

Fertilizing with Biosolids



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Fertilizing with Biosolids

Biosolids are a by-product of municipal wastewater treatment. They contain organic matter and nutrients that are beneficial for soil, crop, and livestock productivity. Raw sewage solids must be processed to meet U.S. Environmental Protection Agency (USEPA) standards before they can be called biosolids.

This publication focuses on how biosolids can be used to supply nutrients for crop production. Other aspects of biosolids utilization are addressed briefly, including:

- Biosolids quality factors (trace element concentrations and pathogen levels)
- Applicable regulations
- Questions about biosolids safety and application practices



Biosolids as a nutrient source

Nutrient content

Biosolids usually are applied at rates designed to supply crops with adequate nitrogen. They also contain other nutrients that reduce fertilizer requirements.

Table 1 shows the typical macronutrient content of biosolids produced by Pacific Northwest wastewater treatment facilities. The total nutrient content shown in Table 1 includes rapidly and slowly available nutrient forms. Biosolids also provide plant-essential micronutrients, including copper, boron, molybdenum, zinc, and iron.

Table 1. Biosolids organic matter and macronutrients (dry weight basis).^a

Nutrient	Usual range ^b
	%
Organic matter	45–70
Nitrogen (N)	3–8
Phosphorus (P) ^c	1.5–3.5
Sulfur (S)	0.6–1.3
Calcium (Ca)	1–4
Magnesium (Mg)	0.4–0.8
Potassium (K) ^c	0.1–0.6

^aNutrient concentrations expressed on a total elemental basis; not all of the elemental content is in a plant-available form.

^bUsual range for freshly digested biosolids. Lagooned biosolids, composted biosolids, and alkaline-stabilized biosolids typically have lower nutrient concentrations.

^cPhosphorus and potassium expressed on an elemental basis. To convert to units used for fertilizer marketing: Multiply P x 2.29 to get P₂O₅ (phosphate). Multiply K x 1.2 to get K₂O (potash).

Balance between biosolids nutrient inputs and crop nutrient removal

The nutrients supplied by biosolids are not present in the same ratio as they are found in plant tissue. Therefore, biosolids supplied at an agronomic rate for nitrogen supply an excess of some nutrients (e.g., phosphorus) and not enough of others (e.g., potassium).

Table 2 gives a general example of the relationship between biosolids nutrient inputs and crop removal of nutrients. The general soil nutrient balance illustrated in Table 2 (positive or negative for a particular nutrient) is valid for most crops. In cropping systems where only a portion of crop biomass is removed from the field (e.g., grass managed for seed production, or grass managed by grazing), nutrients accumulate to a greater extent.

Table 2. Example: Annual change in soil nutrient status with biosolids fertilization. Tall fescue grown for grass hay or silage.

Nutrient	Biosolids nutrient input ^a (lb/acre)	Grass nutrient removal ^b (lb/acre)	Net nutrient input to soil ^c (lb/acre)
Nitrogen	400	220	130
Phosphorus	160	32	128
Potassium	24	240	-216
Sulfur	80	40	40
Zinc	6.8	0.4	6.4
Copper	4.7	0.1	4.6

^aEstimated nutrient input with application of 4 dry tons biosolids per acre per year.

^bBased on field research in western Oregon and Washington; tall fescue harvested four or five times each year, yielding about 1 ton of dry forage per cut.

^cCalculated as total nutrient inputs minus grass harvest removal. Loss of 50 lb N/acre as ammonia was estimated at application. Leaching losses of all nutrients are assumed to be insignificant.

Soil testing at biosolids application sites

Soil testing can be used to monitor the change in soil fertility resulting from biosolids application. A long-term monitoring plan to track soil nutrient levels over the years should use consistent sampling and analysis methods. Several Extension publications, listed in “For more information” (page 14), provide guidelines for designing a sampling and testing program.

Biosolids nitrogen (N)

Nitrogen forms

Wastewater treatment facilities routinely monitor biosolids ammonium, nitrate, and organic N concentrations. Little nitrate-N is present in most biosolids, so it will be ignored in the remainder of this discussion. Organic N in biosolids is calculated as total N minus ammonium-N.

