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November 2003

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Introduction

Sewage sludges and sludge-based products can be used as agricultural soil amendments. They can provide a free or low-cost source of organic matter, nutrients and sometimes lime. Those entities responsible for sludge management provide farmers with their assessment of the benefits of land application. There are specific considerations regarding sludge use on dairy farms for animal, human, soil and plant health as well as for relationships with neighbors. This document is intended to help dairy farmers and their advisors make informed decisions regarding the use of sewage sludges, sludge-based products and septage and to outline measures that can reduce the risks that may be associated with application on dairy farms.

Summary Guidance

General Guidelines

- **Be sure you have a reason to use the material.** If your operation is "land lean" (having more manure nutrients than needed for the amount of land in production), accepting additional nutrients in the form of sludges may not be a good idea. Dairy producers that have more than 1.5-2 animal units per spreadable acre may not want to import more nutrients via sludge, particularly on land that regularly receives manure. (1.5 animal units per acre is a little more than one mature Holstein cow per acre. 2 animal units per acre is about 1 mature cow plus her replacement per acre.)
- **Be sure the economics are favorable.** In calculating fertilizer value of sludge materials, consider whether the P is a benefit or a detriment (if P is already in excess on the farm).
- **Have a sound nutrient management plan.** A nutrient management plan allocates on-farm nutrient sources and quantifies supplemental nutrients from all sources for each field. Fields which can benefit from supplemental nutrients are potential candidates for application of sludge products. Use material at agronomically sound rates considering both N and P. A crop consultant, Cooperative Extension agent or, Soil and Water District specialist may be able to assist you in developing a plan. "Cropware" software is available and may also be used (see http://www.css.cornell.edu/nmsp/software/cropware.asp).
- **Do a mass nutrient balance for your farm.** Understand how importing more nutrients in sludge impacts this balance.
- **Consider animal nutrition.** Become familiar with potential interactions of copper (Cu), molybdenum (Mo), sulfur (S), iron (Fe) and cadmium (Cd) with each other and with other elements in soils and animals. Consider the concentration of these elements in the sludges you apply. Sludges with more than 10mg/kg (parts per million, ppm) of Mo or Cd should probably not be used on dairy farms.
- **Inject or till into the soil whenever possible**. This process minimizes odor and the possibility of runoff from a rainstorm or blowing off site. Stockpiling increases the risks of odors.
- **Be cautious if applying to hayfields and pastures**. Because of concern about direct ingestion, apply just after cutting and allow sufficient regrowth before recut to minimize sludge on surfaces of plants. The risks posed by direct ingestion of the sludge or sludge product by livestock is higher if they are applied to hay crops or pasture.
- **Think about neighbors and runoff risk reduction.** Most sludge products have an odor. Avoid applying on weekends and fields close to houses. Minimize time spent loading, unloading and spreading. Observe good housekeeping practices with equipment, stockpile areas and travel routes. Ensure that application will not result in sludge entering a waterway or well.
- **Obtain test results for the specific load of material being applied to your land** (particularly for Mo)**.** Be aware that testing of sludge is reported on a dry weight basis, but products are delivered as liquids or semi-solids. Test results commonly provided will be average values from occasional samples taken over a year.

- **Consider freezing and labeling a sample from each load in case questions arise in the future.** The analysis supplied with the product is not likely from the specific load delivered to your farm. Variability among loads may be significant.
- **Randomly analyze loads on your own periodically for nutrients and contaminants.** (Refer to the "What to Test For" section below.)
- **Record what, where and how much is spread, the supplier of the material, who did the spreading, when, and at what rate per acre.** These documents may be invaluable if questions arise in the future.
- **Minimize the amount of persistent bioaccumulative chemicals that may be ingested by the farm family.** Sludges contain toxic chemicals that build up in body fat and last a long time (so called "persistent bioaccumulative toxics" such as PCBs). There is no requirement for testing of sludges for these chemicals. High intake of products from animals exposed to sludges (particularly if sludges are applied to pasture or forages without tilling into the soil so that the animals may ingest sludges directly) would increase risks.
- **Minimize human exposure to Class B sludges.** Ensure workers immediately wash hands after working with the material. Wash outer clothing before rewearing. Do not track the material inside on shoes or via pets.
- **Find out about the experience of others.** Talk with others that have or are using products from the same company or generator.
- **Check with NYSDEC, the municipality, the farm lender, and dairy processors to determine applicable requirements before applying sludge or sludge products**. Dairy processors, milk handlers and farm lenders may apply restrictions on the use of these products. Check on their policies before application.
- **Clearly define legal responsibilities.** Enter into a signed contractual arrangement and obtain indemnification from the generator and/or spreader. Talk with the generator and/or spreader about any concerns.

What to Test for

Suggested analyses for farmers:

Sludge or septage – nitrate, ammonia, TKN, P, fecal coliform bacteria, trace metals*
Forage - nitrate, sulfur, calcium, magnesium, potassium, trace metals*
Soil - soluble nitrate, available P, sulfur, trace metals*

*Total Cd, Co, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Zn using EPA methods 3050 or 3051 (nitric acid digestion)

Site Specific Considerations

- **Soil test your fields and assess environmental risks**. Know exactly what you need for your cropping system. Request reports for Mo, Cd and S with your soil tests. Use the N-leaching index and the P index to assess potential movement to groundwater.
- **Be sure soil conditions are appropriate when spreading.** Avoid spreading on wet soils to limit compaction. Incorporate into the soil before next forecast rainfall.
- **Calculate the cumulative addition of metals resulting from application on each field.** Follow guidelines in the current Cornell Guide for Integrated Field Crop Management (refer to Table 1)**.**
- **Be sure the spread pattern is uniform. Know the lower application limits of your spreader.** Some spreaders are not accurate under 3-4 tons/acre. Material should be evenly applied for maximum efficiency and to avoid "hot spots." For low application rates (less than 3-4T/ac), this can be difficult.
- **For more guidelines, refer to USDA NRCS** (Natural Resource Conservation Service) standard NY590, Nutrient Management and NY633, Waste Utilization. (http://www.ny.nrcs.usda.gov/standards/index.htm).

Use of Advanced Alkaline Stabilized Sludge Product for pH Adjustment

- **Consider Mo concentration in the product and the Cu:Mo ratio in animal diet**. While many metals are less soluble at high pH, Mo is more soluble and more readily taken up into crops at high pH.
- **Soil test your fields.** Get current pH readings.
- **Do a cost analysis**. Ensure there is a cost benefit over standard lime based on effective neutralizing value (ENV).
- **Consider the nutrients.** Even though used for pH adjustment, advance alkaline stabilized sludge products contain nutrients that should be accounted for in your nutrient management plan. (One typical product contained 0.4% total N or 8 lb/ton dry wgt; 2% P_2O_5 or 40 lb/ton and 0.3% K or 6 lb/ton.)
- **Apply product at the recommended rate for achieving desired pH adjustment.** Use the lime evaluation chart in the current Cornell Guide for Integrated Field Crop Management handbook. If your soil tests show that you need more than 4 tons/acre of 100% ENV lime, split the application. Work in the first half with primary tillage and the second half in the upper soil profile with secondary tillage. The lime in this product is much more alkaline, fast acting and available than standard ground limestone, so do not overapply. Recheck soil pH the following year since the pH change may not persist.
- **More intensive management is needed if soil pH is less than 5.** Many soil tests tend to be inaccurate at the extreme lower and upper ranges of the pH scale. If you have a really low pH consider split application of a total of no more than 8-10 tons/acre of advanced alkaline stabilized biosolids and then recheck the following year. Adjust as needed. Check with your soil lab and ask what the lower limits of the test are.
- **Increasing soil pH takes time.** Usually lime or liming byproducts need to be applied 1 year in advance of seeding or planting sensitive crops such as soybeans and alfalfa.
- **Avoid stockpiling if possible.** If stockpiling product is necessary, locate the piles where water will not collect. Exclude or divert run off water from entering the pile. Piles may have odor, so locate them appropriately.

