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Land application of municipal sludge

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Quick Facts

Land application is a feasible alternative for municipal sewage sludge disposal.
Sludge is a plant nutrient source.
The composition of sludge should be checked for plant nutrients and heavy metals.
Land receiving sludge should be checked through a regular soil-testing program.

The 1972 Federal Water Pollution Control Act Amendments (PL92-500) encourage the recycling of plant nutrients through land application and production of agricultural, forestry, and/or aquacultural products. The management of sludge from wastewater treatment plants in Colorado is subject to regulations set by the Colorado Board of Health, the Water Quality Control Commission, and the Department of Agriculture. Producers and users of sludge must obtain a letter of approval from the Colorado Department of Health's Water Quality Control Division.

Sewage Sludge Characteristics

The solids content is the main physical characteristic affecting handling and land application methods for sludges. If a sludge has 5 percent solids, it is 95 percent water.

Normally, a sludge with more than 10 percent solids will not flow by gravity through a six-inch (15-centimeter) pipe. Sludges with a solid content of 10 to 20 percent are difficult to handle as a liquid or solid.

Three common solids content ranges are shown in Table 1.

Table 1: Sludge solids content and handling characteristics.

Type	Solids content	Handling methods
Liquid	1-10%	Gravity flow, pump, tank transport
Semi-solid ("wet" solids)	20-30%	Conveyor, bucket, truck transport (water-tight box)
Solid ("dry" solids)	25-80%	Conveyor, auger, truck transport (box)

Plant Nutrients

Sludges contain plant nutrients and organic matter. This makes them a beneficial soil additive for crop production. Municipal sludges can supply appreciable amounts of nitrogen (N) and phosphorus (P), but only small quantities of potassium (K). Organic matter content in sludge promotes desirable soil conditions for microbial activity and plant growth. However, some metals and other contents are potentially harmful if not managed correctly. Table 2 gives the analysis for Metropolitan Denver sewage sludge, the concentration range for sludge, and the average "typical" liquid digested sewage sludge value as it comes from the digestor. These values are given as a general guideline. The composition of individual sludges can vary appreciably from the values shown, and each should be analyzed for exact composition.

On the average, a ton (907 kilograms) of dry sludge contains approximately 100 pounds (45 kg) of nitrogen, 120 pounds (54 kg) of phosphate (P_2O_5) and 10 pounds (4.5 kg) of potash (K_2O). All of the phosphorus and potassium is considered available to the plant.

All of the ammonium (and nitrate) is immediately available to the plant. Much of

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the ammonium nitrogen evaporates if liquid sludge is spread on the soil surface and allowed to dry there. If liquid sludge is mixed into the soil promptly after application, or if it is injected directly into the soil, most of the ammonium nitrogen is absorbed by the soil. In the soil, ammonium nitrogen is changed into the nitrate form where it may be absorbed by the crop.

The organic nitrogen in sludge must be converted to minerals before crops can absorb it. It is estimated that 25 percent of the organic nitrogen is available the first year of application. Sewage sludge loses most of its ammonium nitrogen in the drying process, so most nitrogen in dried sludge is organic in form.

Table 2: Composition of fresh, heated, anerobically digested sewage sludge (dry weight basis).

