Saving Soil

Biosolids Recycling in New England

New England Biosolids and Residuals Association
September 2001

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Saving Soil: Biosolids Recycling in New England

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Chapter I – Executive Summary

Over the past several years, public interest in the recycling of biosolids has grown in New England and in several other regions of the United States. In particular, concerns have been raised about the potential impacts of biosolids recycling on public health and the environment. This has led to a demand for accurate information and data regarding current biosolids recycling practices and the quality of biosolids products. In an effort to meet this demand, the New England Biosolids and Residuals Association (NEBRA) has created this report, *Saving Soil: Biosolids Recycling in New England*.

This report provides background information about biosolids recycling, applicable regulations, and state-by-state summaries of recent developments in biosolids management in the region. Included are definitions of common terms, explanatory charts, tables, and graphs, and five specific case studies of representative New England biosolids recycling operations.

Saving Soil provides the best current estimates of how biosolids are managed in each of the New England states, including the percentages of biosolids landfilled, incinerated, and recycled through heat drying, composting, or land application.

There are about 600 publicly owned wastewater treatment facilities throughout New England that managed approximately 425,000 dry tons of sewage sludge in 2000. Just over one-fifth of the regional sewage sludge total was recycled as biosolids and soil amendment products. Of the more than 93,000 dry tons of biosolids recycled in 2000, 18.5% were treated to Class B standards for bulk use on agricultural land and 81.5% were treated to Class A standards for general landscape and gardening use through composting or heat drying.

If they had been thrown away, the New England biosolids recycled in 2000 would have required an estimated 350,000 cubic yards of landfill space (i.e. 6 landfills, each the size of a football field and 33 feet deep). In addition, New England biosolids recycled in 2000 provided an estimated 3.7 million pounds of nitrogen (assuming a conservative average biosolids content of 2% nitrogen). NEBRA estimates that an equivalent amount of chemical fertilizer nitrogen would have cost $1.3 million.

Individual biosolids recycling rates and systems vary within New England. In recent years, Maine has had the highest recycling rate in the region, with more than 90% of its sewage sludge treated for beneficial use in agricultural and general landscaping applications. Vermont recycles about 75% of its sewage sludge, primarily through composting. New Hampshire's rate of recycling has declined from 50% in 1996 to 30% in 2000, due primarily to public scrutiny and stricter state and local biosolids land application regulations. Massachusetts recycles about 20% of the sewage sludge produced in the state, almost all of it as Class A material, including a large proportion of

Boston's Massachusetts Water Resources Authority (MWRA) heat dried "Bay State Fertilizer." Connecticut and Rhode Island each have recycling rates below 10%.

Much of the *Saving Soil* report focuses on the quality of New England's recycled biosolids, including chemical and trace metals data. Analysis of seven years of data for 37 New England biosolids products shows that average concentrations of the ten metals for which testing is typically required are remarkably consistent across the region.

NEBRA found that state averages of trace metals in biosolids from recent testing data are uniformly well within the federal Exceptional Quality ("EQ:" Part 503, Table 3) standards and individual states' strictest standards. Further analysis of the trace metals data shows a downward trend in trace metals levels over recent years as improved industrial pretreatment, pollution prevention, and other programs continue to reduce the concentration of trace metals in wastewater. The data also shows that, from 1994 to 2000, the average concentrations of the trace metals of greatest concern to the public (mercury, cadmium, arsenic, and lead) are also very low.

Saving Soil notes that some decline in biosolids recycling rates has occurred in most New England states in the past few years, despite significant improvements and investments in biosolids recycling programs. The future of biosolids recycling in New England will depend on further public acceptance, continuing growth in demand for biosolids products, and other factors.

Chapter II - Background and Biosolids in New England

2.1 Some History

Human wastes have been recycled to soils throughout history. Wastewater sewage solids have been recycled since the first wastewater treatment facilities were constructed in the 19th century. Today, the term "biosolids" describes those wastewater solids that have been treated and tested and are safely and beneficially used to fertilize plants and build healthy soils.

A recent steady growth in the recycling of biosolids in the United States (U.S.) grew out of early 1970s regulations to clean up the nation's waterways, which had become polluted by decades of raw sewage dumping. The Clean Water Act of 1972 set uniform technology-based effluent standards and a national discharge permit system to control the quality of wastewater entering natural waterways. Grants were made to municipalities to assist in constructing the wastewater treatment facilities needed to meet the new discharge standards.