Minimizing Odors

- **Immediately incorporate or inject the sludge directly into the soil.** This is the best way of keeping application odors to a minimum.
- **Avoid stockpiling the material.** Since stockpiles may create odors and generate runoff, they should be avoided if possible.
- **Consider time of day and weather**. Cold weather reduces volatilization and resultant odors. Morning may be best in warm weather since increasing air temperatures cause air to rise and carry odors away. Drying during the day also reduces odors before neighbors' evening activities begin. Avoid spreading immediately before weekends and holidays when neighbors are likely to be engaged in outdoor recreational activities. Dry, windy days produce fewer odors than calm, humid days. The wind provides greater dilution of the odors. However, strong winds may blow sludge off-site.
- **Be sensitive to neighbor homes and public spaces.** Be aware of wind direction and avoid fields that are upwind of specific odor-sensitive areas.
- **Apply close to the ground in a thin layer.** Use of spreading equipment that applies sludge closer to the ground produces less odor than spreading equipment that discharges sludge into the air. Spreading sludges in a thin layer will promote drying and reduce the length of time that the odors will be generated.

Risk Reduction Measures

Issue	Potential/concern	Potential Causes	Risk Reduction Measures[1]
Animal health	Hypocuprosis	Excess Mo, Cd, S, Fe	• Don't apply sludges with >10ppm Mo or Cd • Limit bovine diet to <300ppm Fe • Consider need for dietary supplement
Animal health	Various	Pathogens Chemicals	• Incorporate sludge into soil • Observe waiting period before harvesting forage and grazing • Avoid pasture application • Apply only Class A sludges
Crop production	Phytotoxicity, reduced yields	Excess Cu, Ni, Zn	• Obtain data on the sludge • Select sludge low in metals • Limit cumulative amount applied
Crop production	Phytotoxicity, reduced yields	Decreased pH	• Monitor and adjust pH[2]
Water pollution	Nutrient loading	Excess N Excess P	• Consider N and P needs and sources • Test soils • Obtain data on the specific loads of sludge applied to your land • Apply according to management plan
Human health	Cancer Developmental impacts	Toxic organic compounds[3]	• Limit consumption of animal products from animals exposed to sludges • Avoid application of sludges to pasture • Incorporate sludges into the soil
Human health	Various	Pathogens Endotoxins Irritant gases	• Minimize contact with sludge, dusts, aerosols • Restrict public access for a year • Incorporate sludges into the soil • Practice good hygiene
Nuisance	Odors Vectors (flies)	Poorly stabilized sludge	• Incorporate sludge into soil • Reject loads that are odorous • Be considerate about when sludge is applied
Liability	Lawsuits	Odors Other nuisances Disease Water or land contamination	• Obtain indemnification agreement from supplier • Execute a contract with supplier and applicator • Accept only non-odorous sludges • Apply according to management plan • Incorporate sludges into the soil promptly • Keep records • Obtain data on the specific sludge applied to your land • Archive sludge samples

[1] These are measures that may help to reduce but may not eliminate the risks.
[2] Note that many metals are more prone to leaching and uptake into plants at low pH, but that molybdenum is more leachable and available to plants at higher pH.
[3] Many of the toxic organics that may be present in sludges tend to accumulate in animal products.

What are Sludges, Sludge Products and Septage?

Municipal sewage sludges (also known as biosolids or wastewater treatment sludges) are a mixture of water and solids: the dry weight of the solids varies from about 5% to more than 50%. On a dry weight basis they are organic-rich solids (usually greater than 50% organic matter) that contain sufficient N (2–7 %) and P (1–5%, equivalent to 2–10% P_2O_5) to make them potentially useful as farm fertilizers and a source of organic matter. Sludges, however, are generally low in K. Heavy additions of sludge can improve the physical properties of soil such as bulk density, aggregation, porosity and water retention, but such additions may lead to excessive nutrient losses to the environment.

> ***Sludge Terminology***
>
> In this report the term "sludge" refers to the array of different treated sludges and sludge-products that may be land applied.

Sewage sludges are a by-product of sewage treatment processes designed to clean water before it is discharged to lakes, rivers or the ocean. (See Figure 1.) Some pollutants are destroyed during treatment, but others end up concentrated in the sludges. Sludges thus contain not only nutrients and organic matter but also a complex mixture of contaminants including pathogens, metals and synthetic organics discharged into sewers from homes, industries, and businesses and leached from pipes. Because most heavy metals remain in the soil for a very long time, all additions should be considered permanent additions to the total quantity in the soil. Sludges also contain high levels of pathogens, which can be reduced or eliminated through sludge treatment. Sludges, once treated to reduce pathogen levels, can be applied to land directly or may be further processed into fertilizer pellets, compost, or a liming agent.

Domestic septage, the material removed from septic tanks, can also be applied to land. There are environmental and health considerations, particularly concerning pathogens, nutrients and contaminants such as some metals, which have led to federal and state rules for land application.