Ammonium-N is available to plants immediately after application. Organic N provides slow-release N for crops after application. The proportions of ammonium and organic N in biosolids vary with the stabilization process (e.g., digestion, composting) used at the wastewater treatment facility. Anaerobically digested liquid biosolids often contain more ammonium-N than organic N. Other biosolids contain most of the N in organic form.

Calculating biosolids application rates based on plant-available nitrogen

A companion publication, PNW 511-E, *Worksheet for Calculating Biosolids Application Rates in Agriculture*, provides a step-by-step process for calculating application rates that supply crops with adequate available nitrogen. The worksheet estimates ammonium-N retained and organic N mineralized from different types of biosolids.

Plant-available N from biosolids is estimated as:

$$a \text{ (ammonium-N in biosolids)} \\ + b \text{ (organic N in biosolids)}$$

where:

a = fraction of ammonium-N retained after application

b = fraction of organic N mineralized during the first growing season

Ammonium-N retained after application

When biosolids are surface applied (not tilled or injected into the soil at application), a portion of the biosolids ammonium-N is lost as ammonia gas. Ammonia loss is very rapid during the first hours after application. Immediate tillage or sprinkler irrigation with clean water after biosolids application increases ammonium-N retention. However, tillage or immediate irrigation is not feasible or desirable for many cropping situations.

When biosolids are not incorporated into the soil, ammonium-N retained is greater for liquid biosolids than for dewatered cake biosolids. With liquid biosolids, some of the ammonium-N moves into the soil, reducing ammonia loss.

Organic N mineralized

Organic N in biosolids is converted to plant-available forms (ammonium and nitrate) by soil microorganisms after field application (a process known as mineralization). The biosolids treatment process affects the organic N mineralization rate after land application. Freshly digested biosolids usually contain more mineralizable N than do biosolids produced with more intensive stabilization processes (composting or long-term lagoon storage).

The organic N mineralization rate also is affected by soil temperature and moisture conditions. Mineralization is most rapid in warm, moist soils.

Mineralization proceeds most rapidly immediately after biosolids application, provided

soil temperature and moisture are favorable. Usually, more than half of first-year N mineralization occurs within the first 3 to 6 weeks after biosolids application. When biosolids are applied to dry soil and not incorporated by tillage, N mineralization is delayed until moisture is present.

The organic N not mineralized during the first year after application is mineralized slowly in succeeding years. Thus, when biosolids are applied repeatedly to the same site, the annual application rate needed to meet crop needs decreases each year.

Using university fertilizer guides

Agronomic application rates of biosolids application (PNW 511-E) are designed to replace fertilizer nitrogen. The recommended calculation method in PNW 511-E estimates crop N needs using fertilizer guides. However, subtle differences in appropriate utilization strategies between soluble N fertilizers and biosolids are sometimes important, and this information is not provided in fertilizer guides. For example:

- The OSU fertilizer guide for pastures in western Oregon recommends application of N in fall and early spring. Research has shown that a single application of biosolids in the late summer or fall can substitute for both the recommended fall and spring fertilization with commercial N fertilizer.



Biosolids applied at a typical application rate (about 4 dry tons per acre).

- The OSU fertilizer guides generally recommend no N application for alfalfa, because nitrogen fixation by bacteria living in alfalfa roots can supply all of alfalfa's nitrogen needs. When fertilized with biosolids, however, alfalfa roots adapt to their environment and take up the N provided by biosolids. Therefore, biosolids application to alfalfa is a reasonable practice. When hardpans and other rooting-restrictive layers are absent, alfalfa has a deep root system and can recover water and nitrogen from the top 6 feet of soil.

Alfalfa is best suited to liquid biosolids application, because liquids can be applied via sprinkler, avoiding vehicle traffic on the field. Driving a spreader over an established alfalfa field can compact soil and damage alfalfa crowns, reducing hay yield and the longevity of the alfalfa stand.

Because biosolids management is more complex than commercial fertilizer management, it may be helpful to seek help from a certified soil scientist or other agricultural professional in calculating and monitoring agronomic biosolids application rates.



Biosolids composts and other biosolids products have been used to grow prize-winning flowers and vegetables for the Puyallup (Washington) fair.

Biosolids phosphorus (P)

When applied to meet crop nitrogen needs, biosolids supply large quantities of phosphorus. This phosphorus can provide a long-term benefit to soil fertility when applied to P-deficient soils. However, in soils that already have high P, application of P can increase the potential for P loss from the field to surface water.

