# GUIDELINES FOR AGRICULTURAL AND RECLAMATION UTILIZATION OF SEWAGE SLUDGE

**UNDER**

**The Municipal Waste Regulations of the**
**Department of Environmental Protection**

**Commonwealth of Pennsylvania**

**For holders of permits issued under Chapter 275**
**of the Department's Municipal Waste Regulations**

**July 7, 2000**

**DEPARTMENT OF ENVIRONMENTAL PROTECTION**
**BUREAU OF WATER QUALITY PROTECTION**

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**TITLE**: Guidelines for Agricultural Utilization of Sewage Sludge

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**AUTHORITY**:

The Clean Streams Law, 35 P.S. §§691.1 – 691.1001.

Solid Waste Management Act, 35 P.S. §§6018.101 – 6018.1003.

Municipal Waste Planning, Recycling and Waste Reduction Act, 53 P.S. §§4000.101 – 4000.1904.

Administrative Code of 1929, 71 P.S. §§510-5, 510-17 and 510-20, Sections 1905-A, 1917-A and 1920-A.

**POLICY**: This document provides a coordinated and consistent statewide process in determining compliance with requirements contained in permits issued under Chapter 275.

**PURPOSE**: To provide guidance to Department staff and holders of permits issued under Chapter 275 of the Department's Municipal Waste Regulations.

**APPLICABILITY**: This guidance will assist Department staff in determining compliance with requirements contained in permits issued under Chapter 275. This guidance will also assist holders of permits issued under Chapter 275 in complying with the permitting and regulatory requirements.

**DISCLAIMER**: The policy and procedures outlined in this guidance are intended to supplement existing requirements. Nothing in the policies or procedures shall affect regulatory requirements.

The policies and procedures herein are not an adjudication or a regulation. There is no intent on the part of the Department to give the rules in these policies that weight or deference. This document establishes the framework within the Department will exercise its administrative direction in the future. The Department reserves the discretion to deviate from this policy statement if circumstances warrant.

**PAGE LENGTH**: 25 Pages

**LOCATION**: Volume 33, Tab 3

**DEFINITION**:

I. Introduction

These guidelines identify the quality criteria and requirements for pollutant concentrations, pathogen reduction, and vector attraction reduction for sewage sludges that are used for agricultural and reclamation utilization at sites permitted under Chapter 275 of the Department's Municipal Waste Regulations. The guidelines also identify site restrictions and the cumulative pollutant loading rates that must be met at a land application site. Furthermore, the guidelines provide a uniform method for calculating the cumulative pollutant loading rates at a land application site where sewage sludge was applied.

II. Discussion

Use of this guidance will result in more consistent cumulative pollutant loading rates tracking.

III. Process for Calculating Cumulative Pollutant Loading Rate and Sewage Sludge Application Rate.

Cumulative pollutant loading rates, CPLRs, are the maximum concentration of pollutants which may be in a soil before the land application of sewage sludge is prohibited. Generally, CPLRs are tracked using (1) background soil analysis for the fields receiving sewage sludge (in lb/acre), (2) sewage sludge pollutant concentrations (in mg/kg) on a dry weight basis, and (3) application rates (in dry ton/acre). Once calculated, the CPLR must be compared to the concentration listed in Table 3 of these guidelines for that pollutant. If the calculated CPLR exceeds the limit in Table 3 for that pollutant, then the field or site can no longer be used for land application of sewage sludge.

Annual soil samplings of fields or sites that received sewage sludge during the calendar year are required in permits issued under Chapter 275 for the pollutants listed in Table 3 of this guidance. If the soil analysis results exceed the CPLR for any given pollutant, the field or site can no longer be used for the land application of sewage sludge.

Sewage sludge must also be applied at a rate which is based on the nitrogen content of the sewage sludge and the crop nitrogen requirements. Other nitrogen sources must be taken into consideration when determining the application rate. This rate, known as an agronomic rate, is the annual whole sludge application rate (dry weight basis) designed to (1) provide the nitrogen needed by the food crop, feed crop, fiber crop, silvicultural crop, cover crop, horticultural crop or vegetation grown on the land; (2) minimize the amount of nitrogen in sewage sludge that passes below the root zone of the crop or vegetation grown on the land to the ground water.

The CPLR must be tracked for each field receiving sewage sludge. These guidelines provide different "Worksheets" with simple instructions for each worksheet as a reference and a guide to calculate the agronomic rates for both sewage sludge and residential septage as well as to track the CPLRs for fields receiving sewage sludge. An alternative method of calculating agronomic rates may be used if approved by the Department.

# I. Introduction

These guidelines identify the quality criteria for sewage sludges, which are used for agricultural utilization at sites permitted under Chapter 275 of the Department's Municipal Waste Regulations. The guidelines provide pollutant concentration, pathogen reduction, and vector attraction reduction requirements for sewage sludges that will be land applied. Cumulative pollutant loading rates at a land application site are also identified, as well as the method for calculating cumulative pollutant and agronomic loading rates. The guidelines also provide guidance for both soil and sewage sludge sampling and analysis. Some additional requirements are also addressed.

Regulatory references throughout these guidelines are to the Municipal Waste Regulations, unless otherwise specified.

These guidelines are incorporated as part of the regulations under 25 PA Code Section 275.201(b)(3) and must be followed unless otherwise specified in Section 275.201(b)(3) relating to land reclamation purposes.

# II. Sewage Sludge Quality

Sewage sludge must meet several quality criteria if it is to be land applied in Pennsylvania at a site permitted under Chapter 275 of the Municipal Waste Regulations. The generator or preparer must demonstrate that the sewage sludge meets the pollutant concentration requirements in Section A, one of the pathogen reduction alternatives listed in Section B, and one of the vector attraction reduction options listed in Section C.

The monitoring frequency for pollutants is discussed in Section A. The monitoring frequencies for pathogen reduction and vector attraction reduction are discussed in Section D.

## A. Pollutant Concentrations

The concentration of pollutants in the sewage sludge must not exceed the ceiling concentration listed in Table 1.

