NEW HORIZONS IN SOIL SCIENCE

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Land Applying Municipal Biosolids in Wisconsin

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Introduction

Municipal biosolids are the product of the treatment of domestic wastewater. Formerly called sewage sludge, they reflect the current best technology for the biological treatment of wastewater and contain plant nutrients, organic matter, and other materials that reflect their origin. There are three methods for handling biosolids, which include land-filling, incineration, and land application. Landfilling and incineration are expensive alternatives that require specialized management and facilities. Furthermore, these methods do not utilize the plant nutrients and organic matter that are valuable soil amendments. The Wisconsin Department of Natural Resources (WDNR) estimates that approximately 80% of the state's biosolids are land applied to approximately 70,000 acres. This fact sheet will discuss considerations for the safe and effective recycling of biosolids by land application in Wisconsin.

Rules Governing Application

The U.S. Environmental Protection Agency (USEPA) established regulations for the final use and disposal of biosolids in 40 Code of Federal Regulations (CFR), Part 503 in 1993. These rules were refined over 10 years of study and utilize a research-based risk assessment process. Based on this course of action, the USEPA adopted a national policy to promote beneficial use through land application. Wisconsin adopted these guidelines in WDNR Chapter 204 in which it explicitly states that *"…recycling to the land as a fertilizer or soil conditioner is encouraged, rather than disposing of sludge through incineration or landfilling."*

Biosolids are classified as either Class A or B, based upon how they are managed for three major criteria; namely heavy metal content, pathogen density, and vector (flies, rodents, etc.) attraction reduction. Class A biosolids have lower heavy metal levels (Table 1) and no detectable pathogens, making them suitable for horticultural and home use in landscaping, gardens, and lawns. A well known example is the product Milorganite®, a Class A bagged

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product produced by the Milwaukee Metropolitan Sewerage District since the 1930s, which is distributed nation-wide. Because Class A materials are more expensive to produce, most Wisconsin municipalities produce Class B biosolids that are suitable for application to agricultural land, and can also be used in forestry and other non-agricultural settings.

Table 1. Metal concentration and loading limits for biosolids applied in Wisconsin (Chapter NR204).

Element	Ceiling concentration (ppm)		Lifetime loading limit (lb/acre)
	Class A ex. quality	Class B	
Arsenic	41	75	36
Cadmium	39	85	34
Copper	1500	4300	1339
Lead	300	840	268
Mercury	17	57	15
Molybdenum	†	75	†
Nickel	420	420	375
Selenium	100	100	89
Zinc	2800	7500	2500

† Deleted until USEPA revises.

Class B biosolids are treated to reduce the number of pathogens to a level that significantly reduces the risk to public health. They are handled in bulk and utilized primarily in agriculture as a fertilizer and soil amendment. The risk associated with heavy metals is managed by both adjusting soil pH and the establishment of biosolids metal ceiling concentrations that are somewhat higher than Class A materials or a limit on the lifetime loading of a field of each metal. Fields receiving Class B biosolids must have a soil pH greater than 5.5, which reduces the availability of heavy metals by forming insoluble compounds in the soil. The soil pH of most Wisconsin crop production fields is 6.0 or higher due to liming or calcareous parent material and therefore most fields meet this criterion for application. Municipalities must monitor metal concentrations in their biosolids. Metal levels in domestic wastewater are naturally low, but when the level of a metal increases often from an industrial source, that business may be required to take steps to limit metal discharge to the sewerage system. Applications also must meet numerous site and cropping conditions such as soil depth, slope, and distances from wells, schools, and surface water. The site criteria depend on the method of application as shown in Table 2.

Another criterion for limiting the risk of exposure to pathogens in Class B biosolids is the time interval between application and harvest (Table 3). These restrictions effectively direct the majority of Class B biosolids to field crops, with the majority applied for corn production.

Table 2. Site criteria for the land application of Class B biosolids (Chapter NR204).