In the mid-late 1900s, wastewater solids separated out through the treatment system generally were disposed of at sea, incinerated, or landfilled. However, in some locations, these sewage sludges were used in agriculture. For instance, Milwaukee, Wisconsin began creating and selling dried sewage sludge fertilizer– Milorganite®–in 1926.

In the late 1970s and early 1980s, federal source control and industrial wastewater pre-treatment programs were initiated to ensure that industrial wastes discharged to municipal sewers would not be toxic, pass through treatment systems, or negatively impact the quality of biosolids. Because of these controls, municipal wastewater and the resulting biosolids today contain very low levels of trace contaminants.

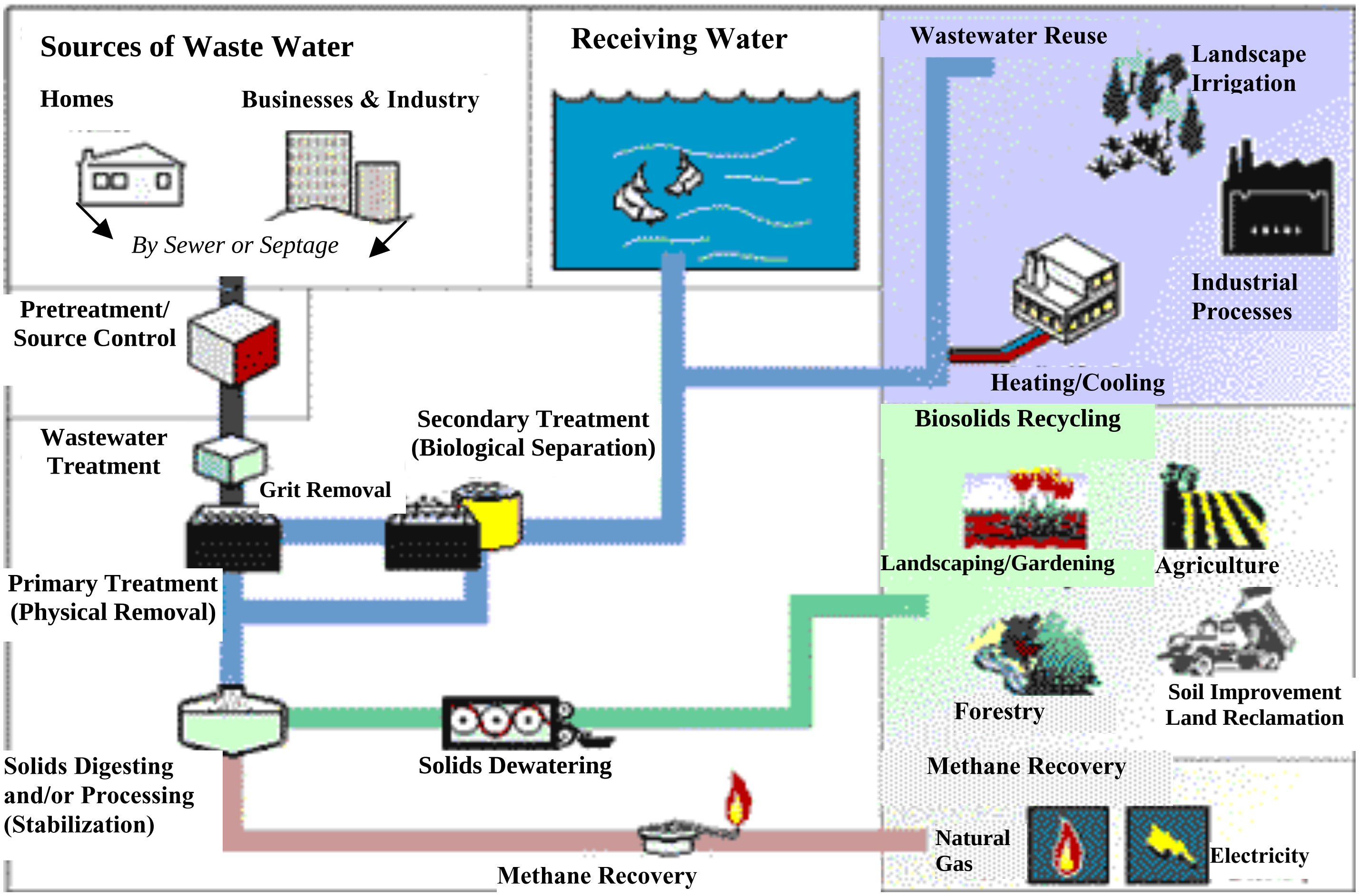
biosolid n. (1990) 'bI-O-"sä-lîd: solid organic matter recovered from a sewage treatment process and used esp. as fertilizer -- usu. used in pl. --*Merriam-Webster's Collegiate Dictionary, Tenth Edition*