Element	Denver sewage sludge†	Concentration range for sludge*	Typical sludge concentration*	
	%	%	%	lbs/ton
Nitrogen:				
Ammonium (NH_4)	6.2 ± 0.9	1 to 6	2	40
Organic N	- -	2 to 3	3	60
Total N	11.4 ± 0.4	1 to 11	5	100
Phosphorus:				
P	3.4 ± 0.3	0.8 to 6	2.6	52
P_2O_5	7.8 ± 0.7	1.8 to 13.7	6	120
Potassium:				
K	1.0 ± 0.2	0.1 to 1.0	0.4	8
K_2O	1.2 ± 0.2	0.1 to 1.2	0.5	10
	PPM	**PPM**	**PPM**	
Iron (Fe)	7506 ± 982	1,000 to 50,000	40,000	80
Zinc (Zn)	1384 ± 125	50 to 50,000	5,000	10
Copper (Cu)	946 ± 66	200 to 17,000	1,000	2
Manganese (Mu)	122 ± 10	100 to 800	500	1
Cadmium (Cd)	52.4 ± 7	3 to 3,000	150	0.3
Nickel (Ni)	156 ± 11	25 to 8,000	400	0.8
Lead (Pb)	549 ± 156	100 to 10,000	1,000	2
Chromium (Cr)	701 ± 136	50 to 3,000	3,000	6
Total solids	2.7%	1 to 10%	5%	—

†*The average analysis from composite samples taken from January, 1981, through June, 1981, as reported by Metropolitan Denver Sewage Disposal District No. 1, Courtesy: John C. Baxter, Environmental Agronomist.*

**Source: "Utilization of Sewage Sludge on Agriculture Land." University of Illinois Soil Management and Conservation Series No. SM-29. 1975. 7 pages.*

NOTE: Values vary according to source, treatment and other factors. Sludges held in storage lagoons for long periods may be considerably lower in nitrogen content.

Sludge Fertilizer Value

On a dry weight basis typical municipal sludge contains approximately 5 percent (or 100 pounds) total nitrogen, 6 percent (120 pounds) P_2O_5, and 0.5 percent (10 pounds) K_2O per ton (Table 2). Half of the available nitrogen (50 pounds) is considered available the year of application.

In most instances, however, sludge is available in liquid form and seldom contains more than 5 percent solids. Typically, one ton of dry sludge would be equivalent to 5,000 gallons of liquid sludge (5 percent solids).

Based on a soil test, a 150 bushel-per-acre corn crop in Colorado may require approximately 200 pounds of nitrogen, 60 pounds of P_2O_5, and 60 pounds of K_2O. Using a typical sludge to provide the 200 pounds of nitrogen needed by this corn yield, 20,000 gallons per acre would have to be applied. Such an application would provide 480 pounds of P_2O_5 (eight times as much needed) and 40 pounds of K_2O. This example illustrates the importance of knowing the nutrient content of the sludge to be used, the nutrient needs of the specific crop to be grown, and the nutrient status or fertility of the soils involved.

Since sludge is not a balanced fertilizer, application over time may result in an imbalance of nutrients. Soils should be checked through a regular soil testing program.

Use on Disturbed Lands

As the mining industry develops in northwestern Colorado, the human population undoubtedly will grow. So will the acres of disturbed mine lands that will require revegetation and reclamation. The population growth will result in increasing sewage sludge production. Typically when municipal sewage is treated by anaerobic digestion, the equivalent of one ton of dried sludge per day will be produced per 10,000 population. If the population increased to 500,000 it would result in 50 tons of sludge per day or about 18,000 tons per year. The disposal of that much sludge would pose a problem unless suitable lands are available for recycling. Disturbed lands provide one of the best sewage sludge utilization opportunities. These lands generally are low in organic matter, nitrogen and phosphorus. They often have serious physical property problems such as slow infiltration and permeability, poor aeration and poor drainage.

Sludge will provide ample nitrogen and phosphorus and is an excellent soil amendment for disturbed lands. Most of the potential problems associated with sludge addition to agricultural lands will be minimized when applied to disturbed lands. Food crops are usually not grown on reclamation sites that generally are removed from housing and municipal areas. When sewage sludge is used, with proper management in the reclamation of disturbed mine lands, two contemporary problems can be solved.

Heavy Metals and PCBs

Repeated sewage sludge applications on land can load the soil with heavy metals that may adversely affect food crop production. The most common problem is metals like lead, zinc, copper, nickel and cadmium.