**Table 1 - Ceiling Concentrations**

| Pollutant | Ceiling Concentration (milligrams per kilogram)* |
|---:|:---:|
| Arsenic | 75 |
| Cadmium | 85 |
| Copper | 4,300 |
| Lead | 840 |
| Mercury | 57 |
| Molybdenum | 75 |
| Nickel | 420 |
| Selenium | 100 |
| Zinc | 7,500 |
| Poly-Chlorinated Biphenols (PCBs) | 8.6 |

*Dry weight basis

A generator or preparer of sewage sludge, which is land applied, shall analyze for the pollutants listed in Table 1 at least every 4 months, unless otherwise specified in the permit. The results of the analysis shall also be submitted to the Department upon request. (Section 275.207(a))

The sampling procedures described in Section V of these guidelines should be followed.

## B. Pathogen Reduction

Pathogen reduction is defined as decreasing the presence of disease-causing organisms through sewage sludge processing and site management practices.

One of the alternatives listed for pathogen reduction must be met prior to the land application of sewage sludge.

A generator or preparer of sewage sludge being land applied at a site permitted under Chapter 275 must, at a minimum, demonstrate that the sludge to be land applied meets one of the Class B alternatives, unless otherwise specified in the permit.

Land appliers of **residential septage** must meet, at a minimum, the requirement described in subsection (10).

(1) *Class A – Alternative 1*

(i) Either the density of fecal coliform in the sewage sludge shall be less than 1,000 most probable number (MPN) per gram of total solids (dry weight basis), or the density of salmonella sp. bacteria in the sewage sludge shall be less than three most probable number per 4 grams of total solids (dry weight basis) at the time the sewage sludge is land applied.

(ii) The temperature of the sewage sludge that is used shall be maintained at a specific value for a specific period of time.

(A) When the percent solids of the sewage sludge is 7% or higher, the temperature of the sewage sludge shall be 122 degrees Fahrenheit, or 50 degrees Celsius, or higher; the time period shall be 20 minutes or longer; and the temperature and time period shall be determined using Equation (1), except when small particles of sewage sludge are heated by either warmed gases or an immiscible liquid.

$$D = \frac{131,700,000}{10^{0.1400T}} \qquad \text{Equation (1)}$$

Where:

D = Time in Days
T = Temperature in degrees Celsius

(B) When the percent solids of the sewage sludge is 7% or higher and small particles of sewage sludge are heated by either warmed gases or an immiscible liquid, the temperature of the sewage sludge shall be 122 degrees Fahrenheit (or 50 degrees Celsius) or higher, the time period shall be 15 seconds or longer; and the temperature and time period shall be determined using Equation (1).

(C) When the percent solids of the sewage sludge is less than 7% and the time period is at least 15 seconds, but less than 30 minutes, the temperature and time period shall be determined using Equation (1).

(D) When the percent solids of the sewage sludge is less than 7%; the temperature of the sewage sludge is 122 degrees Fahrenheit (or 50 degrees Celsius) or higher; and the time period is 30 minutes or longer, the temperature and time period shall be determined using Equation (2).

$$D = \frac{50,070,000}{10^{0.1400T}} \qquad \text{Equation (2)}$$

Where:

D = Time in Days
T = Temperature in degrees Celsius

(2) *Class A – Alternative 2*

(i) Either the density of fecal coliform in the sewage sludge shall be less than 1,000 most probable number per gram of total solids (dry weight basis), or the density of salmonella sp. bacteria in the sewage sludge shall be less than three most probable number per 4 grams of total solids (dry weight basis) at the time the sewage sludge is land applied.

(ii) pH adjustment as follows:

(A) The pH of the sewage sludge that is used shall be raised to above 12 and shall remain above 12 for 72 hours.

(B) The temperature of the sewage sludge shall be above 125 degrees Fahrenheit (or 52 degrees Celsius) for 12 hours or longer during the period that the pH of the sewage sludge is above 12.

(C) At the end of the 72-hour period during which the pH of the sewage sludge is above 12, the sewage sludge shall be air dried to achieve a percent solids in the sewage sludge greater than 50%.

(3) *Class A – Alternative 3*

(i) Either the density of fecal coliform in the sewage sludge shall be less than 1,000 most probable number per gram of total solids (dry weight basis), or the density of salmonella sp. bacteria in the sewage sludge shall be less than three most probable number per 4 grams of total solids (dry weight basis) at the time the sewage sludge is land applied.

(ii) Virus monitoring requirements are as follows:

(A) The sewage sludge shall be analyzed prior to pathogen treatment to determine whether the sewage sludge contains enteric viruses.

(B) When the density of enteric viruses in the sewage sludge prior to pathogen treatment is less than one plaque-forming unit per 4 grams of total solids (dry weight basis), the sewage sludge is Class A with respect to enteric viruses until the next monitoring episode for the sewage sludge.

(C) When the density of enteric viruses in the sewage sludge prior to pathogen treatment is equal to or greater than one plaque-forming unit per 4 grams of total solids (dry weight basis), the sewage sludge is Class A with respect to enteric viruses when the density of enteric viruses in the sewage sludge after pathogen treatment is less than one plaque-forming unit per 4 grams of total solids (dry weight basis) and when the values or ranges of values for the operating parameters for the pathogen treatment process that produces the sewage sludge that meets the enteric virus density requirement are documented.

(D) After the enteric virus reduction in clause (C) is demonstrated for the pathogen treatment process, the sewage sludge continues to be Class A with respect to enteric viruses when the values for the pathogen treatment process operating parameters are consistent with the values or ranges of values documented in clause (C).

(iii) Helminth monitoring requirements are as follows:

(A) The sewage sludge shall be analyzed prior to pathogen treatment to determine whether the sewage sludge contains viable helminth ova.

(B) When the density of viable helminth ova in the sewage sludge prior to pathogen treatment is less than 1 per 4 grams of total solids (dry weight basis), the sewage sludge is Class A with respect to viable helminth ova until the next monitoring episode for the sewage sludge.