biosolids: plural noun: organic matter recycled from sewage , especially for use in agriculture. --*New Oxford Dictionary of English, 1998*

Biosolids means any sludge derived from a sewage wastewater treatment facility that meets the standards for beneficial reuse specified by the department. -- *New Hampshire law, Senate Bill 307, adopted 2000.*

When Congress banned the ocean disposal of sewage sludge in the late 1980s, coastal cities, such as Boston, were required to seek alternative sewage sludge management practices. This factor, along with new, more stringent air quality regulations of the 1990s (which impacted incineration), limited landfill space, and an interest in developing sustainable systems, further encouraged biosolids recycling.

Chart 2.1: Typical Wastewater Treatment Process



Source: Northwest Biosolids Management Association

2.2. How Are Biosolids Created?
Biosolids are a byproduct of municipal wastewater systems (illustrated in Chart 2.1) that manage and treat much of the organic waste people produce every day. In urban areas, human waste, food scraps, and used water flows from homes, offices, and factories into sewers.

In more rural areas, septage removed from septic tanks is stored in lagoons, recycled on farm fields, or trucked to wastewater treatment facilities for treatment. Wastewater treatment facilities separate organic matter and other solid materials from the wastewater. The water is treated and discharged to a river, groundwater, or

Wastewater treatment facilities are often called ***POTWs***--Publicly-Owned Treatment Works.
Sewage sludge is the federal legal term for the solids removed from wastewater at wastewater treatment facilities; also called "sludge," although "sludge" can refer to many other things as well.
Wastewater solids is another way of describing sewage sludge.
Septage is what is pumped out of septic tanks.
Water quality professionals, or ***operators***, who work at wastewater treatment facilities use the terms "sludge" or "solids" to refer to the liquid or semi-solid materials removed from wastewater that have not been treated or tested.

the ocean. The wastewater solids, removed from the wastewater, are also called *sewage sludge*. They are treated so that they can be landfilled or incinerated, or they are treated more extensively and converted into a useful fertilizer or soil amendment product. Wastewater solids that are processed for safe land application are called *biosolids*, and they come in several forms including liquid, cake, compost, and heat-dried granules.

2.3. What Can Be Done with Sewage Sludge and Biosolids?
Sewage sludge can be managed through means of disposal or recycling. Disposal of sewage sludge involves either landfilling–with other municipal solid waste or separately–or incineration. Recycling, or "beneficial use," of treated sewage sludge–biosolids–includes land application on farm land and general use as a gardening or landscaping fertilizer and soil amendment after composting, heat drying, or another advanced treatment.

2.4. What is Biosolids Recycling?
Biosolids recycling recognizes that organic wastes should cycle back through the biosphere, through soils, as happens in nature. As illustrated in Chart 2.2, plants animals and humans all depend on the same basic nutrients for a healthy life. Fueled by sun and water, agricultural crops grow by using carbon and other nutrients such as nitrogen, potassium, phosphorous, zinc, and molybdenum that they extract from the soil. Humans, and all animals, require the same essential nutrients, which we

Sewage Sludge Management Practices

Beneficial Use of Biosolids

- ***Land Application***: the practice of applying treated biosolids to permitted farm fields or forests to fertilize crops or trees or reclamation sites to restore vegetation.
- ***Advanced Treatment***: processing biosolids for general garden and landscape use through technologies such as *composting, heat drying, or advanced lime stabilization*.