Site criteria	Surface	Incorporation by tillage	Injection
Depth to bedrock (ft)	3	3	3
Depth to high groundwater (ft)	3	3	3
Allowable slope (%)	< 6	0 to 12	0 to 12
Distance to wells			
Community or school (ft)	1,000	1,000	1,000
Private (ft) †	250	250	250
Residence, business, recreational area (ft)	500	200	220
Schools, health care facilities (ft)	1,000	1,000	5,000
Property lines (ft) ‡	50	25	25
Streams, lakes, wetlands (ft)			
0 to 6%	200	150	100
6 to 12%	NA §	200	150
Soil permeability (inch/hour)	0.2 to 6.0	0 to 6.0	0 to 6.0

† Distance to non-potable (e.g., irrigation) may be reduced to 50 ft.

‡ Distance may be reduced by written agreement between both property owners.

§ NA, not allowed.

Balancing the Benefits and Concerns

The American Water Works Association estimates the per capita water use to be over 127,000 gal per year. The majority becomes wastewater which is delivered to municipal wastewater treatment plants (WWTPs) where it is processed. Increasingly septage and holding tank waste pumped from rural homes or other non-sewered facilities is taken to nearby municipal WWTP. Therefore, rural residents also have a stake in biosolids management. Through land application they can benefit economically from low cost fertilization of their crops, while providing a service to their city neighbors.

Biosolids contain substantial amounts of plant nutrients and can supply the entire nutrient requirement of a corn crop. Many WWTPs offer soil testing and other services, plus inject or incorporate the biosolids providing primary tillage, at little or no cost to the farmer. The combination of applied nutrients and services can be valued at over $100 per acre. Several Wisconsin WWTPs use lime stabilization as a means to reduce pathogens and vector attraction. The biosolids from these treatment plants has been shown to be an effective liming material.

Table 3. Minimum duration between application and harvest/grazing/access for Class B biosolids (Chapter NR204).

Criteria	Months Surface	 Incorporated by tillage	 Injection
Food crops that may touch soil (e.g., beans, melons, squash, etc.)	14	14	14
Food crops with harvested portion in soil (e.g., potato, carrot, beets, etc.)	20/38 †	20/38	38
Animal feed or other food crops (e.g., field corn, hay, sweet corn)	1	1	1
Forage for animal grazing	1	1	1
Areas with public access			
High contact potential ‡ (e.g., parks, golf courses)	12	12	12
Low contact potential (e.g., landfill cover, forests)	1	1	1

† 20 months if biosolids left on surface > 4 months; 38 months if incorporated before 4 months. Related to effect of UV radiation on pathogen viability.

‡ Includes turf from sod farms placed in areas of high public exposure.

Nutrient Management

Most biosolids are capable of supplying the crop requirement of N for high-N demanding crops such as corn. Biosolids can also be applied to forage legume crops and soybean at rates that supply 200 and 140 lb available N/acre, respectively. According to Chapter NR204 a nutrient management plan is required if biosolids comprise more than 30% of the crop N recommendation. Such a plan would need to include N contributed from all sources, including fertilizer and credits from manure and legumes. All biosolids require an analysis that includes total N, inorganic N (ammonium-N), total P and K, and dry matter content. These values can be entered into the Snap Plus nutrient management software to determine the application rate needed to supply the correct rate of available N and the loading of P and K. A long-term study conducted in Walworth County that compared N fertilizer and biosolids applied to meet corn N need confirms the fertilizer value of biosolids as shown in Figure 1.