(C) When the density of viable helminth ova in the sewage sludge prior to pathogen treatment is equal to or greater than one per 4 grams of total solids (dry weight basis), the sewage sludge is Class A with respect to viable helminth ova when the density of viable helminth ova in the sewage sludge after pathogen treatment is less than 1 per 4 grams of total solids (dry weight basis) and when the values or ranges of values for the operating parameters for the pathogen treatment process that produces the sewage sludge that meets the viable helminth ova density requirement are documented.

(D) After the viable helminth ova reduction in clause (C) is demonstrated for the pathogen treatment process, the sewage sludge continues to be Class A with respect to viable helminth ova when the values for the pathogen treatment process operating parameters are consistent with the values or ranges of values documented in clause (C).

(4) *Class A – Alternative 4*

(i) Either the density of fecal coliform in the sewage sludge shall be less than 1,000 most probable number per gram of total solids (dry weight basis), or the density of salmonella sp. bacteria in the sewage sludge shall be less than three most probable number per 4 grams of total solids (dry weight basis) at the time the sewage sludge is land applied.

(ii) The density of enteric viruses in the sewage sludge shall be less than one plaque forming unit per 4 grams of total solids (dry weight basis) at the time the sewage sludge is land applied.

(iii) The density of viable helminth ova in the sewage sludge shall be less than 1 per 4 grams of total solids (dry weight basis) at the time the sewage sludge is land applied.

(5) *Class A – Alternative 5*

(i) Either the density of fecal coliform in the sewage sludge shall be less than 1,000 most probable number per gram of total solids (dry weight basis), or the density of salmonella sp. bacteria in the sewage sludge shall be less than three most probable number per 4 grams of total solids (dry weight basis) at the time the sewage sludge is land applied.

(ii) Sewage sludge that is land applied is treated in one of the processes to further reduce pathogens (PFRP) discussed on page 9.

(6) *Class A – Alternative 6*

(i) Either the density of fecal coliform in the sewage sludge shall be less than 1,000 most probable number per gram of total solids (dry weight basis), or the density of salmonella sp. bacteria in the sewage sludge shall be less than three most probable number per 4 grams of total solids (dry weight basis) at the time the sewage sludge is land applied.

(ii) Sewage sludge that is land applied is treated in a process that is equivalent to a process to further reduce pathogens (PFRP), as determined by the EPA.

(7) *Class B – Alternative 1*

(i) Seven samples of the sewage sludge shall be collected at the time the sewage sludge is used.

(ii) The geometric mean of the density of fecal coliform in the samples collected in subparagraph (i) shall be less than either 2 million most probable number per gram of total solids (dry weight basis) or 2 million colony forming units per gram of total solids (dry weight basis).

(8) *Class B – Alternative 2*

Sewage sludge that is land applied shall be treated in one of the processes to significantly reduce pathogens (PSRP) discussed below.

(9) *Class B – Alternative 3*

Sewage sludge that is land applied shall be treated in a process that is equivalent to a process to significantly reduce pathogens (PSRP), as determined by the EPA.

(10) *Residential Septage*

Residential septage shall be stabilized to meet processes to significantly reduce pathogens or processes to further reduce pathogens prior to land application, and the site restrictions in (1) through (4) on page 10 shall be met. For alkali stabilization, the pH of residential septage applied to agricultural land, forest or a reclamation site shall be raised to 12 or higher by alkali addition and, without the addition of more alkali, shall remain at 12 or higher for 30 minutes and the site restrictions in (1) through (4) on page 10 shall be met.

**Processes to Significantly Reduce Pathogens** (PSRP)

1. *Aerobic Digestion* – Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 40 days at 68 degrees Fahrenheit (or 20 degrees Celsius) and 60 days at 59 degrees Fahrenheit (or 15 degrees Celsius).

2. *Air Drying* – Sewage sludge is dried on sand beds or on paved or unpaved basins. The sewage sludge dries for a minimum of 3 months. During 2 of the 3 months, the ambient average daily temperature is above 32 degrees Fahrenheit (or 0 degrees Celsius).

3. *Anaerobic Digestion* – Sewage sludge is treated in the absence of air for a specific mean cell residence time at a specific temperature. Values for the mean cell

residence time and temperature shall be between 15 days at 95 to 131 degrees Fahrenheit (or 35 to 55 degrees Celsius) and 60 days at 68 degrees Fahrenheit (or 20 degrees Celsius).

4. *Composting* – Using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the sewage sludge is raised to 104 degrees Fahrenheit (or 40 degrees Celsius) or higher and remains at 104 degrees Fahrenheit (or 40 degrees Celsius) or higher for 5 days. For 4 hours during the 5 days, the temperature of the compost pile exceeds 131 degrees Fahrenheit (or 55 degrees Celsius).

5. *Lime Stabilization* – Sufficient lime is added to the sewage sludge to raise the pH of the sewage sludge to 12 after 2 hours of contact.

**Processes to Further Reduce Pathogens** (PFRP)

1. *Composting* – Using either the within-vessel or the static aerated pile composting method, the temperature of the sewage sludge is maintained at 131 degrees Fahrenheit (or 55 degrees Celsius) or higher for 3 days.

   Using the windrow composting method, the temperature of the sewage sludge is maintained at 131 degrees Fahrenheit (or 55 degrees Celsius) or higher for 15 days or longer. During the period when the compost is maintained at 131 degrees Fahrenheit (or 55 degrees Celsius) or higher, there shall be a minimum of five turnings of the windrow.

2. *Heat Drying* – Sewage sludge is dried by direct or indirect contact with hot gases to reduce the moisture content of the sewage sludge to 10% or lower. Either the temperature of the sewage sludge particles exceeds 176 degrees Fahrenheit (or 80 degrees Celsius) or the wet bulb temperature of the gas in contact with the sewage sludge as the sewage sludge leaves the dryer exceeds 176 degrees Fahrenheit (or 80 degrees Celsius).

3. *Heat Treatment* – Liquid sewage sludge is heated to a temperature of 356 degrees Fahrenheit (or 180 degrees Celsius) or higher for 30 minutes.