Disposal of Sewage Sludge or Biosolids

- ***Landfill***: all forms of surface disposal including landfilling with municipal solid waste and monofilling.
- ***Incineration***: burning in sewage sludge/biosolids-only (or other) incinerators.

gain, along with carbohydrates, fats and proteins, by eating plants and animals. In fact, nearly all of the naturally occurring elements, including most trace metals, are needed in small quantities for healthy life functions.

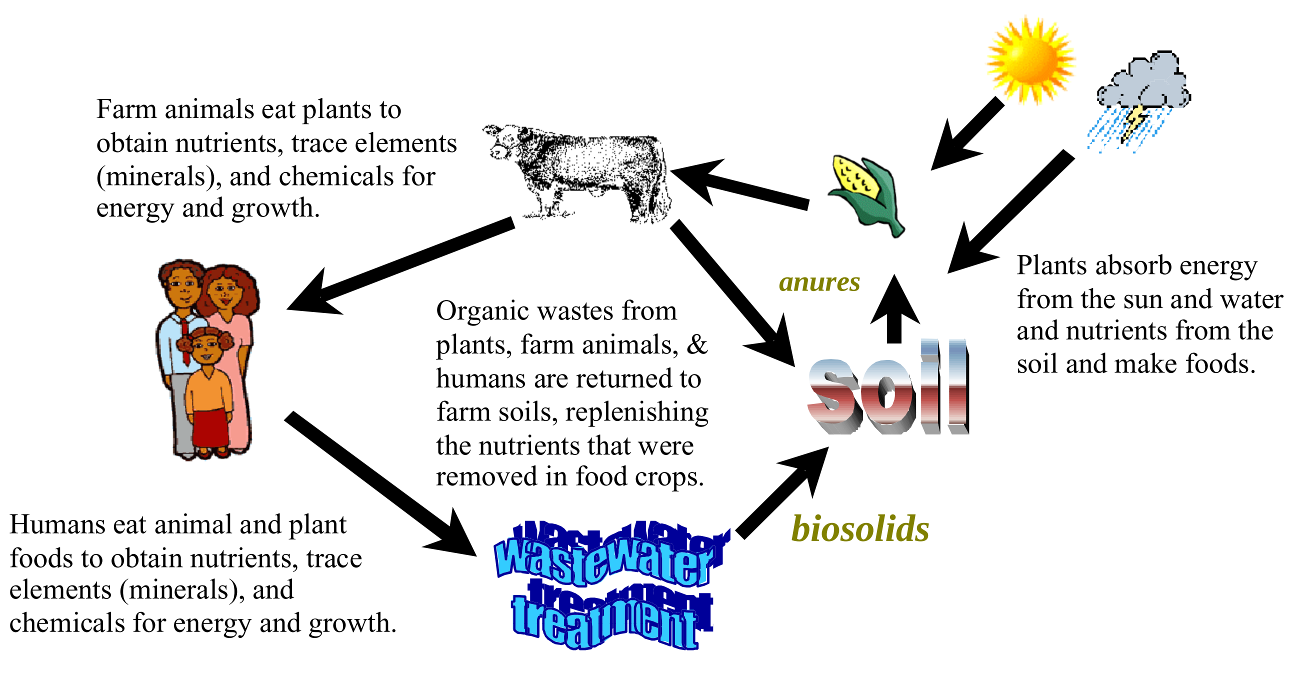
The human wastes and table scraps that enter our wastewater systems contain the same essential nutrients that are found in the food we consume. Biosolids, in turn, become a rich source of essential plant nutrients and organic matter when recycled into the living soil environment.

Humans have recycled organic matter for centuries to improve soil fertility and productivity. Before chemical fertilizers became widely utilized in the mid-1900s, the most common way to fertilize farmland was to mix organic material – such as manure, human wastes, crop residues, and food wastes – into soil. When properly applied and managed, today's biosolids serve the same purpose as manures and provide essential plant nutrients, improve soil structure and health, add organic matter, enhance moisture retention, and reduce soil erosion.

2.5. Recycled Biosolids Classifications

There are two types or “classes” of biosolids identified and regulated by federal law: Class A and Class B. The biosolids’ class is determined by how

Chart 2.2: Biosolids Recycling is Part of the Natural Cycling of Nutrients



extensively the biosolids are processed to control for disease-causing organisms – or "pathogens."

