UNIVERSITY OF
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COOPERATIVE EXTENSION

BEST MANAGEMENT PRACTICES:

BIOSOLIDS

Tom Buob
Dr. George O. Estes
Dr. James R. Mitchell
David Seavey

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ISSUES

Overview

The economic and environmental aspects of solid waste management are overwhelming to many communities across the nation. This publication is intended to offer some management practices which landowners can use to minimize the risks associated with the use of municipal wastewater treatment biosolids. As we gain more information about the long term effects of biosolid applications, these practices may be modified. For the purposes of this publication biosolids are defined as the solid or semisolid organic materials produced by water and wastewater treatment plants.

A recent Environmental Protection Agency (EPA) regulation, **The Standard for the Use and Disposal of Sewage Biosolids** was published in the Federal Register on February 19, 1993 and became effective on March 22, 1993. In preparing this Best Management Practices publication, the above so-called part 503 rule has been carefully considered. The EPA is expecting states to become "delegated" for biosolids management and assume the permitting responsibility. However, the states must have the administrative, technical, and legal capabilities to run the program as determined by the EPA; no state has yet been delegated. New Hampshire is not planning to request delegation, allowing all the permits to go directly through the EPA Region 1 Office in Boston, Massachusetts. For this reason, use of BMPs has special relevance to New Hampshire landowners.

Three major disposal options exist for biosolids — incineration, landfilling and landspreading. Each option has serious drawbacks. Incineration is costly, poses risks from air pollution and must rely on landfills for ash disposal. Small, poorly constructed landfill sites are rapidly being closed. Large-scale operations costing millions of dollars with tipping fees exceeding $65/ton are now in common use.

Landspreading of wastes is an expanding option to reduce the cost of waste disposal and improve farm profitability. However, farmers, the owners of the nation's most arable land can jeopardize their most valuable resource in the absence of proper management. The development of **Best Management Practices (BMPs) is of paramount importance if waste products such as Municipal Solid Waste (MSW) compost, sewage biosolids or septage are to be landspread.**

Biosolids Issues

Land application of municipal biosolids offers opportunities for nutrient enrichment and organic matter improvement to soils. Only biosolids that are nutrient-rich, stabilized to significantly reduce pathogens and low in metals are suitable for landspreading. Biosolids often have over 90% of their total nitrogen in the organic form which is mineralized to plant-available nitrate nitrogen (NO_3-N) by microbial activity. Since the rate of mineralization is governed by soil moisture and temperature, the quantity of NO_3-N supplied from a broadcast, preplant, soil incorporated application of biosolids is difficult to predict. The use of bulky, low-N, and organically-based biosolids require keen attention to management practices to address agronomic, economic and environmental issues. The use of Best Management Practices (BMPs) will help optimize crop use of N and minimize losses to the environment, particularly NO_3-N losses to groundwater. However, municipalities with significant industry may produce biosolids with high levels of heavy metals which may make them unsuitable for land application. Heavy metals of concern include zinc (Zn), copper (Cu), nickel (Ni), cadmium (Cd), chromium (Cr), lead (Pb), arsenic (As), mercury (Hg), selenium (Se) and molybdenum (Mo). They occur in all soils, crops, fertilizers and manures. The maximum amount of these metals that can be applied to land from biosolids is regulated by federal law.

Mineral soils ordinarily contain low concentrations of heavy metals. The mean concentration of the above metals in soils is 54 ppm Zn, 25 ppm Cu, 20 ppm Ni, <0.3 ppm Cd and 20 ppm Pb (McKeague and Worynetz 1980). Manures also contain such metals. Loehr (1976) showed that dairy manure contained 190-300 ppm Zn, 27-40 ppm Cu, 1-30 ppm Ni and 0.12-0.38 ppm Cd.

The critical point in landspreading of MSW, biosolids or septage is to avoid elevated soil levels of regulated metals that jeopardize the production of crops for human and animal consumption. For example, the National Research Council lists the maximum level of heavy metals in the daily diet of the dairy cow (1989). One of the most important findings of biosolids research is a recent conclusion that permits definition of low metal biosolids as having "no observed adverse effect level" (NOAEL) quality biosolids (Chaney 1990). These biosolids have especially low risk to land and crops and represent a technical basis for application criteria in the Clean Water Act 503 Regulation.

The lack of public acceptance to the land application of biosolids may be a barrier. The range of concerns involves the real case of odors to the perception of diminished property values. Strong educational programs, involving research based information, are needed to help assess the true risks.

Integrated Use

Landspreading of biosolids must be integrated into the total nutrient management plan common to most farms. Satisfactory crop production requires careful attention to testing of soils to assure that nutrients are present in adequate quantity and proper balance. **A proper nutrient management plan must consider existing soil nutrient levels and all sources of nutrients such as manures, legumes, wood ash and fertilizers. Use of a worksheet (page 10) is a commonly used method to develop proper nutrient management plans.**

Management Considerations in the Application of Biosolids to Agricultural Land

Benefits

Biosolids (nutrient-rich, stabilized to significantly reduce pathogens and low in metals) can be a valuable resource in a well managed land application program. When applied to agricultural land the advantages include:

* An inexpensive nutrient source for nitrogen and phosphorus plus small amounts of potassium and trace elements (i.e., Zn, Cu and Fe).

