

**40 CFR Part 503 and
Application of Municipal Sewage Sludges to Alfalfa**

David M. Crohn, Ph.D.¹

ABSTRACT

In 1977, and again in 1987, Congress directed the United States Environmental Protection Agency (EPA) to develop guidelines and regulations for the safe use and disposal of municipal sewage sludges (Clean Water Act, Section 405(d)). After extensive consultations with industry, interest groups, and academia, the EPA promulgated 40 CFR Part 503 which was published in the Federal Register on February 19, 1993. Note, however, that state or local regulators are free to impose and enforce rules stricter (but not less strict) than Part 503. 40 CFR Part 503 represents a minimum standard which, according to current scientific information, will allow safe use of the nutrients and beneficial organic properties of biosolids. Because of its relatively long growing season and its ability to assimilate large amounts of nitrogen, alfalfa is an attractive crop for land applicators.

Key Words: 40 CFR Part 503, alfalfa, sewage sludge, regulations, biosolids, land application

INTRODUCTION

Each year in the United States, some 13,000 publicly owned treatment works (POTW's) generate approximately 5,400,000 megagrams DRY WEIGHT of sewage sludge (Outwater 1994). Disposal costs have increased in many areas as alternatives such as ocean dumping, incineration, and landfilling have been curtailed or eliminated. In some regions, it is not unusual for sludge management costs to exceed \$500 per megagram DRY WEIGHT (Jewell 1994). The United States Environmental Protection Agency (USEPA) regulates sewage sludge disposal ("Standards" 1993; "Plain English" 1994) while actively promoting their use as soil amendments in agriculture ("Biosolids Recycling" 1994). To encourage public acceptance, the USEPA and others have begun to refer to sewage sludges as "biosolids" when they are used beneficially ("Biosolids Recycling" 1994; Sorber 1994).

Under current rules, pathogen concentrations may restrict biosolids to certain crops, while heavy metals can constrain long-term cumulative applications to particular sites ("Standards" 1993). It is biosolids N, however, that determines season-to-season operational loading rates (Crohn 1995; Kaufman and Haith 1986; "Process Design" 1983). Federal regulations limit applications to "agronomic rates" designed to "provide the amount of N needed by a crop or vegetation to attain a desired yield while minimizing the amount of N that will pass beneath the root zone of the crop or vegetation to the groundwater." ("Plain English" 1994). Methods for determining agronomic rates are not specified, although applicators are directed to local agents of their state university Cooperative Extension

¹Department of Soil and Environmental Sciences, University of California, Riverside, CA 92521

sion program or the Natural Resource Conservation Service for advice. Biosolids-based products that meet the highest "Exceptional Quality" (EQ) standards for metals, pathogens, and "vector attraction reduction" are exempt from the "agronomic rate" criteria under the assumption that such products will be of sufficient value that users will not over-apply them ("Standards" 1993). Nevertheless, EQ biosolids users are urged to respect agronomic rates appropriate for fertilizers ("Plain English" 1994). EQ products most often appear as composts, pelletized organic fertilizers, or lime-stabilized soil amendments (Outwater 1994).

SCOPE

Table 1 lists the regulations and exclusions in the new rule. The EPA reports that it is confident that Part 503 will protect the public from all "reasonably anticipated" danger because, according to the agency:

- There are virtually no effects on public health from land application in compliance with Part 503.
- Research found no evidence of any significant adverse effects of land application from past activities.
- The EPA will continue to study land application and is prepared to move quickly to revise Part 503 should problems arise.

Table 1 Sludge types and practices regulated by 40 CFR Part 503.