Class A biosolids undergo an advanced treatment process such as composting, heat drying, or advanced lime stabilization, to ensure that the product meets the highest regulatory standards. Class A biosolids have very low levels of pathogens–levels similar to those found in the environment (and lower than many commonly recycled animal manures).

Class A biosolids that also meet regulatory limits on trace metals and chemicals can be applied safely and without limitation on residential lawns and gardens, sports fields, or public parks.

Class B biosolids are extensively treated to control pathogens, but do not undergo the advanced treatments applied to Class A biosolids. Class B products have pathogen levels similar to manures and can be safely used on specifically permitted agricultural sites where the biosolids application is carefully monitored and public access is limited.

While the pathogen levels set for Class A and Class B biosolids differ, *the regulated management of all biosolids ensures protection of public health and the environment*.

Biosolids products can also be differentiated as either *bulk* or *bagged*. Bulk biosolids are typically Class B products which are land applied in mass, and sometimes in liquid form, in a manner similar to the application of animal manures. Bagged products are Class A biosolids that are distributed in bags or other containers for use on smaller landscaping, gardening, or mulching projects. Typical bagged products are composted biosolids or heat dried biosolids fertilizer pellets. Compost products may include sawdust or other organic residue, such as short paper fiber waste from paper mills. This produces a finished compost product that is more similar to topsoil and better suited to the needs of landscapers, contractors, and gardeners than the more nitrogen-rich, manure-like “bulk” biosolids preferred by many farmers.

2.6. Regulatory Overview

In the United States, biosolids are regulated by both the federal and state governments. The U.S. Environmental Protection Agency (EPA) administers the federal biosolids regulation, *Standards for the Use or Disposal of Sewage Sludge*, Title 40 of the Code of Federal Regulations [CFR], Part 503. Part 503 sets forth the minimum requirements for the quality and management of beneficially used biosolids. These include specific pollutant limits and requirements for management practices. In addition, Part 503 establishes operational standards, such as pathogen and vector attraction reduction, monitoring, record-keeping and reporting. The Part 503 rule addresses sewage sludge land application, surface disposal, and incineration.

Pathogens are germs--microorganisms that cause disease in humans.
Vectors are animals that can carry germs from one place to another, such as flies or rodents.
Vector attraction reduction refers to management methods that are required for biosolids; these management methods ensure that animals are not attracted to the biosolids because of decay or odor, thus reducing any chance of spreading pathogens.

The federal regulations are based on more than three decades of continuous operational experience and extensive evaluation of the benefits and risks of using and disposing of biosolids. Some have questioned the federal regulatory program (e.g. Cornell Waste Management Institute, 1999: *The Case for Caution*). However, a large majority of agricultural, soil science, and waste management experts find the federal regulations entirely appropriate. Nonetheless, to further ensure the quality of the federal regulatory standards, a second National Academy of Sciences review is currently underway. (More information, including responses to critics, is available from NEBRA.)

Individual states and localities may set stricter quality standards than the federal standards for beneficial use of biosolids processed and/or utilized within their borders. All six New England states have stricter regulations than the federal Part 503 regulations. All have staffed sewage sludge / biosolids regulatory programs within their environmental agencies (see Chart 2.3).

The federal Part 503 rule is designed to protect public health and the environment from any reasonably anticipated adverse effects of pollutants (contaminants) that may be present in biosolids. In addition to the limits on pathogens discussed in Section 2.5, the federal rule sets strict limits on the concentration of some trace metals and chemicals present in biosolids products.

Nine metals are regulated under Part 503: arsenic, cadmium, copper, mercury, molybdenum, nickel, lead, selenium, and zinc. Several New England states also regulate at least one additional metal not currently included in Part 503: chromium. New England biosolids facilities generally test for all ten metals, as their products may be used in states with different standards. State- and federally-regulated chemicals

Chart 2.3:
State Biosolids, Sewage Sludge, and Septage Management Regulatory Staff in New England

Connecticut	1
Maine	4
Massachusetts	1
New Hampshire	4
Rhode Island	1
Vermont	3

The number of full-time equivalent staff dedicated to regulatory oversight of septage, sewage sludge, and biosolids use or disposal. In the states with high rates of biosolids recycling, there are more regulatory staff.

occasionally found in biosolids in trace amounts include volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), dioxins, and polychlorinated biphenyls (PCBs).