* Slowly available organic nitrogen in biosolids can be less likely to cause groundwater pollution than chemical nitrogen fertilizers.

* Addition of organic matter improves soil structure, permeability, water and nutrient holding capacity.

* Provides a solid waste management strategy that is a less costly option to taxpayers than either landfills or incineration.

Other Factors

Care must be taken to reduce health and environmental risks when applying biosolids to farmland. Good planning and management include biosolid and soil analysis, pre-treatment of biosolids, proper site selection, long term site utilization plan, crop selection, approved application rates and storage requirements. In addition, record keeping and continual monitoring of heavy metal and nutrient concentrations will continue to be an essential part of any land application program. Additional considerations may include:

* less convenient to use than commercial fertilizer

* odor

* public acceptance

* nutrient imbalance, particularly with lime-stabilized biosolids.

Management Considerations

The N, P and K contributions from biosolids can be of major value in crop production. To fully maximize the benefits of biosolids application and reduce potential negative impact, the following considerations include biosolids composition, site, soils, crop selection and application techniques.

Biosolid Composition

The nutrient and metal concentrations in biosolids are highly variable. Chemical comparison of selected biosolids is given in Table 1 for nutrients and regulated metals along with EPA standards for metals.

Table 1. Total elemental composition of wastewater biosolids from a number of municipalities in the U.S.[a] and lime-stabilized biosolids from Concord, N.H.[b] compared to USEPA maximum permissible limits for metals in biosolids[c].

Constituent	Range [a]	Average [a]	Range [b] Concord Biosolids
	<———	% DRY WEIGHT	———>
Total Solids	10 - 80	25	25 - 42
Total Nitrogen	< 1 - 18.2	6.0	0.6 - 2.3
Ammonia Nitrogen	< 0.01 - 6.8	0.16	.08 - .13
Nitrate Nitrogen	< 0.1 - 0.5	< 0.1	< 0.1
Organic Nitrogen	< 1 - 12.9	5.8	0.5 - 2.1
Total Potassium	0.3 - 0.4	0.36	< 0.01 - .64
Total Phosphorus	2.6 - 3.1	2.9	< 0.01 - 2.1
	Range [a]	USEPA Limits mg/kg (ppm)	
	<———	Ceiling Concentration / Pollutant Concentration	---------->
Arsenic	6 - 230	75 / 41	0.5 - 1.0
Cadmium	< 1. - 3400	85 / 39	2.1 - 7.5
Chromium (Total)	50 - 2000	3000 / 1200	116 - 404
Copper	80 - 10000	4300 / 1500	190 - 350
Lead	10 - 19700	840 / 300	60 - 241
Mercury	< 1.0 - 5.0	57 / 17	> 1.0 - 3.0
Molybdenum	5 - 39	75 / ---	< 1 - .1
Nickel	2 - 3600	420 / 420	17 - 350
Selenium	------	100 / 36	0.5 - 1.0
Zinc	101 - 27800	7500 / 2800	567 - 800

a. Sommers, L.E. 1977.Chemical composition of sewage biosolids and analysis of their potential use as fertilizers. J. Environ. Quality. 6:225.
b. Concord Wastewater Treatment Facility, Concord, N.H. (1992-93 Sampling period).
c. EPA 503 Limits above which biosolids may not be applied to land.

The composition of nitrogen, phosphorus and potassium of the Concord, N.H. biosolids cake is shown in Table 2. The nitrogen concentration is often the most important factor affecting its application rates for crops. The chemical composition of biosolids may be highly variable due to the treatment processes.

Table 2. An Example of N, P, K Analysis - One Ton Biosolids Cake Dry (Concord, 2/2/93)

	Nitrogen (TKN)	Phosphorus(P)	Potassium(K)
Lbs.	23.2	22.9	7.6
Parts per million	11,600	21,210	3822
Percent	1.16	2.12	.38

Another factor determining biosolids application rates is its heavy metal content. Certain limitations have been placed on the allowable levels of heavy metals in biosolids and soils for agricultural use (Table 1). A high Cation Exchange Capacity (CEC) of soil (governed by its clay and organic matter content) and a high (> 6.5) soil pH increases the binding of heavy metals.

* The most desirable biosolid contains only small amounts of heavy metals and toxic organic compounds. Biosolids must meet EPA metal criteria (Table 1) before being land applied.
* Application rates are primarily determined by the nitrogen contribution of the biosolid and its concentration of heavy metals. The nitrogen requirement for the crop is determined by the yield potential of the specific soil type. Other considerations include crop needs, soil test information and the allowable maximum cumulative loading rate (EPA 503 Regs).
* All biosolids applied to agricultural land are treated to reduce pathogens (disease-causing organisms).
* Composting of municipal biosolids is a growing practice that reduces volume, controls odor, kills more pathogens and improves physical characteristics.