Regulated	Excluded
land application systems	processing prior to use or disposal
surface disposal systems	industrial or hazardous sludge
monofills (sludge-only landfills)	sludges with > 50 ppm PCB's
sludge incineration systems	co-disposal or co-firing with municipal solid waste

Part 503 regulates land application and surface disposal systems separately. According to the rule, land application is "the spraying or spreading of sewage sludge onto the land surface; the injection of sewage sludge below the land surface; or the incorporation of sewage sludge into the soil so that the sewage sludge can either condition the soil or fertilize crops or vegetation grown in the soil." Biosolids must be applied at appropriate "agronomic rates." An agronomic rate refers to the amount of applied nitrogen that meets crop needs while minimizing nitrogen leaching. The preamble to the rule suggests that applicators consult local Cooperative Extension or Soil Conservation Service officials to determine appro-

priate loading rates². In addition, biosolids must be applied so that (1) endangered or threatened species are not disturbed, (2) the materials do not enter wetlands, and (3) it is at least 10 meters from surface waters.

Part 503 regulates land application of municipal biosolids and biosolids products such as mixed green waste/biosolids composts. Land application may be practiced to benefit agriculture, forests, reclaimed lands, or home and commercial landscapes³. Restrictions depend on the biosolids product's (1) marketing, (2) trace element concentration, and (3) pathogen treatment level. Depending on the trace element or pathogen treatment level of a biosolids product, its use for land application may be banned, regulated, or completely unrestricted (see *Table 2*). This paper summarizes those aspects of 40 CFR Part 503 that may be of interest to farmers, farm advisors, turf and nursery managers, or others considering the use of biosolids or biosolids products as a soil amendment. Selected components of the rule are shown in *Figure 1*.

Table 2 40 CFR Part 503 regulatory categories.

Issue	Regulatory Categories
Marketing	<ul style="list-style-type: none"> • Biosolids“sold or given away in a bag or other container for application to land” • “Bulk” biosolids
Trace element concentrations	<ul style="list-style-type: none"> • no restrictions • some restrictions • not fit for land application
Pathogen treatment levels	<ul style="list-style-type: none"> • Class A - no restrictions • Class B - restricts some practices • not fit for land application

MARKETING

Biosolids products are regulated differently depending on how they are marketed. The EPA has established two categories related to biosolids marketing. The first has the lengthy name, Biosolids “sold or given away in a bag or other container for application to land.” For brevity, I will call this “bagged” biosolids here. Bagged biosolids include all containerized biosolids, either open or enclosed, as well as truck or wagon loads of less than one metric ton (2205 lbs.) Bagged products are usually distributed widely in relatively small amounts for use as potting media or lawn and garden amendments. The other category, “Bulk” biosolids, includes all other delivery alternatives. “Bulk” biosolids are usually applied in large quantities to an established site by professional applicators and is therefore easier to monitor.

²If a site is loaded above the appropriate agronomic rate it is considered to be a surface disposal, rather than land application system. Part 503 regulates surface disposal systems separately.

³Land application of septage, although not discussed here, is also regulated by 40 CFR Part 503.