4. *Thermophilic Aerobic Digestion* – Liquid sewage sludge is agitated with air or oxygen to maintain aerobic conditions and the mean cell residence time or the sewage sludge is 10 days at 131 to 140 degrees Fahrenheit (or 55 to 60 degrees Celsius).

5. *Beta Ray Irradiation* – Sewage sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (CA. 68 degrees Fahrenheit or 20 degrees Celsius).

6. *Gamma Ray Irradiation* – Sewage sludge is irradiated with gamma rays from certain isotopes, such as Cobalt 60 and Cesium 137, at room temperature (CA. 68 degrees Fahrenheit or 20 degrees Celsius).

7. *Pasteurization* – The temperature of the sewage sludge is maintained at 158 degrees Fahrenheit (or 70 degrees Celsius) of higher for 30 minutes or longer.

**Site Restrictions**

The site restrictions in (1) through (8) must be met in areas for sewage sludges that only meet one of the Class B pathogen reduction alternatives. Site restrictions in (1) through (4) must be met in areas where residential septage has been applied.

Additional requirements identified in the permit or in Chapter 275 of the Department's Municipal Waste Regulations must also be met.

1. Food crops with harvested parts that touch the sewage sludge/soil mixture and are totally above the land surface may not be harvested for 14 months after application of sewage sludge.

2. Food crops with harvested parts below the surface of the land may not be harvested for 20 months after application of sewage sludge when the sewage sludge remains on the land surface for 4 months or longer prior to incorporation into the soil.

3. Food crops with harvested parts below the surface of the land may not be harvested for 38 months after application of sewage sludge when the sewage sludge remains on the land surface for less than 4 months prior to incorporation into the soil.

4. Food crops, feed crops and fiber crops may not be harvested for 30 days after application of sewage sludge.

5. Animals may not be allowed to graze on the land for 30 days after application of sewage sludge.

6. Turf grown on land where sewage sludge is applied may not be harvested for 1 year after application of the sewage sludge when the harvested turf is placed on either land with a high potential for public exposure or a lawn, unless otherwise specified by the Department.

7. Public access to land with a high potential for public exposure shall be restricted for 1 year after application of sewage sludge.

8. Public access to land with a low potential for public exposure shall be restricted for 30 days after application of sewage sludge.

**C. Vector Attraction Reduction**

Vector attraction reduction is defined as decreasing the characteristics of sewage sludge that attracts rodents, flies, mosquitoes, or other organisms capable of transmitting disease.

Generators or preparers of sewage sludge must meet, at a minimum, one of the vector attraction reduction options either prior to land application (options 1 through 8) or at the time of land application (options 9 and 10).

Residential septage must meet either option 9, 10, or 11.

A generator or preparer of sewage sludge or land applier of residential septage may choose an option, unless otherwise specified in the permit.

*Option 1* – The mass of volatile solids in the sewage sludge shall be reduced by a minimum of 38% (see calculation procedures in “Environmental Regulations and Technology – Control of Pathogens and Vector Attraction in Sewage Sludge,” EPA – 625/R-92/013, 1992, United States Environmental Protection Agency, Cincinnati, Ohio 45268).

*Option 2* – When the 38% volatile solids reduction requirement in option 1 cannot be met for an anaerobically digested sewage sludge, vector attraction reduction can be demonstrated by digesting a portion of the previously digested sewage sludge anaerobically in the laboratory in a bench-scale unit for 40 additional days at a temperature between 86 and 98 degrees Fahrenheit (or 30 and 37 degrees Celsius). When, at the end of the 40 days, the volatile solids in the sewage sludge at the beginning of that period is reduced by less than 17%, vector attraction reduction is achieved.

*Option 3* - When the 38% volatile solids reduction requirement in option 1 cannot be met for an aerobically digested sewage sludge, vector attraction reduction can be demonstrated by digesting a portion of the previously digested sewage sludge that has a percent solids of 2% or less aerobically in the laboratory in a bench-scale unit for 30 additional days at a 68 degrees Fahrenheit (or 20 degrees Celsius). When at the end of the 30 days, the volatile solids in the sewage sludge at the beginning of that period is reduced by less than 15%, vector attraction reduction is achieved.

*Option 4* – The SOUR (Specific Oxygen Uptake Rate) for sewage sludge treated in an aerobic process shall be equal to or less than 1.5 milligrams of oxygen per hour per gram of total solids (dry weight basis) at a temperature of 68 degrees Fahrenheit (or 20 degrees Celsius).

*Option 5* – Sewage sludge shall be treated to an aerobic process for 14 days or longer. During that time, the temperature of the sewage sludge shall be higher than 104 degrees Fahrenheit (or 40 degrees Celsius) and the average temperature of the sewage sludge shall be higher than 113 degrees Fahrenheit (or 45 degrees Celsius).

*Option 6* – The pH of the sewage sludge shall be raised to 12 or higher by alkali addition and, without the addition of more alkali, shall remain at 12 or higher for 2 hours and then 11.5 or higher for an additional 22 hours.

*Option 7* – The percent solids of sewage sludge that does not contain unstabilized solids generated in a primary wastewater treatment process shall be equal to or greater than 75% based on the moisture content and total solids prior to mixing with other materials.

*Option 8* – The percent solids of sewage sludge that contains unstabilized solids generated in a primary wastewater treatment process shall be equal to or greater than 90% based on the moisture content and total solids prior to mixing with other materials.

*Option 9* – Sewage sludge shall be injected below the surface of the land. No significant amount of sewage sludge may be present on the land surface within 1 hour after the sewage sludge is injected. When the sewage sludge that is injected below the surface of the land surface is Class A with respect to pathogens, the sewage sludge shall be injected below the land surface within 8 hours after being discharged from the pathogen treatment process.

*Option 10* – Sewage sludge applied to the land surface shall be incorporated into the soil within 6 hours after application to the land. When sewage sludge that is incorporated into the soil is Class A with respect to pathogens, the sewage sludge shall be applied within 8 hours after being discharged from the pathogen treatment process.