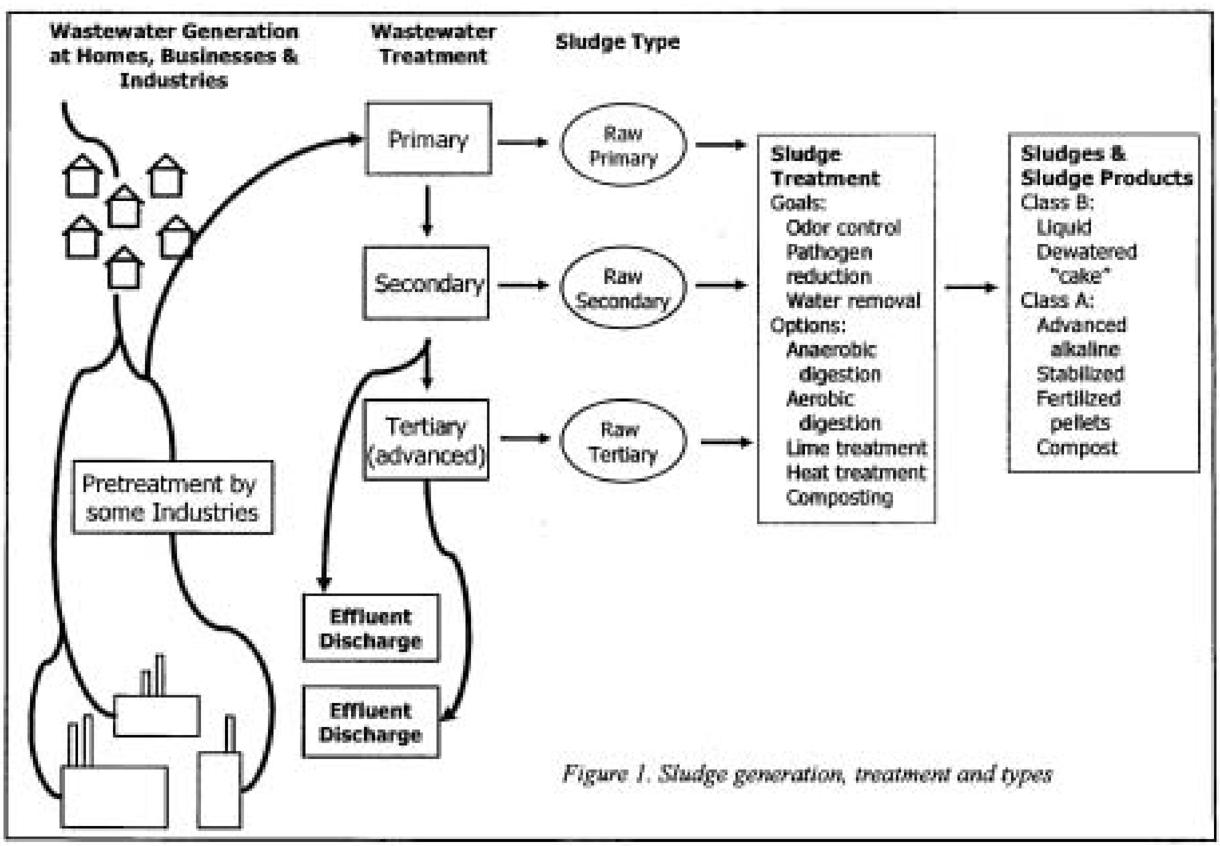

Figure 1. Sludge generation, treatment and types

There are Different Types of Sludges and Sludge Products

Treatment of municipal wastewater produces different types and volumes of sludges. Raw primary sludges are produced during the first phase of wastewater treatment. Primary treatment removes 40-50% of the solids in the water. They are removed by bar screens, grit chambers and primary sedimentation tanks. Primary sludges contains solid organic materials.

Secondary sludges are generated after the wastewater travels through a treatment tank and is allowed time to settle; it consists of microscopic material remaining after biological processes have removed dissolved organic matter. A third stage of water treatment at some wastewater treatment plants generates tertiary sludge by advanced processes such as chemical treatment and filtration designed to remove specific chemicals such as phosphorus from the water.

These sludges are mixed together and must be treated or stabilized before land application. Typical goals of sludge processing and stabilization include reducing water content, reducing disease causing organisms called pathogens, reducing the potential for sludges to attract vectors such as rodents or birds and controlling odors. Odors will depend greatly on the effectiveness of treatment at the wastewater treatment plant.

To achieve these goals, various treatment and stabilization methods may be used including anaerobic (without air) or aerobic (with air) digestion, dewatering, lime treatment, composting and heat drying (pelletization). Each of these methods reduce both pathogen levels and odor potential of the sludge and breaks down some pollutants. Under federal pretreatment rules, some wastewater treatment plants require specified industries to meet standards for certain chemical contaminants before their wastewater is discharged into the sewer system. Once generated at the wastewater treatment plant, sludges are not treated to reduce chemical contaminants. Chemical polymers and sometimes iron may be used to dewater the sludges. These additons will become part of the sludge.

The amount and type of industrial inputs, pretreatment of industrial discharges to reduce contaminants and wastewater treatment processes all affect the quality of the sludge. Even at a specific sewage treatment plant, sludge quality may vary over time and from load to load.

The primary types of sludges used on dairy farms in NYS include relatively liquid sludge and dewatered sludge “cake.” These Class B sludges will still contain a reduced level of viable pathogens. Farmers are generally paid to accept these materials or receive them at no cost. The other primary sludge type used on NYS dairy farms are sludges that have been mixed with alkaline materials (advanced alkaline stabilization). This process generates significant heat and raises the pH to >12 with the goal of essentially eliminating pathogens from this product. Farmers use this material primarily for pH adjustment of their soils and there is usually a charge for the product. Fertilizer pellets produced from heat drying sludges are produced in NYS, but most are shipped out of state. Some sludge-based composts are produced in NYS, but these are primarily used in parks and gardens, not in agriculture.

What are the Rules Pertaining to the Use of Sludges and Septage?

Federal and NYS Rules Pertaining to Sewage Sludges

Land application of sludges is regulated under NYS state (Part 360 of NYSDEC regulations) and federal (40 CFR Part 503) regulations. Municipalities in NYS may also adopt local rules. Where different, the most stringent of the federal, state or local rules must be followed. NYSDEC limits for sludges generally are somewhat more restrictive than the federal EPA rules.

Sludges are classified based on the extent of pathogen treatment. Class A is treated to essentially eliminate pathogens. Advanced alkaline treated sludges, composts and fertilizer pellets are among the processes that can make Class A sludge products. Class B sludges receive treatment to reduce, but not eliminate pathogens. Before land application, sludges must also be treated to reduce their attractiveness to vector organisms such as flies, birds and rodents.

Regulatory limits for the maximum concentrations of 10 contaminants in land applied sludges have been set by NYSDEC (Table 1). Cumulative limits which are the maximum amount of a chemical that can be applied to a piece of land through repeated applications over time have also been established.

NYSDEC rules pertaining to land application of Class B sludges (section 360-4) require site-specific permits and include cumulative application limits for several metals. These restrictions do not apply to sludge-based products that are treated to Class A pathogen and vector-attraction reduction standards (such as advanced alkaline stabilized sludges) and that meet NYSDEC maximum contaminant concentrations (Table 1) (section 360-5). Sludges and sludge-based products applied in agriculture are to be used at rates not exceeding the nitrogen needs of the crops to which they are applied.

Federal and NYS rules require waiting periods between the application of Class B sludges and introduction of grazing animals (30 days) and for raising of food crops. For Class A/EQ products, there are no federal restrictions. NYSDEC imposes waiting periods for harvesting of food crops grown where any kind of sludge has been applied (14 months for above ground crops and 38 months for below ground).

Check with NYSDEC and the municipality to determine applicable regulations for sludge or sludge product use. Dairy processors, milk handlers and farm lenders may apply further restrictions; thus, checking applicable requirements and policies is recommended before application.

Table 1. Standards for land application of sewage sludges

Contaminant	***NYS DEC*[1]** *Monthly Average/ Maximum (ppm)*	***EPA 503*** *EQ limit (ppm)*	***EPA 503*** *Ceiling limit (ppm)[3]*	***NYS DEC*[4]** *Cumulative limit (lb/ac)*	***Cornell Field Crop Guide*[5]** *Recommended Maximum Concentration (ppm)*
	Sludge Concentration	*Sludge Concentration*	*Sludge Concentration*	*Applied to Soil*	*Soil Concentration*
Arsenic	41/75	41	75	none	1-10[6]
Cadmium	21/85	39	85	3/4	2[7]
Chromium	1,000/1,000	none	none	300/446	[8]
Copper	1,500/4,300	1,500	4,300	75/112	40-100[9]
Lead	300/840	300	840	267/267	[10]
Mercury	10/57	17	57	none	1[11]
Molybdenum	40/75	none[2]	75	none	2-4[12]
Nickel	200/420	420	420	30/45	25-50[13]
Selenium	100/100	100	100	none	5[14]
Zinc	2,500/7,500	2,800	7,500	150/223	75-200[15]

Note: Concentrations are in dry weight.

[1]The standards apply to all sludges and sludge products except that the standard is 10 ppm for the monthly average Cd concentration in Class A sludge products.
[2] EQ limit for Mo was deleted from U.S. EPA rules pending reconsideration.
[3] No sludges can be applied that exceed these levels. The cumulative addition of these contaminants must be calculated over time for sludges that do not meet the EQ limits.
[4] Part 360-4. Amount that may be added over time. Lower number applies to NYS Ag Soil groups 1–3, higher number to groups 4–10. Applies to land applied Class B sludges but not to sludge products.

[5] 2003 Cornell Guide for Integrated Field Crop Management. Cornell Cooperative Extension.

[6] Risk assessment based on child ingestion and 0.0003 RfD suggests 1 ppm concentration limit for sludges used at home (Texas Natural Resources Commission, 1996). Background soil often exceeds 1 ppm so a range is potentially acceptable.
[7] A limit of 2 ppm is recommended because of crop uptake concerns.
[8] The chemical form of Cr is of critical importance. Cr III is of little concern because it forms relatively insoluble compounds, but Cr VI is highly toxic and soluble. Little information is available on the ionic status of Cr in sludged soils and the potential for chromium oxidation in sludged soils.