If high amounts are applied to soils, these metals potentially can cause plant toxicity problems or increase metal uptake by plants. Sludge must be tested for metal concentrations to determine if it is suitable for farmland applications. However, most sludges from domestic communities, i.e., those without industrial discharges, will contain safe levels of metals.

The solubility of heavy metals is greater if the background soil acidity (pH) is less than 6.5. However, in Colorado potential heavy metal toxicity problems are much less because Colorado soils are usually alkaline (pH greater than 7.0) in reaction.

The heavy metals are not the only toxic materials of interest; many synthetic compounds are classified as toxic. The polychlorinated biphenyls (PCBs) and other persistent organic chemicals and pesticides are receiving much interest as toxic substances.

Sludge with the concentration limits shown in Table 3 will qualify for a letter of approval from the Colorado Department of Health. Sludges containing higher concentrations of the substances shown in Table 3 will be considered for a letter of approval on a case-by-case basis.

Table 3: Maximum concentrations of trace elements and persistent organics permitted in stabilized sludge, which is to be utilized without the issuance of a user permit (dry weight basis).

Element	PPM
Zinc (Zn)	3,000
Copper (Cu)	1,500
Lead (Pb)	1,500
Nickel (Ni)	1,000
Cadmium (Cd)	30
PCB's	10

Source: Guidelines for Sludge Utilization on Land, Technical Policy; Colorado Department of Health.

Public Acceptance

There always are a few people who are reluctant to have sludge applied on land near their homes. Digested, stabilized sludge does not smell like raw sewage, but it does have an earthy odor. This odor is not harmful, but may be noticeable and objectionable to some people. Common sense should be used in selecting the time and place for spreading.

Research indicates that almost all of the bacteria, viruses and pathogenic organisms in sewage sludge are destroyed by the high temperature and pH reached in digesting and stabilizing the sludge. Most of the remaining viable organisms tend to die off quickly in the hostile soil environment. If recommended precautions are followed, they present very little threat to human or animal health.

Where To Go From Here

Is cropland application of sewage sludge and wastewater a feasible and beneficial alternative in our situation? The answer to that question calls for careful evaluation of a community's present and anticipated waste disposal problems, the types of waste involved and the potential sites for disposal.

In summary, the requirements for a successful land disposal operation are:

1. Know the composition of the sludge: nitrogen, phosphorus, potassium and heavy metal concentrations. Wastewater should be checked for irrigation suitability. There are many laboratories that will perform sludge and wastewater analysis.

2. If heavy metal and/or soluble salt concentrations are high, determine, if possible, what effect they might have on soil properties, water quality, plant growth and composition, and animals or people if the plants are consumed.

3. If the sludge contains potentially harmful bacteria and/or viruses, make sure no material is applied to leafy vegetables or shallow root crops. Sludge applied and worked into the soil before seeding should not contaminate such crops.

4. Know the soil at the disposal site and be familiar with those properties that might affect time, method and rate of application. Although soil is an excellent filtering medium, it does have limitations. It should not be overloaded beyond its capacity to do an effective job.

5. Apply sludge to the land at a "reasonable" rate. This means at a rate such that the amount of sludge nutrients applied does not greatly exceed what the disposal site crop can take off. As stated earlier, readily available nitrogen usually makes up one-third to one-half of the total nitrogen in sewage sludge. If calculated for the proper nitrogen level, and either copper, zinc, lead, cadmium or nickel levels are found to be excessive, the sludge application rate should be reduced accordingly. Then meet the needs of the crop with a supplemental nitrogen fertilizer application. If crop requirements for nitrogen are used as a guide, a sludge may contain more phosphorus than is needed. To avoid an excessive phosphorus buildup in the soil, use crop requirements for phosphorus as an application guide.

6. When applying sludge to sloping land, make sure the runoff water does not contaminate streams, ponds or other water bodies.

7. Since sludge is not balanced fertilizer, application over time may result in an imbalance of nutrients (particularly phosphorus). This should be checked through a regular soil-testing program.