Controlling P loss to sensitive water bodies is an important environmental issue. In some surface waters, algae blooms are triggered by P inputs. These blooms can reduce water clarity, create unpleasant swimming conditions and odors, interfere with boating and fishing, and harm fish or other aquatic life. Phosphorus-induced algae blooms occasionally produce substances toxic to humans and livestock. During the past decade, a national effort has been directed toward reducing non-point source P losses from agricultural landscapes to P-sensitive waters.

Ask the following questions before applying biosolids to a field.

- Is the field located in a watershed with an identified water quality impairment associated with phosphorus?



- Is there a pathway (surface runoff, soil erosion by water or wind, tile drainage, or flooding) for P loss from the field to a P-sensitive water body?
- Is the current soil test P value low, medium, high, or very high? As soil test values increase, the potential for P loss from the field via surface and subsurface transport increases (see Table 3). High soil test values for phosphorus may not be a significant environmental issue, however, where no pathway exists to move P from the field to a water body.

If *all of the factors* listed below are present, biosolids applications should be managed carefully to protect surface waters.

- The field is in a watershed with a P-sensitive water body.
- There is a pathway for P loss from the field to a water body.
- The field has high or very high soil test P values.

See OSU Extension publication EM 8848-E for more information on management options for reducing P loss from agricultural fields.

Compared to inorganic P fertilizers, a smaller fraction of the total P in biosolids is soluble. Lower P solubility decreases the environmental risk associated with biosolids P application, but it also reduces the value of biosolids P as a nutrient source for crops.

Research in the Pacific Northwest and in other regions has demonstrated that P solubility in biosolids typically is 40 percent of that in commercial P fertilizers. Therefore, a biosolids containing 2 percent total P (dry weight basis), applied at a typical application rate of 4 dry tons per acre, will supply the equivalent of 64 lb inorganic fertilizer P per acre (146 lb P₂O₅ per acre).

Biosolids processing methods affect P solubility. Some wastewater treatment facilities add aluminum (aluminum sulfate), iron (ferric chloride), or calcium (lime) compounds during wastewater treatment or solids processing. Iron, aluminum, and calcium bind phosphorus, rendering it less soluble. As the concentrations of iron, aluminum, and calcium in biosolids increase, the solubility of P decreases.

A laboratory determination of water-soluble P in biosolids is an excellent indicator of the solubility of the P. A testing protocol is available online at <http://sera17.ext.vt.edu>.

Table 3. Soil test values used to assess field vulnerability to P loss in Oregon and Washington.

Field vulnerability to P loss	Soil test phosphorus	
	West of Cascades Bray P1 extraction (ppm or mg/kg)	East of Cascades Olsen (bicarbonate) extraction (ppm or mg/kg)
None	< 40	< 20
Low	50	30
Medium	60	40
High	80	60
Very high	120	100

Source: Oregon and Washington Natural Resources Conservation Service (NRCS). 2001. *Water Quality Technical Notes: The Phosphorus Index*. Available from state NRCS offices. Soil P test value is 1 of 10 site factors evaluated by NRCS in assessing field vulnerability to P loss using the Phosphorus Index.

Biosolids sulfur (S)

Biosolids supply both rapidly available S (from oxidation of sulfides) and slow-release S (from decomposition of biosolids organic matter). Approximately 15 to 40 percent of biosolids sulfur is oxidized to the plant-available form, sulfate-sulfur, during the first year after biosolids application. Biosolids application rates designed to supply adequate N for crops that have a high sulfur demand (e.g., canola) also provide sufficient S for those crops.

Soil pH

Maintaining an appropriate soil pH is essential in maintaining the productivity of cropping systems. As pH increases, soil becomes more alkaline. As it decreases, soil becomes more acidic. Biosolids application can increase or decrease soil pH (Table 5, page 7), depending primarily on whether alkaline materials are used in biosolids processing.

Fertilizer replacement value of biosolids

Table 4 estimates the fertilizer replacement value of biosolids nitrogen, phosphorus, potassium, and sulfur for the first year after application. This estimate is based on typical biosolids analyses and estimates of nutrient availability from university field trials.