Site and Soils

* Sites for biosolids application normally include soils suitable for agricultural production and land reclamation. Application sites in aquifer recharge areas require extra nutrient management controls. Biosolids application to soils may limit their use for certain crops in the future.
* Soil pH should be maintained above 6.5 to reduce the solubility and plant uptake of metals.
* Loading rate of soils should be governed by its cation exchange capacity (CEC). Heavy upland soils with their high CEC may permit a higher loading of heavy metals than soils with a low CEC. Soil variability should be evaluated when selecting a site.
* Biosolids should not be applied near any watercourse or water supply, on sites that frequently flood, on sites with high water tables or on slopes likely to have surface runoff.

To reduce the potential risk from nutrient contamination of surface or subsurface water:

(1) Biosolids should not be surface applied within 100 feet from any surface water. If biosolids are incorporated into the soil within 24 hours, they may be applied within 50 feet from surface waters, or 33 feet from intermittent streams.

(2) Biosolids should not be applied to the land within 300 feet of any off-site private well, 200 feet from any on-site private well, and 500 feet from any community well or municipal water

supply well.

(3) Biosolids should not be applied during periods of high water table.

Crop Considerations

The ideal crop will exhibit minimal uptake of metals and display significant benefit from the nutrients in biosolids. Since limited research data exists on effects of biosolids application on New England soils, UNH Cooperative Extension prefers to see biosolids first applied to non-agricultural land. The following recommendations from higher priority to lower priority types of land for biosolids application reflect this concern.

Non-Cropland

--Capping landfills --Strip-mined areas --Roadside restoration

Non-Food Crops

* Turf
  --ski slopes --athletic field renovations --landscape sites
* Forests
* Nurseries
  -- many deciduous trees and shrubs (with the exception of evergreens) can be grown in soils with a high pH.
* Gravel pit restoration (single application at seeding)
  -- An extra degree of care is required since many gravel pits are aquifer recharge areas. Minimizing nitrogen application rates should decrease the risk of nitrogen leaching into the groundwater.

Feed Crops

* Ear Corn
  -- The part of the plant which is harvested will govern the nutrient/metal removal; e.g., cadmium does not normally collect in grain (Hermanson et.al. 1987).
* Pasture and Hayland
  -- Fall maintenance applications are **preferred** and should be made before the ground freezes. The preferred application time is immediately after forage harvest. A desirable time period between application and harvest or grazing to preserve animal acceptability should be a minimum of 45 days.
  -- The ideal practice is to make topdressing applications prior to anticipated rainfall.
  -- Incorporate biosolids prior to spring or August seedings.
* Small Grains
  -- Incorporate biosolids prior to planting.
* Silage Corn
  -- Incorporate biosolids prior to planting.

Food Crops

* Vegetables and Small Fruits
  -- Avoid biosolids applications to land where food crops are grown. Leaf and root crops are the greatest accumulators of heavy metals. Careful management and monitoring of the soil and crop is critical (Hermanson et.al. 1987).

Application Techniques

* When possible, biosolids spreading should be done when weather conditions allow rapid odor dissipation.
* Annual biosolids loading rates and supplemental fertilizer requirements are based on biosolids and soil analysis. Total available nitrogen in a given year should not exceed crop requirements.
* The choice of land application equipment is determined by the physical characteristics of the biosolids. Equipment should be calibrated to insure uniform accurate rates of application.
* Biosolids should be spread evenly over the ground and incorporated within 24 hours by discing or plowing whenever possible.
* Heavy equipment should not be used when the soil is wet in order to minimize soil compaction.
* Biosolids should not be applied on soils that are frozen, excessively wet or covered with snow.

Storage

* On-site storage (stockpiling) should adhere to the following setbacks:
  (1) 500 feet from off-site dwellings or private water supply;
  (2) 300 feet from on-site dwellings and wells;
  (3) 100 feet from any public roads.
* Strict access control is necessary.
* Stockpiles should be spread within a six month period.

Nutrient Release From Biosolids

Biosolids normally contains low levels of nitrogen, principally, in organic form. Nitrogen release by microbial activity may be highly variable during the growing season depending on soil moisture and temperature. Organic residuals such as biosolids are usually applied to agricultural soils at rates based on **assumed** contributions of available N to the growing crop. Predicting the amount of available N from biosolids which will be released to the crop during its growing season is an inexact science. The release of nitrogen (N) from residuals to available form to plants is called **mineralization**. Douglas and Magdoff (1991) found that the greatest net mineralization was from uncomposted sewage biosolids (8.6 - 60 lbs/ton) followed by uncomposted manures (-5.2 - 22 lbs/ton); the negative 5.2 lbs/ton indicate N immobilization.