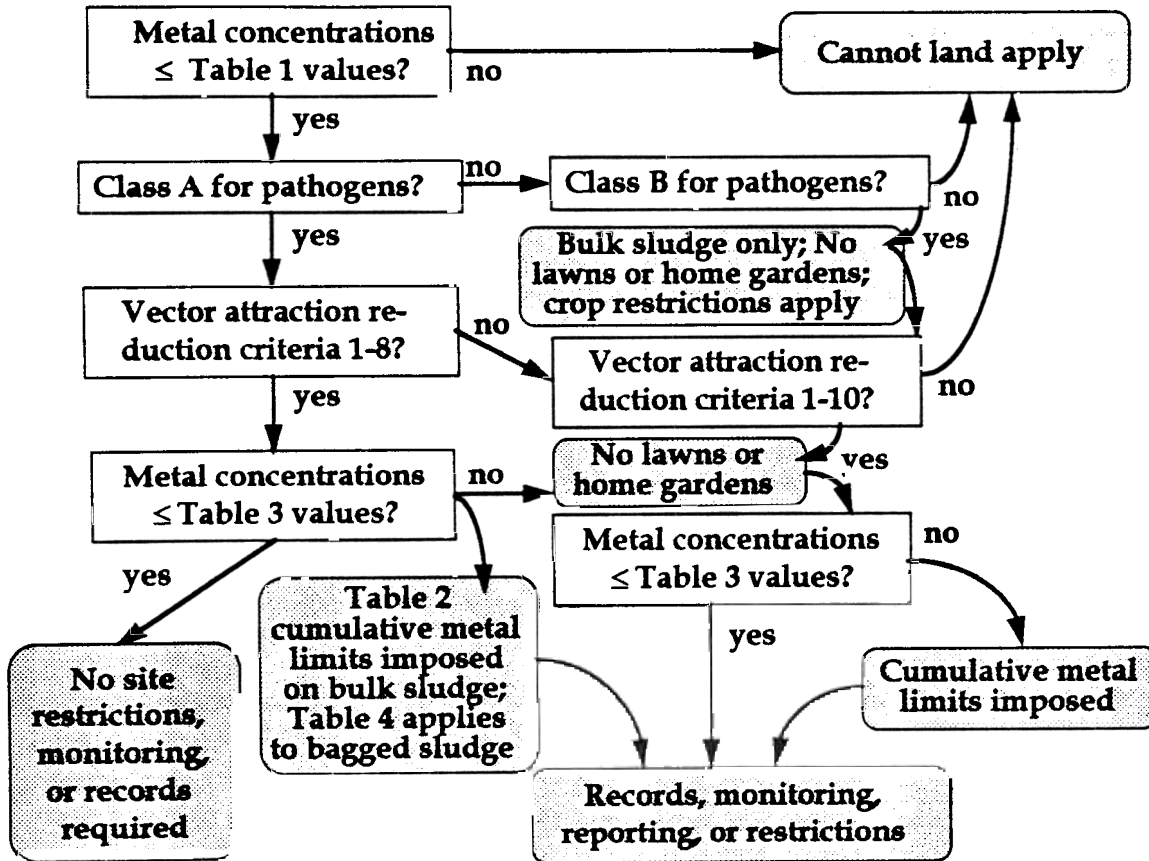


Figure 1 Selected land application components of 40 CFR Part 503.

TRACE ELEMENTS

The presence of trace elements, sometimes referred to as heavy metals, in biosolids stems from the contaminants discharged into the sewage system as well as the effectiveness of sewage treatment. All biosolids contain trace elements, but concentrations tend to be lower than they once were since government regulations have reduced the amount of metals discharged by industry into the sewage system.

EPA regulations limit the concentrations of 10 heavy metals in land-applied biosolids. Numerical limits are expressed for each of the elements in four tables which are gathered together in *Table 3*. If the concentrations of all trace elements in a given product fall below the metal concentrations listed in Part 503 Table 3, there are *no* trace element restrictions and *no* site-specific records are required. On the other hand, if *any* of the regulated metals exceeds the concentrations listed in Part 503 Table 1, land application is forbidden.

Table 3 Part 503 tables of trace element limits. All terms represent the biosolids dry mass (about 2 to 25 percent of the wet mass).

<i>Part 503 Table #:</i>	<i>Table 1</i>	<i>Table 2</i>	<i>Table 3</i>	<i>Table 4</i>
Trace Element	Maximum Concentration for any Land Application [ppm]	Site Maximum Cumulative Load [lb/ac]	Ceiling Concentration for a "Clean" Biosolids [ppm]	Containerized Biosolids Maximum Annual Load [lb/ac-yr]
Arsenic	75	36.6	41	1.78
Cadmium	85	34.8	39	1.70
Chromium	3000	2678	1200	134
Copper	4300	1339	1500	66.9
Lead	840	268	300	13.4
Mercury	57	15.2	17	0.76
Molybdenum	75	n.a. ⁴	n.a. ⁴	n.a. ⁴
Nickel	420	375	420	18.7
Selenium	100	89.3	36	4.46
Zinc	7500	2500	2800	125

Biosolids with all metal concentrations below Part 503 Table 1 limits, but with one or more concentrations above the Part 503 Table 3 limits, may be land-applied. In this case certain record keeping requirements are imposed on the applicator. Bulk biosolids may be applied as long as the cumulative mass of any metal does not exceed its limit listed in Part 503 Table 2⁵. To assure that sites are not overloaded, the EPA requires applicators to maintain records for each site with a description of the site's location, its application area, the time and date of each application, and the dry weight of the sludge applied during each operation.