The fertilizer replacement value for nutrients besides N depends on existing soil test values and the cropping system. Typically, a biosolids application to meet crop N requirements eliminates the need for annual P and S applications.

The fertilizer replacement values shown in Table 4 do not include the potential benefits to soil quality from biosolids. Soil quality benefits are difficult to express in simple economic terms and are unique to every location.

To convert values given for P and K in Table 4 to units used in fertilizer marketing: multiply P by 2.29 to get P₂O₅, and multiply K by 1.2 to get K₂O. For example, biosolids with 2.5 percent P and 0.3 percent K contain 5.7 percent P₂O₅ (phosphate) and 0.36 percent K₂O (potash).

Table 4. Approximate first-year fertilizer replacement value for anaerobically digested biosolids.

Nutrient	Expressed as	Total nutrient	Available nutrient ^a	Nutrient cost ^b	Value per dry ton
		(% dry wt.)	(% of total nutrient)	(\$ per lb)	(\$)
Nitrogen	N	5.0	35	0.41	14.35
Phosphorus	P	2.5	40	0.94	18.80
Potassium	K	0.3	100	0.29	1.74
Sulfur	S	1.0	35	0.13	0.91
Total					35.80

^aEstimated plant-available nutrient released in the first year after biosolids application.

^bApproximate nutrient cost is based on Willamette Valley bulk dry fertilizer prices, June 2006. The actual cost of a pound of fertilizer N, P, or K varies depending on nutrient form and analysis (e.g., costs differ for anhydrous ammonia and calcium nitrate as a source of N), transportation charges, market conditions, and the quantity purchased. Cost of fertilizer application is not included.

Alkaline-stabilized biosolids

Some biosolids are stabilized with alkaline materials (calcium oxide or calcium hydroxide) to reduce odors and meet USEPA pathogen reduction requirements. In a typical alkaline stabilization process, the biosolids/alkaline material mixture reaches a pH of 12 or greater for at least 2 hours. At this high pH, ammonia loss is rapid.

After land application, the residual alkaline material rapidly neutralizes soil acidity, thereby increasing soil pH (the first process in Table 5). Thus, alkaline-stabilized biosolids act as a replacement for agricultural limestone. These biosolids sometimes contain 20 to 40 percent lime (0.2 to 0.4 ton agricultural lime per dry ton of biosolids). Postapplication increases in soil pH and exchangeable soil calcium can be used to determine the liming value of a biosolids/alkaline materials application.

It is important to consider current soil pH and potential crop rotations before applying alkaline-stabilized biosolids to a field. Increasing soil pH may not be beneficial for acid-loving crops such as blueberries, caneberries, and some nursery crops (for example, rhododendrons and maples).

East of the Cascades, the application of alkaline-stabilized biosolids to high-pH soils (pH > 7) needs to be managed carefully. These biosolids can be beneficial in supplying nutrients, but the added lime is not beneficial in high-pH soils. Depending on the soil and crop,



Large on-farm trials have been used to determine appropriate rates of biosolids application for dryland winter wheat in eastern Oregon and Washington.

an acidifying amendment such as elemental sulfur may be needed to neutralize the added lime.

Biosolids stabilized without alkaline materials

When biosolids that do not contain added alkaline materials are applied, the change in soil pH is the net result of the last three factors listed in Table 5. Shortly after application, a drop in soil pH (acidification) may be observed, usually 0.2 to 0.5 pH unit. This pH decrease is caused by the addition of soluble salts and by the oxidation of organic N and S compounds. This pH drop usually is short lived and is offset by the calcium and magnesium added by biosolids. Because several factors are involved, soil testing is recommended to monitor soil pH at biosolids application sites.

Table 5. Biosolids effects on soil pH.

Type of biosolids	Biosolids input	Effect on soil pH	Soil process
Alkaline-stabilized	Ca oxides and hydroxides	Increase	Converts soil acidity to water and carbon dioxide.
All	Soluble salts	Temporary decrease	Cations displace acidity from soil clays and organic matter, bringing it into soil solution.
All	Organic N and S	Decrease	Oxidation in soil to nitrate and sulfate produces acidity.
All	Exchangeable Ca and Mg	Increase	Supplies non-acidifying cations.