Low levels of potassium are also common in sewage biosolids, usually in the order of 0.3-0.4% total K compared to 5-6% total N and 2-3% total P. Thus, nutrient management plans which include significant amounts of land-applied biosolids may need to include supplemental levels of potassium.

One of the special concerns associated with any biosolids which is to be land applied relates to the processes to reduce pathogens, one of which is short-term lime stabilization. This method involves raising the pH to 12 for a short period of time. Hydrated lime is often used to achieve this rapid pH elevation. Use of such stabilized biosolids on agricultural land, therefore, involves a high pH material containing large amounts of readily available calcium. Since proper nutrient balance of K, Ca and Mg is essential for good plant growth, the potential for an imbalance of these bases - brought about by soil

incorporation of calcium-laden biosolids — must be avoided. It is possible that **calcium rather than nitrogen loading** will pose the most limiting factor in using biosolids and septage on agricultural land. Research data (McLean et.al.1983) show results that "strongly suggest that for maximum crop yields, emphasis should be placed on providing sufficient, but not excessive levels of each basic cation". Suggested soil cation saturation ratios of the cation exchange complex (CEC) from many literature sources support the following levels of basic cations:

Potassium 3-6% Magnesium 12-13% Calcium 65-80%

Monitoring and Recordkeeping

In the Northeast two unique situations exist which require long term monitoring: (1) New England soils are naturally acidic and pH levels need to be maintained in the 6.5 range even after the site is closed; and (2) concern exists about the release of heavy metals from organic matter as the organic fraction breaks down and the soil pH declines. Careful attention must be paid to this situation to minimize the uptake of heavy metals into the food chain.

Since no permits are required for land application of biosolids which meet EPA quality standards, good stewardship requires a program of site monitoring. This can help assess the nutrient and metal loading effects during the application period as well as after the site has reached its loading capacity. Major considerations include the potential loss of nitrogen and metals as non-point source pollutants and the development of nutrient imbalances which may have negative effects on long term crop production.

Good recordkeeping is crucial to a successful land application program. In the long term production of any crop field records are an indispensable tool in evaluating the effects of nutrient (fertilizers, manures and biosolids) applications on soil fertility and crop response. In order to evaluate the effectiveness of biosolids applications complete records (soil test results, recommendations, applications rates, nutrient analysis, etc.) are a necessary portion of every land application program.

BMPs Monitoring Plan:

* Complete Soil Sample Analysis prior to each biosolids application is required. In N.H. the use of the Analytical Services Lab at UNH is highly recommended (basic test, organic matter and environmental package etc.).

* As with conventional materials, test **soil nitrate** levels annually when corn is "8-15" tall to determine the crop nitrogen need. Consideration must be given to the amount of residual nitrates in order to better safeguard the drinking water standards. A fall soil nitrate test may be needed in instances where a water quality concern exists.

* Mineral analysis of feed crops from fields which have received repeated applications of biosolids is recommended to enhance dairy ration balancing.

* Complete cropping records should be kept on individual fields to help evaluate the effects of the land application program on crop production.

References Cited

1. Chaney, Rufus L., September 1990. *Twenty Years of Land Application Research.* BioCycle. 31(9):54-59.

2. Chaney, Rufus L., October 1990. *Public Health and Sludge Utilization.* BioCycle. 31(10):68-73.

3. Douglas, B.F. and F.R. Magdoff. 1991. *An Evaluation of Nitrogen Mineralization Indices for Organic Residues.* J.Environ. Qual. 20:368-372.

4. Hermanson, R.E., C. Cogger and C. Engle. 1987. *Sewage Sludge Guidelines for Washington.* Part One: Application to Farmland. Part Two: Site Selection and Management. Part Three: Sample Problem and Worksheet for Calculating Biosolids Application Rates.

5. Klausner, S. and D. Bouldin. March 1983. *Managing Animal Manure as a Resource.* Part II: Field Management. Department of Agronomy Cornell University.

6. Loehr, Raymond C.(ed.). 1976. *Land as a Waste Management Alternative.* Ann Arbor Science Publishers Inc., P.O. Box 1425. Ann Arbor, Michigan 48106.

7. Mathers, A.C. and D.W. Goss 1979. *Estimating Animal Waste Applications to Supply Crop Nitrogen Requirements.* Soil Sci. Soc. Am. J. 43:364-366.

8. McKeague, J.A. and M.S. Worynetz. 1980. *Background Levels of Minor Elements in Some Canadian Soils.* Geoderma. 24:299-307.

9. McLean, E.O., R.C. Hartwig, D.J. Eckert and G.B. Triplett. 1983. *Basic Cation Saturation Ratios as a Basis for Fertilizing and Liming Agronomic Crops II.* Field studies. Agronomy Journal. 75:635-639.