[9] Concentration limits aim to prevent phytotoxicity. Based on the Northeast guidelines (Pennsylvania State, 1985); 40 ppm for sandy soils, 60 ppm for fine sandy loam to silt loam, 100 ppm for silt to clay soils.
[10] The lowest attainable levels are desirable because negative effects on humans continue to be discovered at increasingly low levels. Direct ingestion of soil by children is the primary concern.
[11] The lowest attainable levels are desirable. Ecotoxicologic and groundwater impacts are likely to be the determining factor.
[12] Excessive Mo can result in toxicity (induced copper deficiency) in ruminants. Mo is more available at higher (more basic) pH so the lower value of 2 applies to soils with pH 6.5 or higher.
[13] Concentration limits aim to prevent phytotoxicity. Based on the Northeast guidelines (Pennsylvania State, 1985), 25 ppm for sandy soils, 35 ppm for fine sandy loam to silt loam, 50 ppm for silt to clay soils.
[14] This may be too high. Although sewage sludges in the Northeast do not generally contain significant available Se, some alkaline sludge products using fly ash could be high in soluble Se. Test forages periodically for Se to ensure that concentration does not exceed that considered toxic to animals.
[15] Concentration limit to prevent phytotoxicity. Based on the Northeast guidelines (Pennsylvania State, 1985); 75 ppm for sandy soils, 130 ppm for fine sandy loam to silt loam, 200 ppm for silt to clay soils. Higher concentrations can be tolerated in calcareous soils.

Federal and NYS Rules Pertaining to Septage

Under federal rules, septage (the material pumped out of septic tanks) can be land applied to “nonpublic contact sites,” including agricultural fields, forest land, and reclamation sites. To meet federal regulations for the reduction of vector attraction (such as flies and rats), land applied septage must be treated by one of the three means: subsurface injection; incorporation (surface application followed by plowing within six hours); or alkali stabilization (pH of 12 or greater for 30 minutes prior to application). The federal regulations also include various restrictions on the crops grown on the site and on access to the site by the public.

NYS rules for septage use are more stringent than federal rules. For small septage haulers (two or fewer trucks), the NYSDEC limits application to a maximum of 25,000 gallons/acre/yr. There are no requirements to test septage pumped by these small haulers so a farmer would have no knowledge about the quality of the material. For larger operations, septage requirements are essentially the same as sewage sludge land application rules.

Local Laws

Local regulations pertaining to sludge application may also be enacted so check with your town and county to determine if there are additional relevant requirements. Local laws can range from a prohibition of sludge application to requirements for additional testing. Check with the town or county clerk and local health department to find out if there are local rules.

Relation to Right to Farm Laws

Farming is man’s oldest economic activity. Because some farming practices have a potential to produce such things as odors, noise and dust, there is a long-standing relationship between nuisance claims and agriculture. For this reason, many states and communities have passed “right-to-farm” legislation that protects farms from nuisance law suits as long as the farm practices are within some norm or industry standard.

In the New York State Constitution, Article XIV states, “The policy of the state shall be to conserve and protect its natural resources and scenic beauty and encourage the development and improvement of its agricultural land for the production of food and other agricultural products.” It calls for the legislature to provide for the protection of agricultural lands.

Since 1971, the Agricultural Districts Law, Article 25-AA of the Agriculture and Markets Law, has been the centerpiece of the state and county level efforts to preserve, protect and encourage agriculture. It permits county legislatures to establish Agricultural and Farmland Protection Boards and, in conjunction with county planning boards, allow landowners to enroll their farms in agricultural districts. Only farms within agricultural districts boundaries are afforded the rights, privileges and responsibilities of the Agricultural District Law.

Under this NYS law, farms engaged in "sound agricultural practices" located in agricultural districts or those receiving an agricultural tax assessment are protected from private nuisance suits. If a neighbor alleges that the farm is generating odors, or other nuisances that interferes with his/her enjoyment of their property, and the Commissioner of the NYS Department of Agriculture and Markets (NYSDAM) finds that the farm is using "sound agricultural practices," the allegation would have no standing in court. However, the law does not protect farms that cause damage from negligence or breaking environmental or other laws. Spreading of sludges or septage that follows NYSDEC regulations has been interpreted by NYSDAM as a sound agricultural practice.

Additionally, under NYS agricultural laws, municipalities may not enact laws that "unreasonably restrict or regulate farm operations" within an agricultural district except where public health and safety are threatened. Thus, municipalities in NYS may adopt local laws and rules that restrict spreading of sludges and septage, but within an ag district, if challenged, these local laws must be shown to be necessary to protect public health and safety.

What Testing is Done?

Prior to land application, sludges in NYS must be tested at a frequency determined by the amount of sludge applied, varying from 4 to 12 analyses per year. The parameters tested for are the 10 regulated elements, nutrients, pH, and solids content. In NYS sludges from all but the smallest wastewater treatment plants (WWTP) are also tested for 127 "priority pollutants" once per year or once per 5 years. NYS DEC may require testing for other contaminants on a case-by-case basis. Federal rules tie the frequency of testing for the regulated elements, nutrients and pH to the volume of water processed at the wastewater treatment plant. They do not require testing for organic chemicals or priority pollutants.

There is no requirement that individual loads of sludge be tested. Test results are generally presented as an average of tests taken over the year. NYS standards establish an average monthly limit for 10 contaminants and a maximum limit for any specific test (see Table 1).

For some parameters at some wastewater plants, there is a large variability in tests taken at different times. For example, nitrogen levels in the sludges from one WWTP varied 6 fold over the course of a year. This would make calculation of an appropriate nitrogen-based application rate difficult since the nitrogen concentrations in the particular batch of sludge delivered to the farm would not be known. Depending on the nitrogen content of the sludge actually spread, the nitrogen application rate might be as much as 6 times more than needed or as little as 1/6 the amount required. It is thus recommended that tests be performed on the specific load of sludge to be used on your farm.

Testing Requirements in NYS

For What:	How Often?
As, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Se, Zn	4-12 test/yr for each WWTP
pH, TKN, Ammonia, Nitrate, Total P, Total P, Total K	4-12 test/yr for each WWTP
Total Solids, Total Volatile Solids	4-12 test/yr for each WWTP
127 "Priority Pollutants"	once every 1-5 years

Compliance and Enforcement

Staffing at the federal and state level is not sufficient to provide a high level of oversight and enforcement. It is thus advisable for the farmer to independently review test results and permit requirements and to monitor application practices. Enter into a contract with the sludge management company that specifies testing, application and reporting requirements and allows you to stop the spreading if there is a problem.

How are Sludges and Sludge Products Used?

As discussed above, there are several types of materials that may be used and each has its own application concerns. The typical method of applying any of these materials is either injection into the soil (for liquid Class B sludges) or surface spraying or spreading which may be followed by plowing the material into the soil.

The material most dairy farms in NYS use is advanced alkaline stabilized sludge. This material is considered a liming agent by the NYSDAM and should be used for pH adjustment only. While such products are not a primary source of nutrients, when applied as a means of raising soil pH, the nutrient content should be assessed so that excessive nutrients are not applied.

Due to the lower ENV of the sludge product compared to typical liming materials, higher application rates are required. However, application rates over 8 tons/acre are not recommended as the product is more rapidly reactive than conventional ground limestone, and may lead to an undesirably high pH shortly after application. Most soil pH tests have built in inaccuracies at the extreme ranges of the pH scale. If the pH of your soil is very low (<5), apply up to 8 tons/acre. This application may bring the pH into the working range of the soil test, and further adjustments can then be made. Check pH again the following growing season.