These records must be archived indefinitely. If they are lost, only biosolids meeting Part 503 Table 3 can be applied to that site. Although the information is collected and maintained by biosolids applicators, it is a good idea for landowners to keep duplicate records to guarantee their ability to receive biosolids from any applicator, now and in the future.

⁴ The EPA does not currently enforce cumulative loading numbers for molybdenum. Biosolids either meet the Table 1 standard and can be applied without restrictions, or they do not meet Table 1 and application is prohibited.

⁵ Note that unlike many previous regulatory systems, the concentration and loading rate criteria are independent of soil cation exchange capacity (CEC).

Because bagged biosolids are often distributed widely in small amounts, the EPA does not require cumulative record keeping for these products. Instead it limits the total amount of each metal that can be applied in a single year to the values listed in Part 503 Table 4. Annual loading limits for a particular bagged product will be constrained by the metal with the highest concentration relative to its corresponding Part 503 Table 4 annual bagged biosolids limit.

PATHOGENS

Pathogens are discharged into sewers by infected individuals. Most are destroyed during wastewater treatment, but sufficient numbers remain in biosolids to infect people who work with or eat produce from biosolids amended fields. Once in the soil, they will gradually die over time (see Table 4). Because many pathogens are difficult to isolate and can be dangerous in concentrations that are too small to easily measure, regulators restrict the concentrations of more common indicator organisms that suggest the presence of pathogens in biosolids. The 40 CFR Part 503 regulations control the concentrations of fecal coliforms or *Salmonella* sp., enteric viruses, and helminth ova.

Table 4 Pathogen survival times on plants and soils (“Health” 1985).

Pathogen	Soil		Plants	
	Maximum Observed	Common Maximum	Maximum Observed	Common Maximum
Bacteria	1 year	2 months	6 months	1 month
Viruses	6 months	3 months	2 months	1 month
Helminths	7 years	2 years	5 months	1 month

Fecal coliforms are a class of bacteria excreted in human fecal matter that, while not necessarily pathogenic themselves, suggest the presence of other, harder to distinguish bacteria that can cause disease. Helminths include roundworms and tapeworms. Two quality classes, Class A and Class B, are included in the regulations, where Class A is the more highly treated. Class A quality can be reached through temperature and/or pH elevation, or through one of the so-called “Processes to Further Reduce Pathogens” (PFRPs). The PFRPs include, among other alternatives, a description of the composting management practices needed to reach Class A quality. Class B status can be claimed if measured biosolids fecal coliform concentrations are sufficiently low or if one of the “Processes to Significantly Reduce Pathogens” (PSRPs) is employed. PSRPs and PFRPs are listed in the Appendix.

The EPA imposes no restrictions for controlling pathogens in Class A biosolids. Bulk biosolids applied to a lawn or garden must be Class A as must all bagged biosolids. When bulk biosolids meeting the Class B quality standard are land-applied, restrictions are imposed on the farmer or land owner according to the following calendar:

For the first 30 days after application: No food, feed, or fiber crops can be harvested. No grazing of animals is permitted. Public access to the area must be restricted.

For the first year following application: Access to application sites with a high potential for public exposure, such as an urban park or urban construction site, must be restricted. Similarly, turf cannot be harvested for use on lawns or other areas with a high potential for public exposure.

For the first 14 months following application: No food crops with harvested parts that touch the biosolids or soil can be harvested.

For the first 20 months following application: No food crops with harvested parts below the soil surface can be harvested.