Under the Part 503 rule, biosolids that meet the cleanest (lowest trace metals) standards are classified as "Exceptional Quality" (EQ) biosolids. If they also meet Class A standards, EQ biosolids can be applied in bulk or from bags without restriction--for example, in private or public gardening and landscaping projects. Biosolids that meet the same low-metals EQ concentrations, but meet only Class B pathogen reduction standards can be applied in bulk only on permitted agricultural or other lands.

Almost all biosolids being recycled in New England meet the cleanest (low-metals or EQ) standards and all are processed to meet either Class A or Class B regulatory standards.

2.7. The State of New England Biosolids Recycling

There are about 600 publicly owned wastewater treatment facilities throughout New England that created and managed approximately 425,000 dry tons of sewage sludge in the year 2000.

About one-fifth of this regional total - 93,000 dry tons - are recycled each year in the form of biosolids fertilizer and soil amendment products. Biosolids products are being successfully used to build soil health and fertility on farmland; at sites disturbed by sand and gravel mining; and at nurseries, golf courses, parks, lawns, and gardens throughout New England and the U.S.

As shown in Chart 2.4, the remaining four-fifths of sewage sludge produced in New England in 2000 were managed through disposal. A table of biosolids use and disposal methods for each state is included in the appendix.

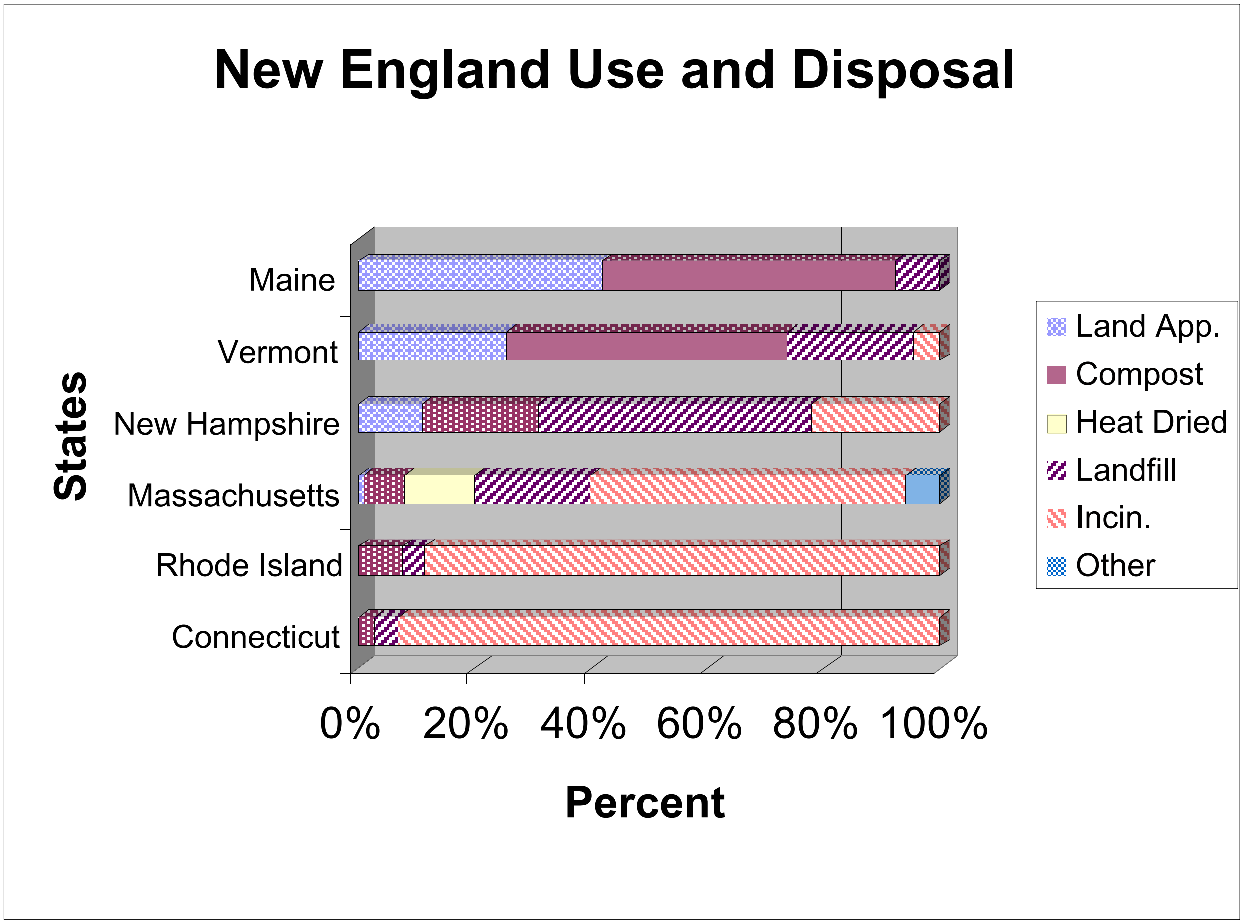
Managing sewage sludge is one of the largest operational expenses at wastewater treatment facilities. This is especially true in New England, where landfill and incineration–the only disposal options–are relatively expensive in comparison to other regions of the country.