A comparison of the effects of biosolids and fertilizer N application on soil pH is shown in Table 6 for one Willamette Valley application site. The soil pH was the same after 7 years of biosolids application or 7 years of ammonium sulfate fertilizer application (100 lb N per acre). The liquid anaerobically digested biosolids applied in the study did not contain added alkaline materials.

Table 6. Surface soil pH (0–12 inches) after 7 years of biosolids or ammonium sulfate application to a Willamette silt loam soil.^a

N Source	Total N applied (lb/acre/yr)	Soil pH
None	0	5.4
Biosolids ^b	140–210	5.2
	290–420	5.1
Ammonium sulfate	100	5.1
	200	4.9
	300	4.7

^aLocation: Aurora, OR. Soil pH (0- to 8-inch depth) at the start of the study was 5.7. The soil had a cation exchange capacity of 15 meq/100 g soil.

^bAverage for liquid anaerobically digested biosolids from three Oregon wastewater treatment facilities: Portland, Salem, and Rock Creek (Washington County). All biosolids sources in the study performed similarly.

Source: Kiemnec et al., 1990.

Soil quality

Biosolids application also affects soil chemical, physical, and biological properties. Together, these properties determine soil quality. Biosolids supply both nutrients and organic matter for soil quality improvement.

The organic matter provided by one biosolids application does not by itself increase soil organic matter a great deal. However, when combined with other soil management practices that favor accumulation of organic matter (e.g., reduced tillage, use of cover crops), biosolids application helps improve soil quality.

The changes in soil quality accompanying biosolids application generally improve the capacity of crops to utilize nutrients. Potential

benefits of biosolids application on soil quality are listed in Table 7.

Table 7. Ways that soil quality can improve with biosolids application.

Physical	Greater water-holding capacity
	Improved tilth
	Reduced soil erosion
Chemical and biological	Increased cation exchange capacity
	Plant-available nitrogen and sulfur slowly released from organic forms
	Micronutrient deficiencies corrected
	Increased earthworm and microbial activity

When biosolids are applied at a site for many years, they can increase soil organic matter.

Example. Ten consecutive annual biosolids applications (6 dry tons per acre per year) to a cool-season perennial grass at agronomic rates increased surface soil organic matter (0- to 3-inch depth) from 3.0 to 4.6 percent in a trial at WSU-Puyallup. The effect of biosolids on soil organic matter to a depth of 12 inches was smaller, but measurable. The increase in organic matter below the 3-inch soil depth likely was due to the action of earthworms and increased root growth, because the site was not tilled.



At many treatment plants, anaerobic digestion in large vessels is used to process biosolids.

Biosolids that are composted or aged for many years in treatment lagoons can be applied at high rates, supplying large quantities of organic matter. These biosolids are suited for high-rate applications because they usually contain very low amounts of plant-available N (3 to 5 lb available N per dry ton) relative to biosolids produced via short-term aerobic or anaerobic digestion (more than 30 lb available N per dry ton).

The most dramatic improvements in site productivity are observed when biosolids are applied to land that is severely eroded or affected by excess sodium. For example:

- Agronomic applications of biosolids have been successful in stabilizing sandy “blow-out” areas (small sand dunes) in dryland pastures near Hermiston, OR. Before biosolids application, revegetation of the blow-outs had not occurred for more than 45 years following range fires. Vegetation establishment accompanying biosolids application likely was due to several positive effects of biosolids on soil quality: increased aggregation of soil at the surface, improved soil nutrient status, and greater water-holding capacity.
- In a replicated field trial, WSU scientists demonstrated that high rates (30 dry tons per acre) of aged lagoon biosolids improved wheat establishment on a sodic soil. The untreated soil had an exchangeable sodium percentage of 40 percent and a pH above 9.5. Soil without biosolids application had zero vegetation. Soil with biosolids and gypsum application had better wheat growth than soil treated with gypsum alone. Biosolids increased soil organic matter and improved soil aggregation in samples taken 18 months after application. Plant response was dramatic at this site even though changes in soil test values for pH, exchangeable sodium, compaction, and water infiltration were small.

- In a 3-year trial on a field with exposed subsoil at WSU-Prosser in the Yakima Valley, biosolids fertilization increased corn grain yield by 10 percent over that attained with commercial N fertilizer. In this trial, some of the yield increase seen with biosolids application was associated with correction of zinc deficiency.