Most of the spreaders used to broadcast advanced alkaline stabilized sludges are spinner type spreaders. Most of these spreaders are not accurate below 3-4 tons/acre which can result in over-application.

Management Practices

Soil incorporation reduces odors and the potential for material to run off or be blown off site. On pastures where the material is surface applied, it is also more likely that grazing animals will ingest it.

Be careful if applying advanced alkaline stabilized sludge to hay crops or pastures. Often the material has lumps. These lumps do not break down very quickly, and can easily be windrowed by the haybine when cutting, or eaten by grazing animals (see photo). This puts the material directly into the feed stream of the farm. This material is better suited for fields that are to be tilled or harvested at a higher height (grain corn, for example).

Stockpiling of any sludge or sludge product should be avoided when possible. Any unavoidable stockpiling should be where odors will not be a concern. Sometimes odors can be strong. If you do stockpile, be sure the pile is located on a well drained site so water does not pond and locate where any rainfall runoff will not immediately enter a water body (ditch, stream, pond).

Soil Fertility

Sludges are generally used as a fertilizer and applied at rates consistent with crop nitrogen requirements. They are generally poor sources of potassium. The advanced alkaline stabilized sludges are used to adjust soil pH and thus can be a substitute for agricultural limestone.

Sludges are high in organic matter. However the amounts applied for agriculture uses will not have a major impact on soil organic matter content.

There have been numerous comparisons of crop yields with sludges, manures and fertilizers as sources of nutrients. Usually when conditions of equivalent amounts of nutrients and water are met, the source of nutrients has not had a significant effect on crop yields in the short term.

Sludges also contain micronutrients and other elements, some of which can benefit crops. Depending on their quality, with repeated applications, however, the long term accumulation of some micronutrients that can cause phytotoxicity (Cu, Ni, Zn) could have a negative effect on yields (see "Phytotoxicity" section on page 15).

Figure 2. Cow ingesting sludge product (courtesy of Molly Bowen)

Nutrient Considerations for Sludges, Sludge-based Products and Septage

Fertilization is a rationale for using sludges and septage on agricultural lands. The goal is to apply them at an agronomic rate sufficient to provide for crop needs but not at excessive rates that might lead to pollution of ground water. Due to the ratio of N and P in sludges, when applied to meet crop N needs, sludges will provide excess P.

Many dairy farms in NYS already import more nutrients in the form of feed and chemical fertilizer than crops can use. Thus, there are concerns with bringing more nutrients in sludges onto a dairy farm. To ensure that soil nutrient levels will not be excessive, a sound nutrient management plan is needed. The plan should be based on current soil and sludge product tests. Because of the potential variability in nutrient content of sludge even from a specific source, the specific load/batch should be analyzed if possible. The plan needs to provide for the acreage that may be required to account for the nutrients resulting from sludge/septage spreading in addition to the existing manure production. Assuming a good nutrient management plan is in place, application should not exceed the appropriate agronomic rate based on N or P, whichever is most limiting. Calculations should be made for both N and P and application rates should not result in an excess of either nutrient.

Nutrient availability from sludges must be estimated in order to determine agronomic application rates. Estimating nutrient availability for organic materials is not as straightforward as for fertilizer nutrients. Nitrogen will be present in both inorganic and organic forms. For sources such as sludges and manures that contain organic nitrogen, only a portion is available in the year it is applied. Some additional fraction will become available in subsequent years, so past practices and applications need to be considered to provide the best estimate of what will be available to crops each year. Soil microbes play an important role in the mineralization of the organic N into available inorganic N. Organic materials are subject to decomposition by soil microbes over time, and nutrients are released as part of the decomposition process.

Estimating availability of nutrients varies for N, P and K. For K, the estimation is easy. Consider all K to be available to crops the year the material is applied. Estimating availability of P is less certain, and, like K, should be based on a soil test. If the soil test calls for more than 25 pounds/acre of P_2O_5, some P should be applied as fertilizer in a band when planting row crops. The rest can come from a combination of manure and/or sludge-based products. Generally, when the soil test shows P sufficiently high to generate a recommendation that is less than 25 pounds/acre of P_2O_5, the best chance for a P response is a highly available source of P close to germinating plant roots.

Estimating N availability is the most challenging. The calculation is complicated because the different processes that sludges undergo before arriving at the farm has important effects on the amount and type of N that remains and how it will react in the soil. Recent work on sewage sludges demonstrates large variation in the mineralization rates of different sludges under different conditions. This makes

Nutrient Management Questions a Producer Should Consider

Are the extra nutrients needed?

Many dairy and livestock farms annually import 60-70% more N, P and K than is exported. The majority of these imported nutrients are in purchased feeds and grains fed to the herd. Most of the extra nutrients are applied to farm fields as manure. Additional nitrogen (N) and phosphorus (P) may not be needed. If your operation is “land lean”, having more than 1.5-2 animal units[1] per spreadable acre, you may not want to import more nutrients via sludge, particularly on land that regularly receives manure.

Will the extra phosphorus present challenges in the future?

The ratio of N and P in sludges generally results in excess application of P if agronomic rates of N are applied. P accumulates in the soil when applied in excess of crop requirements, subject to erosion, runoff and leaching losses. The accumulation of P may cause environmental problems and possibly require export and/or treatment of manure or the acquisition of more land.

How much to apply?

Be sure to obtain a nutrient analysis, even if the product is marketed as a liming material. Just like manure, it is difficult to be sure that any sample is truly representative. However, obtaining an analysis is necessary to calculate crediting nutrients. The Natural Resources Conservation Service standards require a determination of nutrient content. How often is your sludge supply analyzed? Consider saving a sample from each load in case questions arise in the future. Randomly analyze loads on your own periodically.

[1] 1.5 animal units per acre is a little more than one mature Holstein cow per acre. 2 animal units per acre is about one mature cow plus her replacement per acre.

Sample Calculation of Agronomic Rate Based on N

The NYS DEC has established formulas for calculating plant available nitrogen from sludges. (contained in 6 NYCRR Part 360 Solid Waste Management Facilities. April 1995. 360-4.4(c))

As an example we assume:

Crop N requirement-150lbs/acre

The sludge is anaerobically digested sludge cake at 40 % dry matter. The N values are based on dry weight analysis.

The sludge contains 1.2 % N as ammonium N and 5 % N as Kjeldahl N (TKN) and no nitrate N (the ammonium N is an inorganic form of N determined in a special procedure while TKN is a procedure which determines both ammonium and organic N and hence in the following calculations the inorganic N is equal to the ammonical N and organic N is equal to TKN minus ammonical N).

The ammonium N is volatile and unless incorporated immediately after spreading may be lost. Only a portion of the organic N will become available over the growing season.

In the following equations, pounds of available N per ton dry sludge is expressed as “N/ton”.

If incorporated within a few hours after spreading:
N/ton = (percent ammonium N times 20) + (percent nitrate N times 20) + (percent organic N times A)

Where A= 2 for composted sludges
A= 4 for anaerobically digested and other sludges
A= 6 for aerobically digested sludges
A= 8 for lime stabilized primary and activated sludges.

Thus in our example for immediate incorporation:
N/ton = (1.2*20) + (3.8*4) = 24 + 15.2= 39.2 lbs N/ton

To supply 150 pounds of N per acre we need 150/ 39.2= 3.8 tons of dry sludge/acre.

Since the sludge is 40% dry matter, the wet weight is 3.8/0.4 = 9.5 wet tons/ acre.

If not immediately incorporated, the equation becomes:
N/ton = (percent ammonium N times 10) + (percent nitrate N times 20)+ (percent organic N times A

Thus in our example where sludge is incorporated:
N/ton = (1.2*10) + (3.8*4) = 12 +15.2 = 27.2 lbs N/ton

To supply 150 pounds of N per acre we need 150/ 27.2= 5.5 tons of dry sludge/acre.