Likewise, recycling options in New England also tend to be relatively expensive because of the diversity of state and local regulations and because of the relatively small amount of farmland available for the application of

Saving Soil–and LANDFILL SPACE!

If they had been thrown away, the New England biosolids recycled in 2000 would have required an estimated 350,000 cubic yards of landfill space. That's 6 landfills, each the size of a football field and 33 feet deep! Unfortunately, New England states do not include biosolids in their recycling statistics, so the impact of this recycling program is often unrecognized. If biosolids were not recycled, where would New England site the landfills required to dispose of them, and what would be the social and environmental impacts?

Chart 2.4: New England Biosolids Use & Disposal (2000)*



** See table in appendix for specific state data.*

Class B biosolids. Where suitable land is available, Class B land application generally has been the lowest-cost option for managing biosolids in many parts of the country, including New England.

Incineration

Incineration is the most common wastewater solids management option in use in New England, with nearly 60 percent – or over 248,000 dry tons - of the region's sewage sludge disposed of in this manner. Most of this incineration occurs at large municipal or regional sewage sludge incinerators in Connecticut (e.g. Hartford, Naugatuck, New Haven, Waterbury, West Haven), Rhode Island (Cranston, Providence, Woonsocket), and, to a lesser extent, in Massachusetts (Fitchburg, Worcester's Upper Blackstone facility), New Hampshire (Manchester), and New York (Glens Falls, which incinerates some Vermont sewage sludge). Many incinerators burn both locally-produced sewage sludge and other sewage sludges trucked in for disposal from other communities. The cost for contracted incineration range from $55 to$90 per wet ton tipping fee at the incinerator (the cost of transporting sewage sludge to the incinerator can add an additional $20 or more per wet ton).

For the more densely-populated areas of New England, incineration was chosen for sewage sludge management because it:

- ensures full destruction of pathogens,
- reduces by about 4/5ths the volume of material (ash) to be disposed of in landfills, and
- does not require much land area for storage or end-use of biosolids products.

The disadvantages of incineration include the fact that incineration requires the input of energy for the burning process, as well as the need for treatment and monitoring of air emissions. In addition, incineration does not take advantage of the recyclable nutrients and organic matter that are beneficial in biosolids products.

Southern New England invested in incineration facilities in the 1980s and 1990s and now relies predominantly on these facilities. These incinerators are generally publicly owned and operated; however, some are private facilities that contract with wastewater treatment facilities. Some wastewater treatment facilities in the northern New England states rely on the incineration facilities in southern New England for sewage sludge management. For instance, the town of Winchester, in the southwest corner of New Hampshire, trucks liquid sewage sludge to Rhode Island for incineration.

Saving Soil–and FERTILIZER COSTS!
The 93,000 dry tons of New England biosolids recycled in 2000 provided an estimated 3.7 million pounds of nitrogen (assuming an average of 2% nitrogen). Based on a typical 2001 commercial rate for ureaform nitrogen fertilizer of $319/ton, an equivalent amount of chemical fertilizer nitrogen would have cost $1.3 million. Other macro- and micro-nutrients and the organic matter in biosolids also provide significant monetary value.