Crop management considerations

Some examples of how a biosolids application can affect crop management are given below.

Nitrogen management

As with any nitrogen source, overapplication of biosolids can reduce crop yield and quality. Research with dryland wheat grown in the 10- to 14-inch annual precipitation zone (east of the Cascades) has demonstrated that biosolids applications that supply too much N can cause lodging of some wheat varieties, reduce grain yield, and increase protein. In the absence of lodging, the increased grain protein often associated with biosolids application may be an asset for production of hard red or hard white



Small research plots on sodic soil in dryland wheat fields in north-central Washington showed better wheat growth following application of biosolids + gypsum (center) vs. gypsum application alone (left and right).

wheat, as a premium is paid for high protein content in these grains.

To utilize the slow-release N provided by biosolids, cover crops may be needed to capture the N mineralized in late summer and early fall. Otherwise, this slow-release N is likely to be lost via nitrate leaching.

Because most of the nutrients provided by biosolids remain near the soil surface, increased growth of some weedy species may be stimulated by biosolids application. For example, east of the Cascades, cheatgrass (*Bromus tectorum*) growth is stimulated by biosolids application. On dryland pastures, where cheatgrass can be grazed effectively in early spring, the increase in cheatgrass growth is an asset to beef production. In dryland wheat cropping systems where cheatgrass is present, biosolids application may increase cheatgrass competition with the crop.

Biosolids application decreases N fertilizer requirements the second year after application. The worksheet used for estimating agronomic application rates of biosolids (PNW 511-E) includes a credit for previous biosolids applications. Research in the Pacific Northwest has documented credits for previous year biosolids application for several cropping systems:

- **Dryland cropping systems in a 10- to 14-inch precipitation zone in central Washington.** For the second crop following an agronomic biosolids application (4 dry tons per acre), fertilizer N needed to attain maximum yield was reduced from approximately 60 lb N per acre to 20 lb N per acre.
- **Research with tall fescue at WSU-Puyallup.** Following a one-time application of biosolids (4 dry tons per acre), fertilizer N needs were reduced by about 60 lb N per acre during the second year.

Salts

Biosolids contain lower concentrations of salt than most animal manures.

Most of the salts present in wastewater are discharged from treatment facilities in treated water. Liquid biosolids contribute higher amounts of salt than do biosolids that are processed to reduce moisture content. After application to soil, some salts are released from biosolids by decomposition of organic matter.

Repeated biosolids applications have not resulted in detrimental salt accumulations in soil, even at sites with low annual precipitation and no irrigation. For example, annual applications of dewatered cake biosolids (80 percent moisture) have been made for more than 10 years to dryland pastures near Hermiston, OR (6 inches annual precipitation). At this site, electrical conductivity (a measure of soluble salts in soil) has not increased above 1 mmho/cm, a value considered low (OSU *Soil Test Interpretation Guide*, EC 1478).

Forage quality

High-quality grass hay or grass silage can be produced with biosolids. Because biosolids supply both N and S (key nutrients in protein), biosolids application is particularly effective in increasing forage protein. Livestock managers may need to adjust animal diets with appropriate salts or other supplements, or adjust grazing management, to take advantage of the high-protein forage.

When similar amounts of available N are supplied with biosolids or fertilizer N, the biosolids-fertilized forage usually has higher phosphorus and sulfur content. Unlike most dairy and poultry manures, biosolids are low in potassium and generally do not increase forage potassium.

Biosolids-fertilized forage often is higher in micronutrients such as copper, zinc, and manganese. Typical micronutrient concentrations in biosolids-fertilized grasses are far below levels considered detrimental to animal performance.

Site approvals for biosolids application

Is site approval needed?

Whether you need a permit or site approval for biosolids application to cropland depends on the following:

- Trace element concentrations in the biosolids relative to USEPA standards
- Whether the biosolids meet USEPA Class A or Class B pathogen reduction requirements

Site approvals are always required for Class B biosolids application.

Site approvals may be required for Class A biosolids application if trace element concentrations in biosolids exceed Exceptional Quality (EQ) limits, or if biosolids are not stabilized sufficiently via digestion or composting. See “Biosolids quality” (page 12) for details on these regulatory requirements.

Who obtains site approval?

When needed, site approvals for biosolids application generally are obtained by wastewater treatment facility representatives. Some private companies, working under contract with the wastewater treatment facility, may assist in obtaining site approval.