Since the sludge is 40% dry matter, the wet weight is 5.5/0.4 = 13.8 wet tons/ acre

There is no easy way to convert wet tons to volume (spreader or truck loads). This information should be supplied by the person delivering the sludge.

As illustrated above, only a portion of the organic N in the sludge will decompose the year of application. Accordingly, DEC has provided a way to estimate residual effects.

The residual effect is as follows:
N/acre = (original application, dry tons/acre)*(original % N)*(Ar)

Where Ar is given in the following Table:

Year following Sludge application	Ar A=2	A=4	A=6	A=8	(See key above)
1	0.9	1.6	2.1	2.4	
2	0.51	0.72	0.95	0.96	
3	0.5	0.41	0.55	0.43	
4	0.48	0.40	0.31	0.25	

Thus the first year residual effect for example 1 above is:
N/acre = (3.8)*(3.8)*(1.6) = 23 lb/acre

And for example 2:
N/acre = (5.5)*(3.8)*(1.6) = 33 lb of N/acre will be available from application the previous year.

What about P?
In general sewage sludges contain on the order of 2% P, or 40 pounds of P or 90 pounds of P_2O_5 per dry ton. In the case of example 1 above, 3.8 dry tons of sludge will contain 350 pounds of P_2O_5.

calculation of agronomic application difficult. NYSDEC has developed a standard approach for calculating the available N from sludges (see Sample Calculation on page 12).

Risks

Sludges are a complex and varied mixture containing chemicals, pathogens (disease causing organisms) and endotoxins (part of the outer membrane of the cell wall of Gram-negative bacteria. Sludges will differ from each other depending on both the wastewater sources to the sewage treatment plant and the type of treatment processes.

Concerns include potential impacts on soil and plants, on water quality and on human and animal health. Metals, persistent bioaccumulative toxics (PBTs), irritant chemicals, pathogens and endotoxins are among the components present in sludges that may cause adverse reactions. Exposure may occur through direct contact, transport off-site via wind, runoff or pets, or uptake into crops or animal products. Unfortunately there is not much information of the levels of many of these contaminants in sludges, on how much exposure to people and animals results from sludge applications, or on the interactions between contaminants, so the risks are not well characterized.

Risks to Agricultural Productivity

Experience with crops likely to be raised on NY dairy farms suggests several issues that could arise with use of sewage sludges and sewage sludge products. Most risks would arise after repeated long-term application. Risk from pathogens and from molybdenum (Mo) or sulfur (S) might arise more quickly.

Dairy Herd Health

HYPOCUPROSIS

Several elements, notably S, Mo, Fe and Cd, can reduce Cu absorption by ruminant animals. It is generally recommended that feed Cu be supplemented if S exceeds 0.2% in the feed, with 5 ppm additional Cu recommended for each 0.05% increase in feed S above 0.2%. Similarly, for Mo, Cu supplementation is advised to keep the Cu/Mo ratio in the feed in the 5/1 to 8/1 optimal range. A dietary Cu level of 10 mg/kg is generally sufficient for cattle, but Cu supplementation would be required to counter elevated levels of these antagonistic elements, and avoid sub-clinical or clinical hypocuprosis. Sub-clinical (hidden) hypocuprosis is believed to be fairly common in grazing ruminants, leading to reduced weight gain, lower productivity and less reproductive success.

Sewage sludges contain generally higher concentrations of total Mo, S and Cd than manures and therefore have the potential to increase the availability of these elements in soils. All three of these elements are taken up by crops relatively easily. Forage S tends to be elevated in sludge-amended fields. Soil pH determines whether additions of Cd or Mo to the soil have a substantial effect on levels of these metals in forage crops. As a guideline, it is advisable to keep forage Cd less than 0.5 ppm (dry weight basis), and Mo less than 2.5 ppm, to protect cattle health. Soil pH management is critical, with low pH favoring Cd uptake and high pH favoring Mo uptake into forages.

Fe has a strong antagonistic effect on Cu absorption by cattle, and Fe intake in the whole diet at more than 300 ppm must be countered by Cu supplementation. High Fe intake is usually the result of soil ingestion when pastures are very sparse or muddy conditions prevail. Fe is generally low in sludges but will be high in sludges from wastewater treament plants that use Fe

Molybdenum and Cadmium

Sewage sludges with Mo or Cd concentrations higher than about 10 mg/kg total should probably be avoided on dairy farms, as they could increase forage concentrations of Mo or Cd after a few years of application. This would increase the risk of reduced productivity or disease in livestock from copper deficiency (hypocuprosis). It would only take a few applications of a sludge containing 40 ppm Mo to exceed the advised maximum soil concentration limit of 2-4 ppm in the Cornell Guide for Integrated Field Crop Management (see Table 1), a soil level which may produce forages of unacceptable quality, as measured by low Cu:Mo ratio.

in sludge treatment. Sludges are not routinely tested for iron, so inquire about the use of iron at the treatment plant before accepting a sludge or sludge product. One situation that could greatly increase Fe ingestion on sludge-amended pastures is when application of a high-Fe liquid sludge (high Fe resulting from certain wastewater treatment processes) contaminates the forage and insufficient time is allowed for regrowth before allowing livestock to graze.

A Tale of Two Dairies in Georgia

Two dairy farmers near Augusta Georgia used sewage sludge from the Augusta sewage treatment plant as a soil amendment. One began using the sludge in 1979, the other in 1986. Within a few years, the crop yields dropped, milk production dropped and cow deaths increased on these previous award-winning dairies. Once they ceased using feed for the cows which was grown on sludged soils, their dairy herds began to recover, although these damages were significant. The farmers sued for damages alleging that the sewage sludge was the cause of the decimation of their farms.

One of these cases was tried in 2003, after over 5 years of litigation. The jury found in favor of the plaintiffs. They concluded that there had been a breach of contract and that illegally created sludge and hazardous materials had been placed on the farm, causing the harm. However, the jury awarded only $550,000, an amount that does not even cover the costs of the lawsuit. The farm family has sold all their cows and is attempting to liquidate other assets. The city of Augusta has appealed the decision. The suit of the other farmer is still pending, with a trial expected within the next year.

Other Elements

Several other elements not listed in Table 1 and not regulated but that could conceivably pose some risk to crops or livestock include tin (Sn) and silver (Ag), which are found at elevated concentrations in most sewage sludges. These metals are probably too insoluble in soils to present a significant hazard to soil organisms or crops; nevertheless, a small fraction of the Sn in sludges is in the form of organo-tin compounds, highly toxic chemicals which could affect soil organisms or be transferred into livestock by grazing. Research is lacking on the behavior of organo-tin compounds in agricultural soils, but these toxins have been shown to be quite persistent in aquatic environments. Most sludges are low in boron (B), and fluoride (F), but if present in high concentrations in a particular sludge, B may be toxic to sensitive crops, whereas F could cause animal disease.

Pathogens and Endotoxins

Class B sludges can contain pathogens and parasites, some of which may be of concern for animal health. Federal and NYS regulations stipulate that animals are not to graze on Class B-amended land for 30 days in order to reduce the chances of infection. Some parasites can persist far longer in soil. This is another reason why incorporation into the soil is recommended to minimize the potential for animals to ingest pathogens.

Endotoxins in sludges and sludge products have not been investigated. They are expected to be present since they are the result of bacteria death. Exposure through inhalation can cause illness in people and animals.

Soil pH Change

Application of non-alkaline sewage sludges, if continued over a number of years, can be expected to lower soil pH, the result of the acidifying effect of S and N mineralization. It is important to monitor pH and add lime to prevent pH from falling below about 6. Low pH allows certain metals, notably Cd, Cu, Ni and Zn to become more plant-available and thus potentially harmful.