10. Mitchell, J.R. 1990. *Best Management Practices - Nutrients.* University of New Hampshire Cooperative Extension.

11. *Nutrient Requirements for Dairy Cattle.* Sixth Revised Edition. 1989. National Academy Press. Washington, D.C. 1988.

Contributing Authors

Tom Buob. Extension Educator. Agricultural Resources. Grafton County Office. University of New Hampshire Cooperative Extension. North Haverhill, NH.

Dr. George O. Estes. Professor of Plant Biology. University of New Hampshire. Durham, NH.

Dr. James R. Mitchell. Extension Specialist. Agronomy. University of New Hampshire Cooperative Extension. Durham, NH.

David Seavey. Extension Educator. Agricultural Resources. Merrimack County Office. University of New Hampshire Cooperative Extension. Boscawen, NH.

NUTRIENT MANAGEMENT WORKSHEET

Use of this worksheet will assist in determining the proper application rate of biosolids. The amount of biosolids to be applied is the difference between the nutrient requirements for a crop and the sources of nutrient credits available prior to biosolids application. The use of biosolids usually precludes the use of manure (and vice versa). The following examples are for illustration only. For other specific crop requirements contact your County Cooperative Extension office.

Nutrient Requirement Considerations:

Crop: Common uses for biosolids include corn (silage or grain), establishing or topdressing grass hay and turf grasses. Nitrogen is the major nutrient for which most biosolids are used. Many also supply significant amounts of phosphorus.

Table 4: Typical Nutrient Requirements for N.H. Crops

Nutrient	lbs/ton Corn	lbs/acre Turfgrass Estab.	lbs/acre Turfgrass Topdress	lbs/acre Hay Estab.	lbs/acre Hay Topdress
Nitrogen	7	65	85	40	50
Phosphorus	3	130	30	100	0
Potassium	8	65	60	100	50

Yield potential: The soil type is a key factor in determining the yield potential. If data on the specific soil type is not known or available, the following yield potentials should be used:

Corn silage 15 - 18 T/A

For typical corn silage production (18-22 tons/acre) NO more than a total of 150 lbs/acre of available Nitrogen should be applied.

Grass hay 2.2 - 2.5 T/A

Under nominal management (1 - 2 cuttings/yr), NO MORE than a total of 40 - 60 lbs/acre of available nitrogen should be applied.

Under normal management (3 cuttings/yr), NO MORE than a total of 70 - 90 lbs/acre of available nitrogen should be applied.

Under intensive management (4 - 5 cuttings/yr), NO MORE than a total of 100 - 120 lbs/acre of available nitrogen should be applied.

Soil fertility: Nitrogen and phosphorus provide the major nutrient contribution from biosolids. A good soil testing program is crucial to determine the need for supplemental P & K.

Lime equivalent: Since lime stabilized biosolids can contain a significant amount of lime equivalent, caution must be used to reduce the risk of raising the soil pH above a desirable level. (If this occurs, the most common method of adjusting the pH back into the desirable range is applying sulfur.)

Non-nutrient Considerations:

Pasture: Biosolids applied to land used for pasture, or for pasture and hay, can affect palatability of the crop. Scheduling the application after the grazing season is completed for the year reduces the risk of palatability problems.

Sources of Nutrient Credits:

Crop history: Significant credits from crop rotation sequences help to meet the crop requirements.

Manure/biosolids history: The organic nitrogen from previous applications contribute to the nutrient pool over a period of years.

Residual soil nutrients: Soils vary in their native ability to supply nitrogen to a crop. The amount is related to the organic matter content and texture of the soil. Therefore, a soil test including organic matter content is important in estimating the nutrient requirements for the crop to be grown.

Residual nitrogen: A portion of the nitrogen from previous manure or biosolids applications is available each year (Table 5). This must be accounted for in the current year's application rate determination (Line 6) if previous applications were made on the site.

Cover crop: Cover crops planted in the summer or early fall help to recycle nutrients and help to reduce nitrogen leaching losses after harvest.

Nutrient Credits

1. Crop history: Crop rotation sequences can provide significant amounts of nutrients.

   a)
   * Grass sod = credit 40 lbs Nitrogen
   * Legume-grass = credit 40 lbs Nitrogen from grass sod plus 1 lb for each 1% of legume in stand.
   * Corn Silage = credit 0 lbs Nitrogen
   * Corn Stalks = credit 30 - 40 lbs Nitrogen (following corn harvested for grain)

   b) Nitrogen from manure history based on organic decay series (Klausner & Bouldon 1983).

   c) Soil supply approximately 10 lbs of Nitrogen per 1% of organic matter.

   d) Credit 20-40 lbs/acre of Nitrogen for cover crop.

