Best Management Practices

To maximize the efficiency of nutrient use and minimize the environmental impact, the following management practices should be used when applying biosolids to agricultural land:

- Always apply at an agronomic rate,
- Apply biosolids uniformly,
- Inject or incorporate soon after application,
- Minimize erosion by establishing vegetation cover,
- Prevent runoff on biosolids-treated land,
- Avoid surface application on steep sloping land, frozen soil, or near surface waters,
- Maintain a buffer zone (100 feet) between permitted site and adjacent property and 250 feet of a public and private water supply,
- Keep records of amount and time applied, and of soil and biosolids test results; and
- Maintain soil pH above 5.5 as required by Oklahoma DEQ.

Regulations Governing Biosolids Land Application

- Land Application of Sewage Sludge. A Guide for Land Appliers on the Requirements of the Federal Standards for the Use or Disposal of Sewage Sludge, 40 CFR Part 503. United States Environmental Protection Agency, EPA/831-B-93-002b.
- Title 252 Oklahoma Administrative Code, Chapter 606, Subchapter 8, Biosolids Requirements. Oklahoma Department of Environmental Quality.

References

USEPA. 1995. Process Design Manual: Land application of sewage sludge and domestic septage. EPA/625/R-95/001.

Basta, N.T. (ed.). 1995. Land Application of Biosolids: a review of research concerning benefits, environmental impacts, and regulations of applying treated sewage sludge. Oklahoma Agricultural Experiment Station, B-808.

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Using Biosolids as a Plant Nutrient Source

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Biosolids (previously known as sewage sludge) are treated solid, semi-solid, or liquid residues produced from wastewater in a wastewater treatment facility. Biosolids do not include animal manures, untreated septage, municipal solid wastes, hazardous wastes, or untreated industrial wastes. Biosolids are recyclable materials that improve soil tilth and fertility and enhance the growth of agricultural, silvicultural, and horticultural crops. In the United States, 70 percent of biosolids are land-applied to pasture, rangeland, and agricultural land for crop production. More than 80 percent of biosolids produced in Oklahoma are land applied. Farmers and land managers are interested in the value of biosolids.

Land application of EPA recognized biosolids (Class A and B) is beneficial when done in a manner that protects public health and maintains or improves environmental quality. Biosolids provide nitrogen (N), phosphorus (P), potassium (K), calcium, magnesium, sulfur, and micronutrients for plant growth. Applying biosolids to soil has been shown to increase water holding capacity, lessen wind and water erosion, and improve aeration due to the addition of organic matter. Land application of biosolids should be viewed as an opportunity to utilize plant nutrients present in the material rather than a means of disposal. The steps to properly use different types of biosolids as fertilizer are:

- Determining nutrient requirements of the crop at a realistic yield goal;
- Determining the nutrient content of the biosolids;
- Determining the percentages of nutrients that are available to crops; and
- Determining application rate.

These steps will help you apply the proper amount (***agronomic rate***), but the method and timing of application will ensure the effectiveness of applied nutrients.

Crop Nutrient Requirement

Biosolids should not be applied to soil beyond the limits of the growing crop's nutrient needs. Avoiding overapplication will ensure efficient use of nutrients and minimize nutrient leaching and runoff into the water system. Application of biosolids at agronomic rates generally will not create salinity problems and nutrient buildup in soils. Any cropland scheduled for biosolid application should first be soil-tested to determine present fertility. Periodic soil testing is recommended on land receiving biosolids applications to monitor both the amounts and balance of nutrients in soil. The soil test results and subsequent fertilizer recommendations for the crop to be grown are the only reliable way to provide crop nutrient requirement. Soil analyses are performed by the **OSU Soil, Water, and Forage Analytical Laboratory in Stillwater** as well as a number of commercial laboratories. Contact your county Cooperative Extension Service office for instructions and supplies for taking and submitting soil samples. Extension educators in the county office can assist in interpreting test results.

Nutrient Contents of Biosolids

The nutrient content of biosolids is highly variable, depending on treatment and handling methods, as well as age and moisture content of the material. Because of variability in nutrient content, biosolids must be analyzed, and individual land-application decisions should be based on the nutrient content of the biosolids to be applied. Not knowing the nutrient content of the biosolids can result in large errors in application rate, and excess nutrients may cause environmental problems.

To obtain a representative sample of biosolids, the sample must be taken from the correct locations, represent the entire amount of biosolids, and be handled properly from the time of collection through analysis. Appropriate sample containers must be used. Contact the lab you are going to use for detailed information on sample handling and analysis, or consult EPA Land Application of Sewage Sludge guidelines. The OSU soil testing lab currently does not analyze biosolid samples, but several commercial agricultural and environmental laboratories provide biosolid analyses services.

Nutrient Availability of Biosolids to Crops

Nutrients in biosolids cannot be substituted for those in commercial fertilizer on a pound-for-pound basis, because not all nutrients on the biosolids analysis report are readily available to a crop in the year of application. Some elements are released when organic matter is decomposed by microorganisms. Other elements can combine with soil constituents, making them unavailable to the crop.

Nitrogen availability during the year of application varies. Potentially, all of the inorganic N including ammonium-N (NH_4-N) and nitrate-N (NO_3-N) are readily available and can be utilized by plants. However, if biosolids are applied on the soil surface and not quickly incorporated, considerable NH_4-N will be lost to the air as ammonia (NH_3) gas. The ammonium added will be subject to nitrification resulting in rapid formation of nitrate-N, which may be subject to leaching loss. Nitrogen in the organic form must be converted (mineralized) into plant-available inorganic forms. In general, about 10 to 50 percent of the organic N may become available the year of application, 5 to 20 percent will be available the second year. Smaller amounts will be available the third and fourth year. Plant-available nitrogen (**PAN**) should be calculated based on research established availability indexes listed in Table 1. The following formula describes plant-available nitrogen.