For the first 38 months following application: Food crops with harvested parts below the surface of the land cannot be harvested unless the biosolids remain on the soil surface for at least four months before it is incorporated into the soil.

VECTOR ATTRACTION REDUCTION

Vectors are organisms, such as flies, that can carry pathogens from one location, such as a biosolids-amended field, to another where infection can take place, such as a Sunday picnic. The most cost-effective way to diminish this threat is to reduce the attractiveness of the applied biosolids as a food source or breeding place. The EPA requires "vector attraction reduction" for all biosolids, whether they are Class A or Class B. The EPA describes ten approaches for satisfying its vector attraction reduction requirement. Alternatives 1-8 involve various levels of digestion, dewatering, pH adjustment, or temperature elevation. These processes are normally carried out at the biosolids treatment or preparation site. Alternatives 9 and 10 occur at the application site. Alternative 9 involves injecting biosolids into the soil so that no "significant" amount remains on the soil surface one hour later. Alternative 10 requires incorporation into the soil within six hours following landspreading. If either of these last two approaches is adopted for Class A biosolids, injection or spreading operations must take place within eight hours after the material completes its pathogen treatment process. This helps to prevent pathogen regrowth. In addition, alternatives 9 and 10 require the applicator to certify that vector attraction reduction is done properly.

"EXCEPTIONAL QUALITY" BIOSOLIDS

If biosolids or biosolids products fall under pathogen Class A, meet the trace element limits in Part 503 Table 3, and meet one of vector attraction reduction alternatives 1-8, there are *no restrictions or record keeping requirements whatsoever* associated with its use. Because the

EPA anticipates sufficient demand for high quality sludge to prevent waste through over-application, even the requirement for application at agronomic rates is waived. Manufacturers of these high quality biosolids are likely to expect a higher price from the farmer or other consumer for these products. *Figure 1* illustrates many of the significant components of 40 CFR Part 503. However, in most cases applicators will continue to report to the regional water boards or county authorities regardless of biosolids quality.

ENFORCEMENT

The Regional Administrator of the EPA is currently responsible for monitoring compliance with 40 CFR Part 503 in California. It is possible that the California Integrated Waste Management Board or, more likely, the Regional Water Quality Control Boards, will assume responsibility for enforcing the regulations at some time in the future. Currently, the EPA plans to incorporate enforcement activities into the National Pollution Discharge Elimination System (NPDES) licensing program for sewage treatment plants, but sewage treatment facilities, biosolids processors, and applicators cannot wait until they are approached by a permitting authority to initiate compliance with Part 503.

The records required by Part 503 must be kept after July 20, 1993. All other requirements must be met by February 19, 1994, unless a biosolids processing facility requires substantial construction to comply with the regulation, in which case requirements must be met by February 19, 1995. In the case of bulk biosolids, the applicator is responsible for supplying the owner or lease holder of the land receiving the material with the information needed to comply with site management restrictions. For "biosolids sold or given away in a bag or other container for application to land" the person preparing the bagged product must include appropriate information on the package label.

ALFALFA

Alfalfa is an attractive crop for municipalities to consider for land application. Because it is not a human food crop, applicators are permitted to spread Class B biosolids on alfalfa, avoiding the expense of further pathogen treatment. Alfalfa will fix atmospheric nitrogen if necessary, but it prefers to use available soil nitrogen. It is quite efficient at taking up soil nitrogen and can assimilate large amounts compared to other common crops. Because nitrogen limits the amount that can be applied to most systems, higher crop nitrogen uptake rates permit higher biosolids loading rates. Higher loading rates are more economical for applicators who are paid by municipalities to haul and dispose biosolids on a wet ton basis. Because alfalfa produces for three years or more, it can receive biosolids after other crops are harvested or are in sensitive phases of development. The key obstacle for applicators is the need to incorporate biosolids that do not meet the vector attraction reduction requirement. Many Class B biosolids do meet this requirement, however, and can be left on the surface. Farmers who suspect that they have high levels of molybdenum in their soils should be aware that repeated biosolids applications can contribute significant amounts of this metal.