Sewage sludge-lime mixtures are commonly used as limestone substitutes on farms. The “lime” component of these materials is much more alkaline (pH 11-12) than standard limestone (pH 8.0-8.5), and reacts more rapidly with soils because of higher solubility and fine particle size. This more rapid reaction creates the short-term potential for “overliming” if applied at comparable rates to ground limestone, especially if the material is applied unevenly. The harmful effects of overliming (soil pH > 7.5) include crop deficiency of manganese. In addition, the alkaline soil pH increases the plant uptake of Mo, an element that can cause disease in ruminants. Rechecking pH is essential.

Phytotoxicity From Cu, Ni and Zn

All three of these metals are toxic to plants if present in soils at high enough solubility. However, they are not equally toxic, with Cu about twice as toxic as Zn, and Ni as much as 8 times more toxic than Zn. Since toxic effects on crops are likely to be at least partially additive, a "Zinc Equivalent Factor" (ZEF) has sometimes been used to gauge the overall toxic impact on plants:

$$ZEF = Zn\ (mg/kg\ in\ soil) + 2\ Cu\ (mg/kg\ in\ soil) + 8\ Ni\ (mg/kg\ in\ soil)$$

However, soil pH, soil texture, soil cation exchange capacity (CEC) and organic matter content as well as crop type greatly influence toxicity, so that a single "acceptable" ZEF or concentration limit for Zn, Cu and Ni in soils cannot be recommended without specific knowledge of soil properties and crop type. Nevertheless, Table 2 presents some suggestedconcentration limits for total Cu, Ni and Zn in agricultural soils of different pH and textures based on past research.

Table 2. Soil concentration limits (mg/kg) for Cu, Ni and Zn likely to protect most crops, including N-fixing legumes.

Soil pH	Low CEC (sands, loamy sands)	Medium CEC (silts, silt loams)	High CEC (clays, silty clays)
Non-acid (pH>6.5)			Cu=100 Ni=50 Zn=200
Slightly to moderately acid (pH 5.5-6.5)		Cu=60 Ni=35 Zn=130	
Strongly acid (pH<5.5)	Cu=40 Ni=25 Zn=75		

Note: Limits based on research referenced in the NE Guidelines (Penn State, 1985) and research supporting the UK Standards.

The metal limits in Table 2 are relatively cautious, applying a safety margin of about 2 for each metal, as it is likely that some additivity of harmful effects will occur. They also factor in the concern that important soil micororganisms (e.g., Rhizobia) may be negatively impacted at levels below those causing direct toxicity to plants.

There are few data regarding septage quality and for small septage haulers, there are no requirements to test for metals. Examination of the available data for septage quality indicates high variability. For some septage, application could result in reaching these recommended Cu or Zn levels in fewer than 10 applications.

Metals in Sludges

Concentrations of Cd, mercury (Hg), lead (Pb), Ag, Sn and a number of other metals are higher (often much higher) in sewage sludge products than the concentrations of these metals in human waste or manure. The debate about the advisability of applying sewage sludges to farmlands has centered for decades on the degree of risk that would be incurred by increasing the levels of potentially toxic metals in soils in our farms and gardens.

Table 3 illustrates the fact that long-term farm application of sludges with "typical" metal concentrations increases the topsoil concentrations of some or all of the elements listed. Most of the metals listed in Table 3 are relatively immobile in the soil, and are likely to persist for decades, or even centuries, following application. The concern with excessive metal buildup in soils is that some of the metals (Cd, Hg, Pb) are particularly zootoxic (cumulatively toxic to animals and humans), whereas other metals (Cu, Ni, Zn) are known to be phytotoxic (damaging to crops).

The general consensus in the literature is that metals such as Cd and Pb have little potential for transfer into meat and milk. With mercury it is complicated by organo-Hg, which may make up part of sludge Hg. This form of Hg may bioconcentrate in animal fat or milkfat, in theory, but has not been studied.

Calculating Maximum Loading

To calculate the total number of tons/acre of sludge that may be applied without exceeding recommended soil concentrations for a sludge with measured contaminant levels, use the following equation:

Total cumulative application in dry tons/acre of contaminant =1000 x (recommended maximum final soil concentration minus background soil concentration in parts per million) divided by the concentration of the contaminant in the sludge.

For example, if a sludge contains Cd at 10 ppm, background soil is 0.2 ppm, and the recommended maximum soil concentration of 2 ppm is used, a total of 180 tons/acre may be applied [1,000x(2ppm-0.2ppm)/10 ppm] without exceeding the recommended maximum soil concentration. This calculation assumes that all of the Cd applied remains in the soil.

Sewage sludges containing 1,500 mg/kg Cu and 2,500 mg/kg Zn (the NYSDEC monthly average limits), if applied at about 5 tons/acre (~10MT/ha), would build topsoil concentrations of Cu and Zn to the recommended upper limits in about 10 applications. Most sewage sludges are of better quality than this. Nevertheless, Cu and Zn are the metals most likely to limit long-term sludge application. However, Mo may supersede Cu and Zn as the primary concern for livestock farmers.

Table 3. Metals in sludges and soils (mg/kg or ppm except as noted for S)

Metal	*Concern*	*Acceptable Forage Level*	*Typical Sludge Level*	*Background NYS Ag Soil Level*	*Recom. Soil Limit*[2]	*Years to Reach Limit*[3]
Cu	Crop Yield	6-12	300-1500	20	100	11-53
Ni	Crop Yield	1-5	10-150	16	50	45-680
Zn	Crop Yield	20-40	500-2500	60	200	11-56
Mo	Hypocuprosis in livestock	0.5-2.0	5-50	0.5-1.0	2-4	4-40
S	Hypocuprosis In livestock	1.0-2.5 g/kg	7-12 g/kg	0.2-0.6 g/kg	——	——
Cd	Animal toxicity and food crop contamination	0.05-0.30	2-15	0.2	2	24-180
Pb	Animal toxicity	0.1-0.5[1]	100-300	15	——	——-
Hg	Animal toxicity	< 0.1	1-10	0.1	1	18-180

[1] Probably overestimates true value due to poor analytical sensitivity of ICP for this metal.
[2] Limits are for non-acid soils. Lower limits are recommended for acid, coarse-textured soils.
[3] Assuming low and high extremes on the ranges for sludge elemental concentrations, agronomic (5T/ac=10 MT/ha annually) application rates, and no losses by leaching.

Organic Contaminants

Many chemicals that are contained in wastewater become concentrated in sludges. This is particularly true for fat-soluble, persistent organic chemicals (familiar examples are PCBs and dioxins and a more recent example is polybrominated biphenyls). Concerns regarding organic chemicals include ecological impacts to soil health and wildlife and entry into the human food chain particularly through accumulation in dairy products. Whether their presence represents a significant risk to people, agriculture and the environment is under debate.

Neither EPA nor NYSDEC regulate any organic chemicals in sludges and there are very few data on the presence and concentration of these types of chemicals in sludges. The priority pollutant scan required by NYSDEC generates some data on organic chemicals, but it does not include most of the persistent organic chemicals.

Of particular concern for dairy farms are the fat-soluble bioaccumulative chemicals, as these may accumulate in the fat tissue and milk fat of dairy animals when they ingest soil or sludge particles during grazing. These chemicals then become part of the food chain for people. Many of these chemicals pose cancer risks as well as developmental risks. Farm families with high consumption of animal products would be at particular risk. There is a lack of research to evaluate the risk of milk or meat contamination.

A new survey to identify the chemicals in sludges is needed since the previous survey done in 1988 is out of date both because of changes in chemical use and because detection limits in that survey were too high for some chemicals to show whether they were present at levels that might pose a health or environmental risk.