Table 5: Percent of Total Nitrogen Available from Previous Applications of Manure or Biosolids (Klausner & Bouldon 1983; EPA 503 Regs. 1992; Douglas and Magdoff 1991)

Time after biosolids/manure application (Year)	% of Org-N Mineralized from Manure	% of Org-N Mineralized from Activated Sewage Biosolids	% of Org-N Mineralized from Anaerobically Digested Sewage Biosolids	% of Org-N Mineralized from Composted Sewage Biosolids
0 - 1	40	50	30	10
1 - 2	15	30	20	5
2 - 3	5	15	10	3
3 - 4	2	4	5	3
4 + yrs.	2	3	5	3

Worksheet Procedure for Determining the Biosolids Application Rate

1. Determine the crop and crop requirements (Table 4)

2. From the crop history section (above) determine:
   a) Nitrogen from a **previous** crop, if any
   b) Nitrogen from previous manure/biosolids applications (Table 5)
   c) Nitrogen from soil organic matter (soil test)
   d) Nitrogen from cover crop

3. Determine the amount of Nitrogen to be applied from biosolids

   N REQUIRED = N CROP - N CREDITS

Use the Biosolids Nutrient Analysis table [D] to list the nutrients in your biosolids. Then follow steps as indicated on lines 1 thru 9 to determine the actual application rate for the crop to be grown.

Worksheet: Example 1 Turfgrass Establishment

A. Requirements:

Crop - Turfgrass (65-130-65)
Yield Potential N/A

Nutrients required: *(see Text Table 4)*[p.10]

1 N 65 lbs/acre
2 P 130 lbs/acre
3 K 65 lbs/acre

B. Credits: Derived from Crop History [p.11]

	lbs/acre
1 - Corn silage	0
2 - No Manure/Biosolids	0
3 - %O.M. = 2 x 10	20
4 - Rye Cover Crop	0
Total Credits	20 lbs/acre

C. Nitrogen required from Biosolids: 65 lbs/acre [A] - 20 lbs/acre [B] = 45 lbs/acre [C]

D. Biosolids Nutrient Analysis - Activated Sewage Biosolids (Example)

Nutrient		Percent	Nutrient Contribution, lbs/ton	
			Surface Applied	Soil Incorporated
1)	% Total N	1.15	23	23
2)	% NH_4-N*	.13	1.3*	2.6*
3)	% NO_3-N	0	0	0
4)	% Organic N	1.02	20.4	20.4
5)	% Solids	30.		

*When surface applied, approximately 50% of the Ammonium (NH_4-N) Nitrogen will be lost to volatilization.

Biosolids Application Rate in Tons/Acre — Soil Incorporated

Line

1 **Available Nitrate N** = %NO_3-N [D3] — 0 lbs/ton

2 **Available Ammonium N** = Recovery fraction x NH_4-N [D2]
>(Recovery fraction is estimated as .5 for surface-applied biosolids and 1.0 for incorporated biosolids.) — 2.6

3 **Available Inorganic N** = Available NH_4 [line 2] + NO_3 [line 1] — 2.6

4 **Organic N** [D4] = [Total N [D1] - Inorganic N [D2 + D3]] — 20.4

5 **Available Organic N** = Organic N [line 4] x mineralization rate [Table 5]
20.4 x 50% — 10.2

6△ **Residual N** = [30% x Org-N yr 1-2] + [15% x Org-N yr 2-3] + [4% x Org-N yr 3-4]) [Table 5] — 0

7 **Total Available N** = Inorganic N [line 3] + Avail. Org. N [line 5] + Residual N [line 6] — 12.8 lbs/ton

8 **Biosolids Application (dry) Rate** = N Required from biosolids/Avail. N from biosolids
(45/12.8) [C/line 7] — 3.5 tons/acre

9 **Biosolids Application (wet) Rate** = Dry Biosolids Rate/% Solids
(3.5/30%) [line 8/D.5] — 11.7 tons/acre

△ *Line 6 - Residual N is necessary with previous applications only*
NOTE: Heavy metal loading rate may limit application rate based on Nitrogen

Worksheet: Example 2

A. Requirements:

Crop - Corn (7-3-8)
Yield Potential 25 tons/acre

Nutrients required: *(see Text Table 4)*[p.10]

1 N 175 lbs/acre
2 P 75 lbs/acre
3 K 200 lbs/acre

B. Credits: Derived from Crop History [p.11]

	lbs/acre
1 - Grass Sod	40
2 - Manure/Biosolids	0
3 - %O.M. = 3 x 10	30
4 - Rye Cover Crop	0
Total Credits	**70 lbs/acre**

C. Nitrogen required from Biosolids: 175 lbs/acre [A] - 70 lbs/acre [B] = 105 lbs/acre [C]

D. Biosolids Nutrient Analysis - Anaerobic Digestion (Example)

	Nutrient	Percent	Nutrient Contribution, lbs/ton	
			Surface Applied	Soil Incorporated
1)	% Total N	7.2	144	144
2)	% NH_4-N*	.7	7*	14*
3)	% NO_3-N	0	0	0
4)	% Organic N	6.5	130	130
5)	% Solids	16.0		

*When surface applied, approximately 50% of the Ammonium (NH_4-N) Nitrogen will be lost to volatilization.