*Option 11* – The pH of residential septage shall be raised to 12 or higher by alkali addition and, without the addition of more alkali, shall remain at 12 or higher for 30 minutes.

## D. Monitoring frequencies for pathogen reduction and vector attraction reduction

The monitoring of sewage sludge for pathogen reduction or vector attraction reduction is based on the amount of sewage sludge applied to the land by a generator or preparer. The frequencies are listed in Table 2.

Some of the pathogen reduction and vector attraction reduction options require continual monitoring. These requirements are discussed in Section V of these Guidelines.

For land appliers of **residential septage** who use lime stabilization for both pathogen reduction and vector attraction reduction, monitoring is required for each load of residential septage which is land applied, unless otherwise approved by the Department.

In addition to meeting one of the pathogen and vector attraction reduction requirements, **residential septage** must also be screened to remove non-organic matter **prior to** land application.

Table 2 - Frequency of Monitoring

| **Amount of Sewage Sludge** (Dry Tons) | **Minimum Frequency** |
|---|---|
| Greater than zero but less than 319 | Once per year |
| Equal to or greater than 319 but less than 1,650 | Once per quarter (4 times per year) |
| Equal to or greater than 1,650 but less than 16,500 | Once per 60 days (6 times per year) |
| Equal to or greater than 16,500 | Once per month (12 times per year) |

## III. Cumulative Pollutant Loading Rates (CPLRs)

Cumulative pollutant loading rates, CPLRs, are the maximum concentration of pollutants which may be in a soil before the land application of sewage sludge is prohibited. CPLRs must be tracked at a land application site to ensure that the limits in Table 3 have not been exceeded.

CPLRs are required to be monitored by permit holders who land apply sewage sludge. This **does not include** those permitted to land apply only **residential septage**.

**All** permit holders are required to perform annual soil sampling, for the pollutants listed in Table 3, of fields which received sewage sludge during that calendar year. This information is necessary to complete the annual operation report required in Section 275.222. If the soil analysis results exceed the CPLR for any given pollutant, then the field or site can no longer be used for the land application of sewage sludge.

Table 3* - Cumulative Pollutant Loading Rates

| **Pollutant** | **Cumulative Pollutant Loading Rate** (pounds per acre) |
|---|---|
| Arsenic | 36 |
| Cadmium | 34 |
| Copper | 1320 |
| Lead | 264 |
| Mercury | 15 |
| Nickel | 370 |
| Selenium | 88 |
| Zinc | 2464 |

* Table 2 in Section 271.914(b)(2) and in the Department's Sampling Manual for Pollutant Limits, Pathogen and Vector Attraction Reductions in Sewage Sludge, latest edition

Cumulative pollutant loading rates are tracked using background soil analysis for the fields receiving sewage sludge (in pounds per acre (lb./acre), sewage sludge pollutant concentrations (in milligrams per kilogram (mg/kg) on a dry weight basis), and application rates (in dry tons per acre). If the soil background soil test reports are in mg/kg they must be converted to lb./acre. The following equation can be used to convert mg/kg to lb./acre.

$$\text{mg/kg} \times 2 = \text{lb./acre}$$

CPLRs are calculated using the following equation:

$$\text{CPLR} = \text{sewage sludge pollutant (mg/kg)} \times \text{application rate (dry tons/acre)} \times 0.002 + \text{pollutant previously applied (lbs./acre)}$$

Once calculated, the CPLR must be compared with the value listed in Table 3 for that given pollutant. If the calculated CPLR exceeds the limit in Table 3, then that field or site can no longer be used for the land application of sewage sludge.

The cumulative pollutant loading rate must be tracked for each field receiving sewage sludge. **Tracking Worksheet 1** has been included in these guidelines as a reference and a guide.

The cumulative pollutant loading rates should be completed after each year's application to a field or site. Records must be maintained by the generator to demonstrate that the CPLRs have not been exceeded. The regional DEP office having jurisdiction over the land application site must also be notified once 90% and 100% of the CPLR has been reached.

**TRACKING WORKSHEET NO. 1**
**CUMULATIVE POLLUTANT LOADING RATES (CPLRs)**
**ON LAND APPLICATION SITES**

1. Site Name ______________________________
   Field ________________________________
   ________________________________
   ________________________________

2. Application Rate (Dry ton/acre) ________________

3. Year of Application ________________

| Pollutant | **CPLRs lb./acre** | | **Calculation for Determining Cumulative Loading** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100% | 90%[3] | Sewage sludge pollutants (mg/kg) | x | Application Rates (dry ton/acre) | x | 0.002 (lb./ton) | + | Pollutant[1,2] Previously Applied lb./ac. | = | Amount To Date (lb./acre) |
| Arsenic | 36 | 32.4 | ________ | x | ________ | x | 0.002 | + | ________ | = | ________ |
| Cadmium | 34 | 30.6 | ________ | x | ________ | x | 0.002 | + | ________ | = | ________ |
| Copper | 1320 | 1188 | ________ | x | ________ | x | 0.002 | + | ________ | = | ________ |
| Lead | 264 | 237.6 | ________ | x | ________ | x | 0.002 | + | ________ | = | ________ |
| Mercury | 15 | 13.5 | ________ | x | ________ | x | 0.002 | + | ________ | = | ________ |
| Nickel | 370 | 333 | ________ | x | ________ | x | 0.002 | + | ________ | = | ________ |
| Selenium | 88 | 79.2 | ________ | x | ________ | x | 0.002 | + | ________ | = | ________ |
| Zinc | 2464 | 2217.6 | ________ | x | ________ | x | 0.002 | + | ________ | = | ________ |

1. The background soil metals must be added.

2. If the soil test is reported in mg/kg, then the results must be converted to lbs./acre.

3. When 90% of the CPLR is reached, the DEP must be notified.

## IV. Sewage Sludge Application Rates

Sewage sludge must be applied at a rate which is based on the nitrogen content of the sewage sludge and the crop nitrogen requirements. This rate, known as an **agronomic loading rate**, is the annual whole sludge application rate (dry weight basis) designed to do the following:

1) Provide the amount of nitrogen needed by the food crop, feed crop, fiber crop, silvicultural crop, cover crop, horticultural crop or vegetation grown on the land.