What agency is responsible for site approvals?

Oregon	Department of Environmental Quality
Washington	County health departments and Washington State Department of Ecology
Idaho	U.S. Environmental Protection Agency

What about heavy metals?

Heavy metals were a concern when land application of biosolids began in the 1970s. Since then, source control activities have been very effective in decreasing metal inputs to wastewater treatment facilities.

- Wastewater treatment facilities reduce metals in incoming wastewater by issuing permits to industrial wastewater sources. To meet permit requirements, industries adopt cleaner manufacturing processes or pretreat wastewater to remove metals. Industrial sources are required to routinely monitor for specific metals in their wastewater.
- Adjustment of city water supplies to a higher pH has reduced pipe corrosion and the concentrations of zinc, copper, and lead in household wastewater.
- The use of PVC pipe instead of metal pipe has reduced metal concentrations.

Table 8 shows the impact of source control activities on biosolids metal concentrations. Metals in Portland biosolids have been reduced by a factor of 2 to 10 since 1981. Today, biosolids metal concentrations are similar for cities with industrial inputs (Portland biosolids concentrations, Table 8) and smaller treatment facilities with few industrial inputs (average Oregon biosolids concentrations, Table 9, page 12).

Table 8. Metal concentrations in City of Portland biosolids.

Metal	City of Portland biosolids		
	1981 ^a (mg/kg)	1996 (mg/kg)	2005 (mg/kg)
Cadmium	40	5	3
Copper	1,000	481	384
Lead	900	181	108
Nickel	190	39	49
Zinc	2,200	834	921

^a1981 concentrations are approximate values.

Biosolids quality

Biosolids quality is based on:

- Trace element concentrations in biosolids
- The completeness of the pathogen reduction process used by the wastewater treatment facility
- Organic matter stabilization achieved by digestion, composting, or other processes at the wastewater treatment facility. Stabilization, called “vector attraction reduction” in USEPA biosolids rules, is important for reducing odors and making biosolids less attractive to pests such as insects and rodents.

Together, these quality factors determine whether site approvals by a regulatory agency are required for biosolids application (see page 11).

Trace elements

Current trace element concentrations usually are well below concentration standards

set by USEPA for biosolids (Table 9). The current concentrations of trace metals in biosolids allow nearly all wastewater treatment facilities to produce a beneficial product suitable for land application.

In Table 9, the lower concentration standard for trace elements (Exceptional Quality Limit) is for biosolids products distributed to the public. The higher concentration standard (Ceiling Limit) applies to all land-applied biosolids.

If one element in the product exceeds the Ceiling Limit, the product cannot be called biosolids and cannot be land applied. University research with biosolids, conducted for many years at many field sites, supports the USEPA trace element concentration limits.

Pathogen reduction

Pathogens are organisms, such as bacteria, that can cause disease. Before application to cropland, biosolids must be processed to meet either USEPA Class A or Class B pathogen reduction standards.

Class A biosolids are essentially pathogen-free and usually are sold or distributed in urban areas for landscaping or turf fertilization. Because of the greater flexibility in management afforded by Class A treatment, more facilities are moving toward Class A biosolids production. For example, in 2005, the City of Tacoma marketed 88 percent of its annual biosolids production as Class A biosolids products.

Class B biosolids have been processed to significantly reduce, but not eliminate, pathogens. Biosolids of Class B quality usually are delivered to farmers for land application. The most common processing methods for Class B biosolids are aerobic or anaerobic digestion. Some treatment

Table 9. Trace elements in Oregon biosolids compared to USEPA concentration limits for land application.

Trace element	Oregon biosolids	USEPA	USEPA
	average ^a	Exceptional	Ceiling
	(mg/kg)	Quality Limit ^b	Limit ^c
		(mg/kg)	(mg/kg)
Arsenic	6	41	75
Cadmium	3	39	85
Copper	448	1,500	4,300
Lead	76	300	840
Mercury	2	17	57
Molybdenum	14	75 ^d	75
Nickel	36	420	420
Selenium	6	100	100
Zinc	852	2,800	7,500

^aAverage concentration for 37 Oregon biosolids products as reported by the Oregon Association of Clean Water Agencies (2005 data).