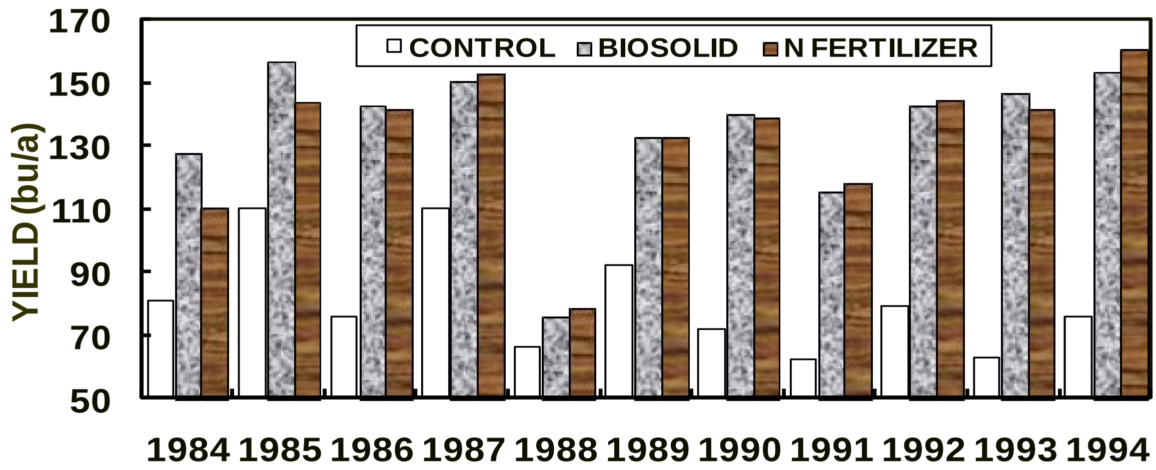

Figure 1. Corn response to municipal biosolids at a Walworth Co., Wis. site (Source Dr. A.E. Peterson, UW Soil Science).

The University of Wisconsin has recently adopted the Maximum Return to Nitrogen (MRTN) approach for corn N rate guidelines. The MRTN approach considers the N:corn price ratio and is most applicable where purchased N fertilizer is used, but can be used to guide manure or other N-containing organic material application rates. The MRTN approach provides greater flexibility to fine-tune N management based on economic factors and site-specific field conditions. These guidelines can be used for municipal biosolids or other wastewater applications where significant N contribution is expected, even though the sources are provided at low cost. Nutrient management planners should select a rate that falls in the 0.05 N:corn price range. Using this price ratio the MRTN rate for a high yield potential soil would be 165 lb N/acre and could range between 135 and 190 lb N/acre. Recognize that the MRTN is the total N applied, including N credits and starter fertilizer. The suggested MRTN rate guidelines for municipal biosolids and other wastewater residual applications are shown in Tables 4. Recognize that the current version of NR204 cites 1991 UWEX nutrient recommendations that did not contain the rate flexibility found in the MRTN guidelines. Application rates should be confirmed with the local DNR representative. Consult UWEX publication A2809, Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin for N recommenda-ions for crops other than corn. Forage legume (alfalfa, red clover, etc.) and manure credits have not changed and should be subtracted from the selected N rate. Where biosolids are applied in successive years, credit 12 and 6% of the residual organic N in the second and third year.

An important consideration when applying biosolids to meet crop N need is the over-application of P. Biosolids contain disproportionately high amounts of P because one of the goals of wastewater treatment is to retain as much P as possible in the solids so that a very low (<1 ppm P) effluent can be discharged back to the surface water. The extra applied P builds the soil test to excessively high soil test levels, which have been shown to increase P loss in runoff. An example of the effect of continuous application of biosolids at a Wisconsin site on soil test P is shown in Figure 2. Therefore, to avoid the buildup of soil test P and to reduce the risk of P loss from biosolids-treated fields, the following guidelines are suggested:

1. Select fields for biosolids application that have low soil test P.
2. Treat fields once every 3 to 4 years rather than annually.
3. Apply biosolids at rates that meet crop P need for the rotation.
4. Maintain soil conservation practices to reduce runoff and erosion.
5. Grow crops that remove higher amounts of P.
6. Avoid applications of manure to biosolids treated fields.

Table 4. MRTN rate guidelines for corn grain where municipal biosolids and other N-containing wastewater residuals (UWEX Pub. A2809).

Soil yield potential and previous crop	MRTN[1]	Range[2]
	--------Available N to apply (lb N/acre)[3] -----------	
High/Very high		
Corn, forage legume, vegetable, green manure[4]	165	135-190
Soybean, small grain[5]	140	110-160
Medium/Low		
Corn, forage legume, vegetable, green manure[4]	120	100-140
Soybean, small grain[5]	90	75-110
Irrigated sands and loamy sands		
All crops[4]	215	200-230
Non-irrigated sands and loamy sands		
All crops[4]	120	100-140

[1] Rate is the N rate that provides the maximum return to purchased N fertilizer (MRTN)
[2] Range is the range of profitable N rates that provide an economic return to N within $1/acre of the MRTN
[3] These rates are for total N applied including N in starter fertilizer and N used for herbicide applications
[4] Subtract N credits for forage legumes, leguminous vegetables, green manures, and animal manures. Do not subtract N credits for leguminous vegetables on sands and loamy sands.
[5] Subtract N credits for animal manures and second year forage legumes.