2) Minimize the amount of nitrogen in the sewage sludge that passes below the root zone of the crop or vegetation grown on the land to the groundwater.

The agronomic loading rate is expressed as either dry tons per acre or, for appliers of residential septage, gallons.

Crops utilize inorganic nitrogen for growth ($NH_4^+$ and $NO_3^-$). Organic nitrogen contained in sewage sludge is mineralized, at a rate known as the mineralization rate, into nitrate nitrogen, $NO_3^-$, through microbial activity to form plant available nitrogen, or PAN. This natural process continues several years following land application and must be accounted for when determining agronomic rates for the following 2 years. The mineralization rate is also variable, depending on the sewage sludge treatment process. Therefore, when determining agronomic rates for sewage sludge, the sludge treatment process must be known, as well as the percent organic nitrogen content and the percent ammonium nitrogen, $NH_4^+$, content of the sewage sludge. The $NO_3^-$ content of sludge is usually negligible, therefore is not taken into consideration when calculating agronomic loading rates. For land appliers of **residential septage**, only the crop nitrogen requirement is needed.

Other nitrogen sources must also be taken into consideration when determining agronomic loading rates. This includes previous legume crops, such as soybeans, alfalfa, and red clover; chemical fertilizers; previous sewage sludge applications, not including residential septage; other sewage sludge or residential septage applications; manure applications, both current and historical; and other sources, such as food processing wastes.

The following worksheets have been provided for use to calculate agronomic loading rates for both sewage sludge and residential septage.

Worksheet 1: **SEWAGE SLUDGE ANNUAL AGRONOMIC RATE**
Worksheet 2: **RESIDENTIAL SEPTAGE ANNUAL APPLICATION RATE**
Worksheet 3: **PLANT AVAILABLE NITROGEN MINERALIZED FROM RESIDUAL ORGANIC N APPLIED AS SEWAGE SLUDGE IN CURRENT YEAR**
Worksheet 4: **MANURE VOLATILIZATION FACTOR AND MINERALIZATION RATE TABLES**

A copy of the latest Penn State publication, The Agronomy Guide, is also necessary to complete the worksheets. The document can be obtained at the local Penn State County Cooperative Extension Service.

Simple instructions and references are provided with each worksheet. The regional DEP office can be contacted for more guidance.

Symbols key:

$NH_4$ = Ammonium nitrogen content of the sewage sludge obtained from analytical testing of the sewage sludge (in % on a dry weight basis)

$K_{vol}$ = Volatilization factor estimating ammonium nitrogen remaining in the sewage sludge following application losses to the atmosphere (Volatilization Rate Table)

Org-N = Organic nitrogen content of the sewage sludge obtained from analytical testing of the sewage sludge (in % on a dry weight basis)

$K_{min}$ = Mineralization rate of the organic nitrogen based on sludge treatment process (Mineralization Rate Table)

An alternative method of calculating agronomic loading rates may be used if approved by the Department.

# WORKSHEET NO. 1
# SEWAGE SLUDGE ANNUAL AGRONOMIC RATE

Field ____________ Crop ____________________
Growing Season Year ____________________ Yield Goal ____________________
Site ________________________________

1. Total available Nitrogen from sewage sludge

   a. $NH_4$-N ______ %$NH_4$[1] x 2000 lb/ton /100 = ______ lb/ton $NH_4$-N
   ______________ $NH_4$ lb/ton x ________ $K_{vol}$ (*Vol. Rate Table*) = _______ lb/ton $NH_4$

   b. Org-N ______ %Org-N[1] x 2000 lb/ton /100 = ______ lb/ton Org-N
   ______________ Org-N lb/ton x ________ $K_{min}$ (*Min. Rate Table*) = _______ lb/ton Org-N

   Total Plant Available Nitrogen (PAN)
   From sewage sludge (a + b) ________________ lb/ton

2. $P_2O_5$ and $K_2O$ fertilizer equivalent in sewage sludge
   (*Nutrient management information for the farmer*)

   a. ______________ % P[1] in sludge x 2.29 = ______ % $P_2O_5$ in sludge
   ______________ % $P_2O_5$ x 2000 lb/ton /100 = ________________ lb/ton $P_2O_5$

   b. ______________ % K[1] in sludge x 1.2 = ______ %$K_2O$ in sludge
   ______________ % $K_2O$ x 2000 lb/ton /100 = ________________ lb/ton $K_2O$

3. Total crop nitrogen requirement (*From soil analysis , historical data, or Penn State Agronomy Guide*) ____________________ lb/acre

4. Nitrogen provided from other N sources either added to or mineralized in the soil

   a. N from previous legume crop (*Penn State Agronomy Guide*) ____________________ lb/acre
   **OR** *(Forage)* **/ AND** *(Soybean)*

   b. Estimate of available N previous sludge application
   (*Worksheet #3*) ____________________ lb/acre

   c. Estimate of available N from **historical** manure application
   (*Worksheet #4*) ____________________ lb/acre

   d. Greater of either **a** or **(b+c)** *(Forage)*
   Sum of **(a+b+c)** *(Soybean)* ____________________ lb/acre

   e. Estimate of available N from **current** manure application
   (*Worksheet #4*) ____________________ lb/acre

   f. N from chemical fertilizers ____________________ lb/acre

   g. Other sources (ex. food processing waste) ____________________ lb/acre

   Total nitrogen available
   **(d+e+f+g)** ____________________ lb/acre

5. Adjusted nitrogen requirement
   **(Subtract 4 from 3)** ____________________ lb/acre

6. Calculate the agronomic rate for sewage sludge
   **(Divide 5 by 1)** ____________________ dry tons/acre

7. Calculate amount of sewage sludge to be applied ______________________________
   (wet tons/acre or gallons/acre)

_______ Wet tons/acre = ________ Dry tons/acre ÷ _________ % Solids (In Decimal)
_______ Gallons/acre = ________ Wet tons/acre x 2000 lb/ton ÷ 8.5 lb/gal

