persons subject to the "503" sludge regulations use agricultural soil testing laboratories, such as the Kansas State University Soil Testing Laboratory, for tests used in determining the agronomic rate for nitrogen and phosphorus. Those labs are accustomed to doing nutrient analysis and making recommendations relating to agronomic production. However, the Kansas State University Soil Testing Laboratory and many other agricultural labs are neither approved nor equipped for analysis of sludges. Check with KDHE for qualified soil testing labs.

All data reports are due to the Kansas Department of Health and Environment by February 28 of each year, based on a January 1 through December 31 reporting period.

For information relating to the regulations and the agronomic rate worksheet, contact:

Kansas Department of Health
and Environment
Bureau of Water
Forbes Field, Bldg. 283
Topeka, KS 66620-0001
913/296-5513

William M. Eberle
Extension Specialist
Land Resources

David A. Whitney
Extension State Leader
Agronomy Programs

G. Morgan Powell
Extension Natural
Resource Engineer

KSU KANSAS STATE UNIVERSITY

Cooperative Extension Service, Kansas State University, Manhattan

Issued in furtherance of Cooperative Extension Work, acts of May 8 and June 30, 1914, as amended. Kansas State University, County Extension Councils, Extension Districts, and U.S. Department of Agriculture Cooperating, Richard D. Wootton, Associate Director. All educational programs and materials available without discrimination on the basis of race, color, national origin, sex, age, or disability.

September 1994 File Code: Environment & Pollution Control 8 MS 9-94—3M