Biosolids Application Rate in Tons/Acre — Soil Incorporated

Line		
1	**Available Nitrate N** = %NO_3-N [D3]	0 lbs/ton
2	**Available Ammonium N** = Recovery fraction x NH_4-N [D2] >(Recovery fraction is estimated as .5 for surface-applied biosolids and 1.0 for incorporated biosolids.)	14
3	**Available Inorganic N** = Available NH_4 [line 2] + NO_3 [line 1]	14
4	**Organic N** [D4] = [Total N [D1] - Inorganic N [D2 + D3]]	130
5	**Available Organic N** = Organic N [line 4] x mineralization rate [Table 5] 130 x 30%	39
6▵	**Residual N** = [20% x Org-N yr 1-2] + [15% x Org-N yr 2-3] + [5% x Org-N yr 3-4]) [Table 5]	0
7	**Total Available N** = Inorganic N [line 3] + Avail. Org. N [line 5] + Residual N [line 6]	53 lbs/ton
8	**Biosolids Application (dry) Rate** = N Required from biosolids/Avail. N from biosolids (105/53) [C/line 7]	2.0 tons/acre
9	**Biosolids Application (wet) Rate** = Dry Biosolids Rate/% Solids (2.0/16%) [line 8/D.5]	12.5 tons/acre

▵ *Line 6 - Residual N is necessary with previous applications only*
NOTE: Heavy metal loading rate may limit application rate based on Nitrogen

Worksheet:

A. Requirements:

Crop - (___ - ___ - ___)
Yield Potential

Nutrients required: *(from Soil Test)*

1 N ___ lbs/acre
2 P ___ lbs/acre
3 K ___ lbs/acre

B. Credits: Derived from Crop History [p.11]

lbs/acre

1 - Continuous Corn ___
2 - Manure/Biosolids ___
3 - %O.M. = ___ x 10 ___

Total Credits ____ **lbs/acre**

C. Nitrogen required from Biosolids: ___ lbs/acre [A] - ___ lbs/acre [B] = ___ lbs/acre [C]

D. Biosolids Nutrient Analysis - (Laboratory Results)

	Nutrient	Percent	Nutrient Contribution, lbs/ton	
			Surface Applied	Soil Incorporated
1)	% Total N			
2)	% NH_4-N*			
3)	% NO_3-N			
4)	% Organic N			
5)	% Solids			

*When surface applied, approximately 50% of the Ammonium (NH_4-N) Nitrogen will be lost to volatilization.

Biosolids Application Rate in Tons/Acre _____

Line

1 **Available Nitrate N** = %NO_3-N [D3] _____ lbs/ton

2 **Available Ammonium N** = Recovery fraction x NH_4-N [D2]
>(Recovery fraction is estimated as .5 for surface-applied biosolids and 1.0 for incorporated biosolids.) _____

3 **Available Inorganic N** = Available NH_4 [line 2] + NO_3 [line 1] _____

4 **Organic N** [D4] = [Total N [D1] - Inorganic N [D2 + D3]] _____

5 **Available Organic N** = Organic N [line 4] x mineralization rate [Table 5]
____ x ____ _____

6▵ **Residual N** = [20% x Org-N yr 1-2] + [15% x Org-N yr 2-3] + [5% x Org-N yr 3-4]) [Table 5] _____

7 **Total Available N** = Inorganic N [line 3] + Avail. Org. N [line 5] + Residual N [line 6] _____ lbs/ton

8 **Biosolids Application (dry) Rate** = N Required from biosolids/Avail. N from biosolids
(/) [C/line 7] _____ tons/acre

9 **Biosolids Application (wet) Rate** = Dry Biosolids Rate/% Solids
(/) [line 8/D.5] _____ tons/acre

▵ *Line 6 - Residual N is necessary with previous applications only*
NOTE: Heavy metal loading rate may limit application rate based on Nitrogen

Read directions on reverse side. Return completed form and sample tags with sample(s).

1. Mailing address
   Name _____
   Address _____
   _____
   Town and zip _____
   Phone _____
   FAX _____
   e-mail _____

Reports will be sent by e-mail or FAX (dedicated line only) if you supply e-mail or FAX information, otherwise reports are mailed to you.

Copies of all commercial reports are sent to the county Cooperative Extension office. Note below any individuals to whom additional copies should be sent:

_____
_____
_____
_____
_____

Commercial Corn/Forage/Pasture and Biosolids Spreading Soil Test Information

Analytical Services Lab
University of New Hampshire
Spaulding Life Science Center, Room G-54
Durham, New Hampshire 03824
http://www.ceinfo.unh.edu/Agriculture/Documents/SoilTest.htm
phone: 603-862-3210, e-mail Soil.Testing@unh.edu

SAMPLE INFORMATION: Fill in information below for each soil sample. See directions, crop codes, *etc.* on reverse side.
Check box if **Diagnosing crop problem** [] or if for **Organic certification** []. These reports will be reviewed by Cooperative Extension prior to mailing.