8. Use ........ $P_2O_5$ And ........ $K_2O$ to calculate net requirement of nutrients .

[1] Value from sewage sludge analysis

**WORKSHEET NO. 2**
**RESIDENTIAL SEPTAGE ANNUAL APPLICATION RATE**

Field ___________ Crop _________________
Growing Season Year ___________ Yield Goal _________________
Site ______________________________

1. Total crop nitrogen requirement ______________________
   (*From soil analysis, historical data, or Penn State Agronomy Guide)* lb/acre

2. Nitrogen provided from other N sources added or mineralized in the soil

   a. N from previous legume crop _____________
      *(Penn State Agronomy Guide)* lb/acre
      **OR** (forage) / **AND** (Soybean)

   b. Estimate of available N previous sludge application _____________
      *(Worksheet #3)* lb/acre
      - does not include previous residential septage applications

   c. Estimate of available N from historical manure application _____________
      (*Worksheet #4*) lb/acre

   d. Greater of either **a** or **(b+c)** (Forage) _________________
      Sum of **(a+b+c)** (Soybean) lb/acre

   e. Estimate of available N from **current** manure application _________________
      *(Worksheet #4)* lb/acre

   f. N from chemical fertilizers or starter fertilizer _________________
      lb/acre

   g. Other sources *(ex. food processing waste)* _________________
      lb/acre

   Total Nitrogen from other sources _________________
   **(d+e+f+g)** lb/acre

3. Adjusted nitrogen requirement ( N for AAR equation ______________________
   **(Subtract 2 from 1)** lb/acre

4. Calculate **AAR** using the equation below. ______________________
   gal/acre

$$\mathbf{AAR} = \frac{N}{0.0026}$$

Where: AAR = Annual application rate in gallons/acre per 365-day period.
N = Amount of nitrogen in lb/acre per 365-day period needed by crop or vegetation grown on land. This is the value on line 3 above.

**WORKSHEET NO. 3**
**PLANT AVAILABLE NITROGEN MINERALIZED FROM RESIDUAL ORGANIC N APPLIED AS SEWAGE SLUDGE IN CURRENT YEAR**

Field ______________________ Crop ____________________
Growing Season Year _______________________ Yield Goal ____________________
Site ____________________________________

Step 1. Column 1.A. - The year of the sludge application and in Column 2.A. and 3.A. put years.
Step 2 Block 1.B. - Obtain by the following equations:

% Organic N in sewage sludge (from analysis x (2000 lbs/ton ÷ 100) = lbs/ton Org-N in sewage sludge

______ %Org-N[1] x (2000 lbs/ton ÷ 100) = ______ lbs/ton Org-N

lbs./ton Org-N x actual application rate (dry tons/acre = Org-N applied (lbs/acre)

______ lbs/ton Org-N x ______ application rate dry tons/acre = ______ Org-N (lbs/acre)

[1] Value form sewage sludge analysis

**Step 3.** Column C - The mineralization rate for the specific sludge treatment for the respective year (i.e. 1, 2, or 3). See $K_{min}$ Table.
**Step 4.** Column D = Column B x Column C
**Step 5.** Column E = Column B - Column D
**Step 6.** Block 2.B. = Block 1.E. number and follow Steps 4 and 5.
**Step 7.** Block 3.B. = Block 2.E. number and follow Steps 4 and 5.

| | A<br><br>Year of Growing Season ________ *(Year of application)* | B<br><br>Organic N (lbs/acre) | C<br><br>Mineralization Rate ($K_{min}$) *(Min. Rate Table)* | D<br><br>Mineralized Organic N in lbs/acre (PAN) | E<br><br>Organic N Remaining (lbs/acre) |
|---|---|---|---|---|---|
| 1. | Sludge Applied Growing Season 0-1 Year ________ | | | | |
| 2. | Growing Season 1-2 Year ________ | (from 1.E.) | | | |
| 3. | Growing Season 2-3 Year ________ | (from 2.E.) | | | |

**WORKSHEET NO. 4**
**MANURE**

Field ______________________ Crop ____________________
Growing Season Year ______________________ Yield Goal ____________________
Site ____________________________________

Manure Residual Nitrogen (Historical)

| Manure Rate ton/acre | x | Manure N lb/ton *(Penn State Agronomy Guide)* | x | N availability Factor *(Penn State Agronomy Guide)* | = | Available Residual Nitrogen lb/acre |
|---|---|---|---|---|---|---|
| | | | | | | |

Manure Nitrogen (Current Year)[1]

| Expected Manure Application Rate ton/acre | x | Manure N lb/ton *(Penn State Agronomy Guide)* | x | N availability Factor *(Penn State Agronomy Guide)* | = | Available Nitrogen lb/acre |
|---|---|---|---|---|---|---|
| | | | | | | |

[1] Includes previous fall application
For nitrogen availability factors, see Agronomy Guide Table 2-13
For total manure nutrient content, see Agronomy Guide Table 2-12
or manure analysis provided by farmer.

Historical Available Residual Nitrogen from Manure = ______________ lb/acre.
Current Available Nitrogen from Manure = ______________ lb/acre.
Total Available Nitrogen from Manure = ______________ lb/acre.

Volatilization Factors ($K_v$)

| **If Sewage Sludge is:** | **Factor $K_v$ is:** |
|---|---|
| Liquid and surface applied | .50 |
| Liquid and injected into the soil | 1.0 |
| Dewatered and applied in any manner | .50 |

Mineralization Rate[1] ($K_{min}$)

| Time after Sewage Sludge Application (Year) | %[2] of Org-N Mineralized from Unstabilized Primary and Waste Activated Sewage Sludges | %[2] of Org-N Mineralized from Aerobically or Lime Stabilized Digested Sewage Sludge | %[2] of Org-N Mineralized from Anaerobically Digested Sewage Sludge | %[2] of Org-N Mineralized from Composed Sewage Sludge |
|---|---|---|---|---|
| 0-1 | .40 | .30 | .20 | .10 |
| 1-2 | .20 | .15 | .10 | .05 |
| 2-3 | .10 | .08 | .05 | .03 |

1 Percentage of Org-N present mineralized during the time interval shown.
2 Expressed as a decimal

# V. Sewage Sludge Sampling and Analysis

## A. Sewage Sludge Sampling

The following guidelines should be used to minimize errors when collecting sewage sludge samples. The frequency of sampling was discussed previously in sections IIA, for pollutants, and IID, for pathogen and vector attraction reduction.