PAN = All Organic N mineralized + NH_4-N (1/2, if surface applied)+ NO_3-N

For example, the biosolids was produced by anaerobic digestion and the PAN is:

PAN = Organic N x 0.2 + NH_4 -N (1/2 if surface applied) + NO_3-N

The availability of phosphorus in biosolids is considered about 50 percent that of commercial fertilizer.

Application Rates

Land application rates should be based on the nutrient requirements of the crop being grown (***Agronomic Rate***). Land application at a rate that is too low will not provide sufficient nutrients, while supplying excess nutrients is a waste of resources, may result in ground or surface water pollution, and may eventually depress crop growth and yields. Soil testing, biosolids analysis, irrigation water analysis, and proper estimation of yield goal are necessary to calculate proper agronomic application rates of biosolids and additional fertilizers. If biosolids are applied to the same field continuously, nitrogen credits should be given to previous year's application due to biosolids' residual properties. Follow the seven steps in the attached worksheet to calculate the application rate.

Federal and state regulations should be followed as to which nutrient should act as the base for the application rate. Oklahoma regulation (Title 252) requires that ***"Annual sludge land application shall not exceed nitrogen and phosphorus rates for the crop grown."*** Check with the Department of Environmental Quality regarding other regulations governing land application of biosolids.

Methods of Application

Liquid biosolids can be applied by surface spreading utilizing farm tractors, tank wagons, tank trucks, and portable or fixed irrigation systems. Incorporation by plowing or other tillage operations within 24 hours after surface application is required in Oklahoma. Incorporation can reduce ammonia volatilization and runoff, as well as odor. Subsurface injection with injection shanks is the preferred method because of minimum odor and decreased nitrogen loss. Dewatered biosolids can be applied to cropland by surface spreading with equipment typically used for spreading animal manures and then incorporated into soil by plowing or disking. It is important to apply biosolids uniformly and have the applicator calibrated so the targeted rate can be achieved.

Time of Application

Biosolids should be applied close to plant needs to minimize nutrient loss. Nutrients, especially nitrogen, can be lost through volatilization, denitrification, leaching, and erosion. Therefore, proper timing of biosolids application is essential for efficient use of nutrients and pollution prevention. Biosolids should be applied far enough in advance of the planting dates to allow for reaction with the soil to prevent possible injury to seeds. Biosolids applied during the spring provide the needed starter nutrients for summer crops and release nutrients through mineralization during the growing season of most fall-planted crops. Depending on field availability and weather conditions, biosolids may be applied at alternate times.

Table 1. Estimated Fraction of Organic N Mineralized for Different Biosolids.

Time after biosolids application (years)	*Unstabilized primary and waste*	*Aerobically Digested*	*Anaerobically Digested*	*Composted*
0-1	0.40	0.30	0.20	0.10
1-2	0.20	0.15	0.10	0.05
2-3	0.10	0.08	0.05	-
3-4	0.05	0.04	-	-

Biosolids Application Rate Calculation Work Sheet

Step 1 **Nutrient needs of crop (lbs./acre)**
Recommendations based on soil test results and a realistic yield goal.

N = _____
P_2O_5 = _____
K_2O = _____

Step 2 **Total nutrient value of biosolids (lbs./ton or lbs./1000gal.)**
Based on biosolids analysis of a representative sample collected close to time of application. If total nitrogen (TN) instead of org-N, or percent and ppm instead of lbs./ton are given, use the following conversion:

lbs./ton = 20 x %; or lbs./ton = 20 x ppm/10,000
Org-N = Total Nitrogen (TN) – (NH_4-N) – (NO_3-N)

Org-N = _____
NO_3-N = _____
NH_4-N = _____
P = _____
K = _____

Step 3 **Determine available nutrients (lbs./ ton or lbs./1000 gal.)**
PAN = Org-N x 0.2 (anaerobically digested, from Table 1)
+ NO_3-N + NH_4-N x 0.5 (surface applied)
+ Org-N x 0.1 (if any applied previous year, from Table 1)
P_2O_5 = P x 2.29 K_2O = K x 1.20
Available P_2O_5 = 0.5 x total P_2O_5 (lbs./ton)

PAN = _____
P_2O_5 = _____
K_2O = _____

Step 4 **Calculate the rates of application needed for N, P, and K (tons/acre or 1000 gal. /acre)**
Divide values from Step 1, nutrient needs, by values from Step 3, available nutrients.

N = _____
P_2O_5 = _____
K_2O = _____

Step 5 **Select the rate of biosolids to be applied (tons/acre or 1000 gal./acre)**
Choose the nutrient for which the biosolids rate are to be based from Step 4. Select the highest of the three if biosolids is used as a complete fertilizer; select the lowest for maximum nutrient efficiency.

Rate = _____

Step 6 **Determine the amount of available nutrients being applied (lbs./acre) at the chosen rate**
Multiply the rate, Step 5, by available nutrients, Step 3.

N = _____
P_2O_5 = _____
K_2O = _____

Step 7 **Determine amount of supplemental nutrients needed (lbs./acre)**
Subtract nutrients applied, Step 6, from nutrients needed, Step 1. If the difference is negative, enter zero.

N = _____
P_2O_5 = _____
K_2O = _____