^bSource: USEPA guidelines for pollutant concentrations in biosolids (40 CFR Part 503). The Exceptional Quality Limit applies to biosolids suitable for distribution without site approval. To be called “Exceptional Quality Biosolids” by USEPA, biosolids must also be Class A for pathogen reduction.

^cThe Ceiling Limit is the maximum for land application of biosolids.

^dThe USEPA Exceptional Quality Limit for molybdenum is under review.

facilities add alkaline materials such as calcium hydroxide to kill pathogens and meet Class B standards.

After land application, pathogens in Class B biosolids are killed by exposure to sunlight, drying conditions, unfavorable pH, and other environmental factors. Site management practices required at Class B biosolids application sites, including setbacks and access restrictions, protect public health.

Organic matter stabilization

Both Class A and Class B biosolids must meet stabilization standards to reduce odors and to reduce attractiveness to insects and rodents.

Questions about biosolids

What limits the rate of biosolids that can be applied?

Application rates are based on supplying N for the crop, without excessive nitrate leaching.

How big of a problem are odors generated by biosolids application?

Odors produced by biosolids application generally are less than for animal by-products such as dairy or chicken manure. The same processes that kill pathogens in biosolids (e.g., digestion) reduce odor after application. Tillage after biosolids application further reduces odor.

What concerns might my neighbors have about a biosolids application?

Neighbors may object to potential nuisances associated with biosolids application, such as truck traffic, dust, and odor. They also may have concerns about protection of local water resources such as wells, streams, and lakes. Biosolids transportation and application practices can be modified to address neighbor concerns. Ask the agency that will provide the biosolids to visit with neighbors before the biosolids application.



Composts produced from biosolids can be used in landscaping. Typically, biosolids are mixed with woody materials, then composted for several months. Biosolids composting operations must document pile temperatures during composting and meet other regulatory requirements.

How much time is required for biosolids application relative to conventional inorganic fertilizer application?

Biosolids application is much slower than conventional fertilizer application, because of the large quantities of material involved. Several weeks may be required to complete application to large fields. Because of the slower pace of biosolids application, perennial grass pastures are one of the most common application sites. Dryland wheat grown on a wheat-fallow rotation (crop planted every 2 years) also offers a good opportunity for biosolids application during the fallow year. Annual crops can be fertilized with biosolids, but careful scheduling is required.

If biosolids are a valuable resource, why are they provided at no charge to the landowner?

Not all biosolids are free. Some municipalities charge a transportation fee, an application fee, or a fee equal to the nitrogen value of the biosolids. In other cases, biosolids application is free, which compensates for landowners'

time and effort. Often, field operations must be scheduled to accommodate biosolids application, and management practices specified by the regulatory agency must be followed after application.

Can biosolids be used on farms that produce crops under organic certification?

Under USDA National Organic Program (NOP) rules, biosolids application is prohibited. This prohibition is based on produce marketing considerations, not on a scientific risk assessment.

In terms of the opportunity for human pathogen infection, Class A biosolids are likely to be safer than manure processed under NOP rules. Treatment facilities producing Class A biosolids are required to demonstrate that their treatment process meets prescribed time and temperature standards. They also are required to monitor biosolids products for human pathogen indicator organisms, such as Salmonella. In contrast, under NOP rules, less stringent documentation of temperatures achieved during composting is required, and composted manure does not have to be tested for the presence of human pathogen indicator organisms before use on organically certified crops.

Should I be concerned about additional contaminants in biosolids that are not addressed under federal and state biosolids rules?

Because wastewater contains a variety of synthetic organic compounds, investigation on the effects of these compounds is an ongoing research area. Recent research has focused on personal care products (pharmaceuticals, cosmetics, etc.) and fire retardants.

Research indicates that the risk to human health and the environment from these compounds is negligible when biosolids are managed according to state and federal rules. There are three reasons why these compounds are not likely to endanger human health or the environment.

- Synthetic organic compounds that survive wastewater treatment are strongly bound to organic matter in soil.
- Plant roots do not take up significant amounts of these compounds.
- Site management practices for biosolids (such as buffer zones and restrictions on application timing) reduce the opportunity for these compounds to move to water bodies.

For more information

Biosolids nutrient management

OSU Extension publications

<http://extension.oregonstate.edu/catalog/>

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