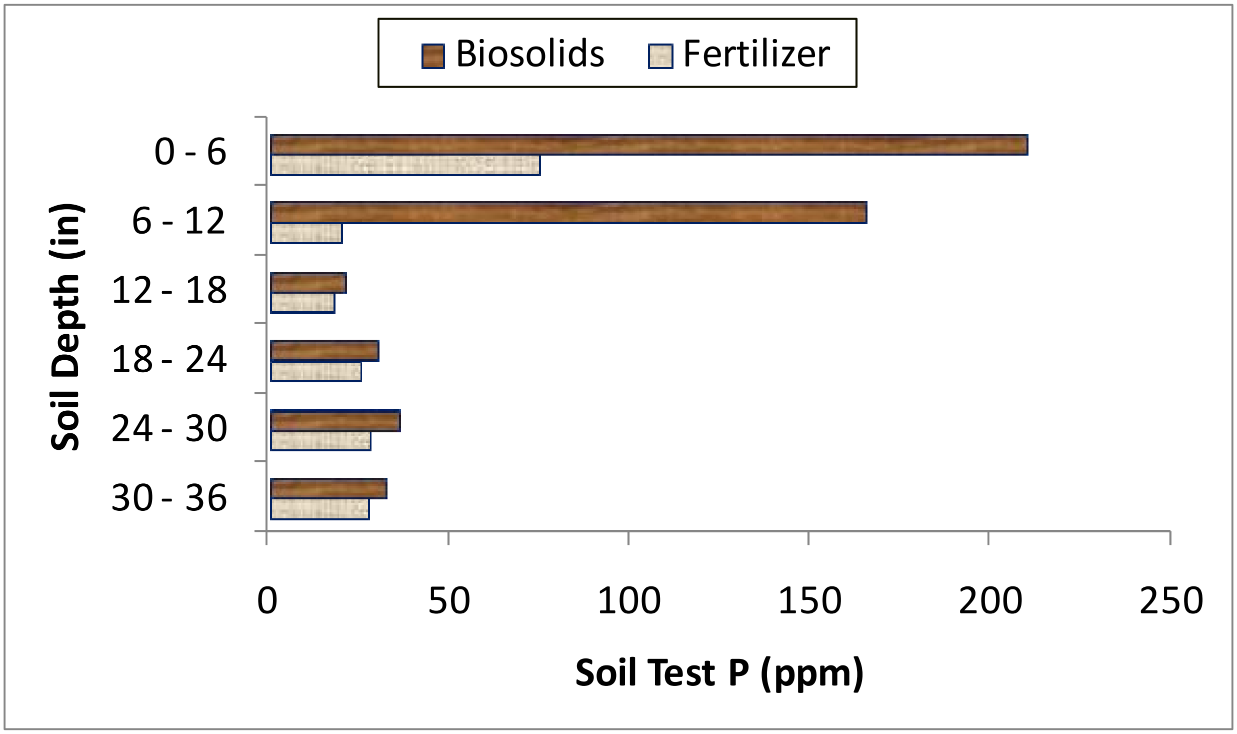

Figure 2. Effect of long-term biosolids application (1979 – 1994) on soil test P at a Walworth Co., Wis. site. Sampled in 2002. (Source Dr. L.G. Bundy, UW Soil Science).

Summary

Biosolids are a byproduct of our modern society and the need to manage their use will continue in the future. They provide an excellent source of plant nutrients and organic matter for agriculture, which should not be wasted by landfilling or incineration. Their creation is carefully managed to reduce the health risks associated with pathogens and heavy metals. Their use is closely monitored by both the USEPA and the WDNR. Research on biosolids process and management has been conducted at the University of Wisconsin for over 80 years and continues to this day. The land application of biosolids should be incorporated into a farm's nutrient management plan to reduce the risk of water quality degradation.