Pathogens and Endotoxins

Sludges contain pathogens and endotoxins (potentially illness-causing cell wall materials that remain after certain bacteria die). Endotoxins have not been studied in sludges, but would be expected to be present in both Class A and Class B sludges.

Sludge regulations require treatment to reduce pathogen levels before sludges can be applied to land. While Class A sludges used in agriculture should be essentially free of pathogens, Class B sludges may contain up to 2 million colony forming units/gram of fecal coliform. In addition to bacteria, sludges also contain viruses and may contain parasites. The ability of pathogens to survive sludge treatment and to survive in the environment varies greatly among different pathogens. Little is known about viruses under these conditions. Given their small size, the potential for surviving viruses to reach groundwater or to blow off sludge sites is a concern.

Persons and animals can be exposed to the pathogens that may remain in sludges by directly contacting the sludge or soil to which sludges have been applied. Federal rules require public access to farm fields to which Class B sludges have been applied to be restricted for 30 days. For other sites where the likelihood of public access is high (such as parks), access is to be restricted for one year. Current rules assume that pathogens will be killed due to environmental exposure over the course of a year. The lesser time restriction for farms is due to the expectation that fewer people might be exposed, not due to different assumptions regarding the inactivation of pathogens. Farmers using Class B sludges are thus required to keep people from their land for at least 30 days. However, it might be advisable to restrict access for at least a year. This includes persons who might use the land for hunting. Since workers can also be exposed, information needs to be provided to workers about the need to maintain high standards for hygiene in order to avoid illness. Current rules require grazing animals to be kept off land to which Class B sludges have been applied for 30 days. The adequacy of that waiting period to prevent disease from parasites has been questioned so a large waiting period may be advisable.

Farm Family Health/Workers

Farmers and farm workers working with sludges and on sludged fields should be aware that Class B sludges contain pathogens. While manures also contain pathogens of human concern, the number of different pathogens likely to affect humans is far higher in sewage sludges. The National Institute for Occupational Safety and Health recently issued guidance for workers that suggests hygiene practices to minimize risks of infection from sludge handling.

Beyond practicing good hygiene, of particular concern for dairy farm families is that persistent bioaccumulative toxic pollutants tend to concentrate in animal fats. There is no requirement for testing of sludges for these bioaccumulative toxics so the concentrations in sludges are unknown. High intake of animal products, which is typical for dairy farm families, and exposure of animals to sludges (particularly if sludges are applied to pasture or forages without tilling into the soil, increasing the potential for animals to ingest sludge) would increase risks.

Liability

Because of the controversial nature of sludge use and concerns about potential risks, farmers should consider liabilities that may be associated with sludge use. They need to exercise appropriate judgement and caution.

Some aspects of liability are not easily addressed. For example, sludges add contaminants to the soil, only a few of which are tested for and regulated. Whether the accumulation of contaminants will prove to be a liability for future use of the land is unknown. Among those concerned are farm lenders since their equity is the land. Farmers should consult their lenders about their policies.

In light of declining staffing levels at regulatory agencies, enforcement and oversight of rules pertaining to sludge may not be sufficient to ensure compliance. A certification by the sludge generators and appliers that the sludges they are applying meet standards will not guarantee sludge quality, but should none the less be obtained.

Sample Indemnification Agreement

Indemnification agreements may provide some protection for farmers. One such agreement suggested by a municipality is:

___________________________ (insert City, Sanitation District or other POTW) as Waste Generator and ___________________________ (insert Waste Hauler, Applicator, etc.) as Waste Contractor jointly and severally agree to fully indemnify, defend and hold harmless _________________, Landowner, and __________________, Leaseholder, from and against any and all claims, suits, actions, demands, losses, costs, liabilities and expenses including remediation costs and reasonable attorney's fees arising out of, resulting from, or in any way relating to the actions of Waste Generator or Waste Contractor or their employees, agents or contractors, including without limitation the processing, hauling, depositing and spreading of biosolids on the lands of Landowner or Leaseholder regardless of the active or passive negligence of Landowner or Leaseholder excepting only such injury or harm caused by the sole negligence or willful misconduct of indemnified party. The parties intend that this indemnity shall extend as broadly as legally permitted and shall apply regardless of whether the loss results from the negligence of the indemnified party or any other cause, except for the sole negligence or willful misconduct of the indemnified party. This agreement shall survive the termination of this agreement and shall run with the land extending to subsequent landowners and leaseholders of the affected land.

Waste Generator and Waste Contractor further jointly and severally represent and warrant that the biosolids and the actions pertaining thereto including without limitation the processing, hauling, depositing and spreading are not harmful to land, water, fish, wildlife, plantlife or humans. This representation and warranty shall survive the termination of this agreement and shall run will the land extending to subsequent landowners and leaseholders of the affected lands.

Relationships with the sludge generator or spreader to develop trust in their practices, contracts to establish roles and responsibilities and examination of tests of sludge quality are among the steps that can help address concerns. Spreading practices including the amount of sludge spread should be monitored. Most sludges are spread without formal contracts. It is recommended that farmers enter into contracts with the spreader and/or generator so that legal responsibilities and management practices are clearly set forth. Your contract should hold them responsible for physical damage that may occur to road, structures, animals, etc, and define a procedure for damage assessment and compensation. It should also allow you to reduce or stop spreading.

Neighbor Concerns

There are a number of issues which may concern neighbors of land application sites. Sludges may generate significant objectionable odors resulting in complaints. There is the potential for blowing of sludge or sludge contaminants onto neighboring lands or for sludge to run off onto neighboring properties or into waterways. The potential for chemical contaminants or pathogens to contaminate water supply wells is another concern. Neighbors' pets or children may enter onto sludge sites and thus be exposed and potentially transfer sludge to their homes and families. Sludge delivery traffic can also be a neighbor concern. Be considerate regarding routes, time of day and speed.

Injection or incorporation of sludges is recommended since it will help to minimize offsite transfer via air, runoff or pets and will help reduce odors. However incorporation will reduce the rate at which pathoens will die off.

EPA sets no restrictions on the proximity of sludge application to neighboring property or dwellings. NYSDEC has established a 500 foot buffer from residences and 50 feet from property lines for Class B applications, but none for Class A. There are no data indicating what an appropriate setback would be to address off-site odors and transport of contaminants and pathogens via wind and runoff.

Odors

Most odors associated with sludge and sludge-based products are volatile organic compounds (VOCs) generated by the microbial degradation of organic matter. The more offensive smelling compounds tend to be generated by anaerobic microbes, those living in limited or the absence of oxygen. Sludges and septage that have not been properly stabilized may produce a sufficient amount of these compounds to cause complaints by neighbors when stored on the farm or spread on the land.

Anaerobic conditions can occur in stored sludges and sludge products when the moisture content is too high. Rain on piles stored outside for even short periods of time will allow for pockets of anaerobic conditions to develop. Crusting on the surface of the pile will limit the volatilization of these compounds until the sludge is loaded and spread on the land; odors may then be strong when the pile is opened.

Immediate incorporation of sludges into the soil will help to minimize odors.

Conclusions

Since the banning of disposal of sludges by dumping into the ocean, more wastewater treatment plants are looking to farmlands for the disposition of sewage sludges. Use of sludges on dairy farms has both short and long-term benefits and risks which a farmer should carefully assess. Sludges from different wastewater plants can have very different properties and quality, so specific knowledge of the sludges that may be applied to a particular farm is needed to make appropriate decisions. Management practices and precautions can reduce risks, so if sludges are used, consideration should be given to how they are applied. A farmer choosing to use sludges should be clear as to why and how the materials will be used.

For Further Information

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