Sampling procedure and preservation should be followed as discussed in the Department's Sampling Manual for Pollutant Limits, Pathogen and Vector Attraction Reductions in Sewage Sludge, latest edition ("Sampling Manual").

Sampling for pollutants should consist of sampling a volume of sewage sludge that best represents the sewage sludge being generated by the facility at that time. A **composite** sample is needed to perform a pollutant analysis. A minimum of 7 grab samples is suggested to comprise a composite sample that will be analyzed for pollutants.

Each pathogen reduction alternative and vector attraction reduction option is discussed in the Sampling Manual. The frequency of monitoring and the record keeping requirements for each alternative and option are discussed. The DEP regional office should be contacted if there are any questions concerning the sampling requirements. Maximum holding times, sample preservation, sample containers, and sample preparation are also discussed in Section IX, Analytical Methods, of the Sampling Manual.

Sampling procedures for pathogen reduction and vector attraction reduction are also discussed in the Environmental Protection Agency's document entitled Environmental Regulations and Technology: Control of Pathogens and Vector Attraction in Sewage Sludge (EPA/625/R-92/013). These procedures, as well as those outlined in the Sampling Manual, should be followed when sampling for pollutants, pathogen reduction and vector attraction reduction.

## B. Sewage Sludge Analysis

The method of analysis for sewage sludge shall be performed in accordance with the most current edition of the following references unless equivalent results can be obtained by other methods. The permittee shall demonstrate to the Department that equivalent results are obtainable based on the nature of the test methodology, the nature of the parameter, and the level of statistical accuracy.

1. Test Methods for Evaluating Solid Waste, EPA, SW-846, latest edition.
2. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020.
3. Standard Methods for the Examination of Water and Wastewater, latest edition.

The Department also has a list of analytical methods in section IX, Analytical Methods, of the Sampling Manual.

# VI. Soil Sampling and Analysis

## A. Soil Sampling

Soil sampling is necessary to monitor pollutants in, and the pH of, the soil. These parameters are required to be monitored in Chapter 275 of the Department's Municipal Waste Regulations. The pollutant information is also necessary to complete the Land Application of Sewage Sludge Annual Operation Report.

The following are the recommended guidelines to be used to minimize error in soil monitoring. Other soil sampling methods may be used if approved by the Department.

1. Take soil cores from at least 15 spots randomly selected over the field to obtain a representative sample. One sample should not represent more than about 15 to 20 acres; however depending on the field size and uniformity, smaller areas may be required.

2. Sample between rows. Avoid old fence rows, dead furrows, and other spots not representative of the field.

3. Remove surface debris before taking sample.

4. Sample cultivated fields to plow depth, no-till fields to a 6 inch depth, and pastures to a 3 to 4 inch depth for lime and fertilizer recommendations and required metals.

5. Collect the sample with a **clean** core sampler or other sampling instrument and place in a clean container.

6. Mix the core samples, air dry, and remove roots and stones.

7. Place sample in a container recommended by the laboratory. Include all the necessary information requested.

8. Correlate the soil sample analysis results with the site map and plot the locations.

## B. Soils Analysis

The method of analysis for soil shall be performed in accordance with the most current edition of any of the following references unless equivalent results can be obtained by other methods. The permittee shall demonstrate that equivalent results are obtainable based on the nature of the test methodology, the nature of the parameter, and the level of statistical accuracy.

1. Test Methods for Evaluating Solid Waste, EPA, SW-846, latest edition.

2. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020.

3. Standard Methods for the Examination of Water and Wastewater, latest edition.

The Department also has a list of analytical methods in Section IX, Analytical Methods, of the Sampling Manual.

## VII. Additional Requirements

### A. Training

Under Section 271.915(j), the Department requires persons land applying sewage sludge to complete training courses sponsored by the Department in a timely and satisfactory manner. Satisfactory completion means attendance at all sessions of the training and attainment of a minimum grade of 70% on tests given as part of the training courses. In the case of a person who prepares sewage sludge that will be land applied, and a person who land applies residential septage, at least one person with responsibility for the land application of sewage sludge shall satisfactorily complete the training in a timely fashion. The Department may suspend or revoke the individual permit under Chapter 275 if the person does not satisfactorily complete the training.

### B. Land Application Vehicle Labeling

Under Section 271.915(k), when land applying sewage sludge, the Department requires persons to display the permit number of the individual permit issued under Chapter 275 on the sides and rear of each vehicle which is used in the land application of sewage sludge. The numbers must be at least 3 inches (or 7.6 centimeters) high in a color contrasting to the background.

### C. Farm Conservation Plan or Erosion and Sedimentation Control Plan

In order to meet the requirements of Section 275.205(a), a site, which is being utilized for the land application of sewage sludge, must have an **implemented** farm conservation plan or erosion and sedimentation control plan which meets the requirements of Chapter 102, Erosion Control, of the Department's regulations.

## References:


- 25 PA Code, Chapters 271 – 285, Municipal Waste, latest publication.
- Penn State, The Agronomy Guide, latest edition.
- DEP, Sampling Manual for Pollutant Limits, Pathogen and Vector Attraction Reductions in Sewage Sludge, latest edition.
- EPA/625/R-92/013, Environmental Regulations and Technology: Control of Pathogens and Vector Attraction in Sewage Sludge, latest edition.
- EPA, SW-846, Test Methods for Evaluating Solid Waste, latest edition
- EPA-600/4-79-020, Methods for Chemical Analysis of Water and Wastes.
- Standard Methods for the Examination of Water and Wastewater, latest edition.
- 25 PA Code, Chapter 102, Erosion Control, latest publication.