	2.	3.	4.	5.		6.			7.		8.	9.	10.
SAMPLE	YOUR SAMPLE NAME	ACRES	SOILTYPE	CROP CODES		Manure applied in past 12 months			Previous Applications of Manure		OTHER (Biosolids, variety, cuttings, yield goal, etc. See back for instructions.)	TEST CODES (See list below)	FEE (See below)
				Prior crop in year _____	Crop for year _____	Type Code	Month #	Tons/Acre	# Years	Tons/Acre			
1.													
2.													
3.													
4.													
5.													
6.													
7.													
8.													

Test Codes and fees*

S	Standard (pH, SMPpH,texture, Ca, Mg, K, P)	$12.00	SM	Standard *plus* micros (Cu, Zn, Fe, Mn, Mo, B)	18.00
OM	Organic matter	5.00			
TC	Texture class (%sand, silt, clay)	25.00			
NO3	Nitrate	8.00			

*Effective through 6/30/03. Call for changes after 6/30/03.

Method of payment

TOTAL FEE _____

[] Cash (do not send cash through the mail)
[] Check (payable to UNH) [] Existing Account
[] VISA [] MasterCard
Card number _____ _____ _____ _____
Expiration date ____ ____
Cardholder's name _____
Signature _____

Rev. 011303

INSTRUCTIONS for Completing the Soil Test Form

Take soil samples with care. If the sample is not representative of the area, the test results and lime and fertilizer recommendations will be of no value! Take samples from 15-20 locations per field, mix well, and submit approximately 1 cup for testing. Sample to the following depths: Corn/Forage/Pasture - to plow depth (or 3" for topdress or no-till). *Samples for nitrate must sampled to 12" depth and dried or frozen immediately after sampling.*

1. FILL IN your NAME and ADDRESS. Include a FAX number or E-MAIL ADDRESS if you wish results transmitted electronically.
2. FILL IN your SAMPLE NAME or ID (*e.g.* Field 1, Lower Field, *etc.*)
3. FILL IN the NUMBER OF ACRES
4. FILL IN the SOIL TYPE
5. FILL IN the **PRIOR CROP** (and year grown) from the following list. (The prior crop is used to calculate nutrient credits for Corn, forage and pasture crops.)

1. Grass Sod	3. Good clover (60-100%)	5. Good alfalfa (60-100%)	7. Cover crop
2. Fair Clover (20-60%)	4. Fair alfalfa (20-60%)	6. Corn for grain	8. None of the preceding

FILL IN THE **CROP** code from the following list and indicate the crop year in the space provided. This is the crop for which you wish lime and fertilizer recommendations.

Corn/Forage/Pasture

151 Corn Silage
152 Corn for grain
153 Alfalfa-grass, seeding
154 Alfalfa-grass, topdress
155 Alfalfa, seeding
156 Alfalfa, topdress
157 Clover-grass, hay, seeding
158 Clover-grass, hay, topdress
159 Clover-grass, pasture, seeding
160 Clover-grass, pasture, topdress
161 Grass, hay, seeding
162 Grass, hay, topdress
163 Grass pasture, seeding
164 Grass pasture, topdress
165 Summer annuals (millet, sudan grass, etc.)
166 Soybeans
199 Other (specify)

6. FILL IN the TYPE of MANURE and TONS/ACRE applied in the past 12 months from the following list , indicating the month number for the application (*e.g.* January = 1, February = 2, *etc.*) For liquid manure, you may enter gallons/acre followed by a "G". This value will be divided by 250 to convert it to a solid manure equivalent. (This information is used on corn, forage and pasture crops to calculate recent nutrient credits.)

1. Cow, solid	3. Poultry, fresh	5. Poultry, dry crumbly	7. Horse
2. Cow, liquid	4. Poultry, sticky crumbly	6. Poultry, liquid	

7. FILL IN the NUMBER OF YEARS and TONS/ACRE for previous manure application. Do not include application in the past 12 months. For liquid manure, you may enter gallons/acre followed by a "G". This value will be divided by 250 to convert it to a solid manure equivalent. (This information is used on corn, forage and pasture crops to calculate long-term nutrient credits. In some cases an ORGANIC MATTER TEST will be used to calculate these credits.)
8. FILL IN OTHER: For corn silage or grain indicate yield goal (15, 20 or 25 tons/acre). For alfalfa, clover, and hay indicate number of cuttings (1-2, 3-4 or 5). If spreading BIOSOLIDS, indicate here by entering "B."
9. FILL IN desired tests using test codes on the front of this form.
10. FILL IN the FEES for each sample, total them, and indicate METHOD OF PAYMENT. Mail or deliver to the address on the front of this form.