REFERENCES

- "Biosolids recycling: beneficial technology for a better environment." (1994). *EPA 832/R-94-009*, U. S. Environmental Protection Agency, Office of Water, Washington, D. C.
- Crohn, D. M. (1995). "Design of long-term sludge-loading rates for forests under uncertainty." *J. Environ. Engrg.*, ASCE, 121(9), 625-632.
- "Health effects of land application of municipal sewage sludge." (1995). *EPA/600/1-85/015*, U. S. Environmental Protection Agency, Office of Water, Washington, D. C. 78 pp.
- Jewell, W. J. (1994). "Engineering and cost considerations: sludge management and land application." *Sewage sludge: Land utilization and the environment*, Clapp, C. E., Larson, W. E. and Dowdy, R. H., eds., American Society of Agronomy, Madison, Wisc., 41-54.
- Kaufman, S. S. and Haith, D. A. (1986). "Probabilistic analysis of sludge land application." *J. Environ. Engrg.*, ASCE, 112(6), 1041-1053.
- Outwater, A. B. (1994). *Reuse of sludge and minor wastewater residuals*. Lewis Publishers, Boca Raton, Florida.
- "Plain English guide to the EPA Part 503 biosolids rule." (1994). *EPA 832/R-93-003*, U. S. Envir. Protection Agency, Office of Wastewater Management, Washington, D. C.
- "Process design manual for land application of municipal sludge." (1983). *EPA 625/1-83-016*, U. S. Envir. Protection Agency, Cincinnati, Ohio.
- Sorber, C. A. "Biosolids: A blueprint for public acceptance." *Water Envir. Tech.* 6(5), 61-63.
- "Standards for the use or disposal of sewage sludge: Final rules." (1993). *Federal Register*, 58(32), 9248-9415.

APPENDIX - PATHOGEN TREATMENT PROCESSES ("Standards" 1993)

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 20 degrees Celsius and 60 days at 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 three months. During two of the three months, the ambient average daily temperature is above zero 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 35 to 55 degrees Celsius and 60 days at 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 40 degrees Celsius or higher and remains at 40 degrees Celsius or higher for five days. For four hours during the five days, the temperature in the compost pile exceeds 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 two hours of contact.

Processes to Further Reduce Pathogens (PFRP)

- 1. Composting:** Using either the within-vessel composting method or the static aerated pile composting method, the temperature of the sewage sludge is maintained at 55 degrees Celsius or higher for three days; Using the windrow composting method, the temperature of the sewage sludge is maintained at 55 degrees or higher for 15 days or longer. During the period when the compost is maintained at 55 degrees 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 percent or lower. Either the temperature of the sewage sludge particles exceeds 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 80 degrees Celsius.
- 3. Heat treatment:** Liquid sewage sludge is heated to a temperature of 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 of the sewage sludge is 10 days at 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.* 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.* 20 degrees Celsius).
- 7. Pasteurization:** The temperature of the sewage sludge is maintained at 70 degrees Celsius or higher for 30 minutes or longer.

Noteworthy EPA 503 Contacts

Health & Ecological Criteria Division

Robert (Bob) M. Southworth (202) 260-7157
Re: General and specific technical provisions.

Permits Division

Wendy Bell (202) 260-9534
Re: Permit requirements and implementation issues.

Wendy Miller (202) 260-3716
Re: Program implementation and state programs.

Enforcement Division

John Dombrowski..... (202) 260-7036
Re: Compliance issues.

George Gray..... (202) 260-8313
Re: Compliance issues.

Joe Theis (202) 260-8185
Re: Enforcement issues

Municipal Support Division

Robert Bastian..... (202) 260-7378
Re: Technical information

John Walker (202) 260-7283
Re: Technical information

California Contact:

Lauren Fondahl (415) 744-1909
Region 9