Landfilling

The least common sewage sludge management practice in New England is landfilling - about 70,000 dry tons (17%) of the region's sewage sludge was landfilled in 2000. Disposal at landfills of untreated sewage sludge or treated biosolids is a simple process: generally, in New England, the wastewater facility de-waters the sewage sludge to make a semi-solid material that can be easily transported by truck. The semi-solid material is brought to landfills where a tipping fee is charged for each wet ton or cubic yard of sewage sludge dumped. In New England, the sewage sludge tipping fee at landfills ranges from $50 to $80 per wet ton (as with incineration, to cost of trucking to the landfill can add $20 or more per wet ton).

Environmental leaders recognize that landfill space is limited and the siting of new landfills is difficult. Thus, landfilling is not encouraged by state and federal regulatory agencies, but it is the easiest and most common "back-up" option for disposal of biosolids, which, for whatever reason, are not recycled. Just as with incineration, the disposal of biosolids in landfills makes no use of the nutrients and organic matter available in the biosolids.

May, 2001: Governor Angus King of Maine applies biosolids compost to the lawn of the Governor's official residence in Augusta.

Three weeks later, greener grass marks the strip of lawn where the Governor applied the biosolids compost at the Blaine House.

Biosolids Recycling in New England

New England beneficially used one-fifth of the biosolids produced in the region in 2000. Of the more than 93,000 dry tons of biosolids recycled in 2000, over 17,000 dry tons were treated for bulk use on agricultural land. The remaining 75,800 dry tons of New England’s recycled biosolids were processed for general landscape and gardening use through advanced treatment methods such as composting and heat drying.

Beneficial use rates vary among the New England states, with Maine and Vermont achieving the highest recycling rates in the region - with two-thirds or more of their biosolids recycled in 2000.

Biosolids Recycling in Maine

In several recent years, Maine has recycled more than 90% of its sewage sludge through land application programs of lime-stabilized or anaerobically-digested bulk Class B biosolids and through composting programs.

The majority of Maine's bulk Class B land application programs are conducted under contract by New England Organics (NEO), a subsidiary of Casella Waste Management. NEO also operates New England's largest composting operation, the Unity, Maine Hawk Ridge facility, which treats sewage sludge from more than 20 Maine communities.

Several Maine wastewater treatment facilities operate their own land application programs (e.g. Ogunquit) or composting facilities (e.g. Lewiston-Auburn, Old Orchard Beach). Other private companies that manage biosolids operations in Maine include Synagro (which currently manages Portland and South Portland biosolids), and Soil Preparation, Inc.

Maine's high rate of biosolids recycling may be attributed to…

- more than a decade of dedicated efforts to recycle biosolids, especially on the part of several wastewater facilities and a few private biosolids management firms;
- wastewater facility staff willing to work with the public on local issues;
- an active state wastewater operators' and engineers' organization (Maine Waste Water Control Association) that has supported biosolids recycling;
- a dedicated effort on the part of the state regulatory agency to create a safe, thorough, and effective regulatory program;
- progressive regulations that integrate biosolids management into agricultural practices and nutrient management, including a statewide nutrient management law; and
- research and educational efforts from the University of Maine and Cooperative Extension.

However, during the past few years, there have been concerns expressed from some local citizens and communities regarding the use of Class B bulk biosolids on local farms. Odors, the presence of trace contaminants in biosolids, and nuisances such as increased truck traffic have been the major concerns expressed. Several towns have adopted local ordinances, in spite of a state preemption regarding biosolids regulation. In 2001, a bill challenging the state preemption was defeated, and the state Department of Environmental Protection was directed to create guidance to towns as to how they can be involved in regulating and overseeing biosolids management within their borders.

See the Appendix case studies of the Lewiston-Auburn and Ogunquit biosolids recycling programs.

Biosolids Recycling in Vermont

In Vermont, as in other parts of northern New England, about half of the population is linked to sewer systems; the other half depend on septic systems. In 1999, 70% of the state's septage was processed at wastewater treatment facilities; most of the remainder was directly land applied.

About three-quarters of the 8,200 dry tons of Vermont sewage sludge is recycled, mostly by composting (48%), but also by bulk Class B land application (26%). Composting is done in Bennington, Johnson, Springfield, and Wilmington, as well as at facilities in New York and Quebec. Bulk Class B

Wastewater solids slide from the Middlebury, VT belt filter press, ready to be treated to make biosolids.

land application is managed mostly by the local public facilities (e.g. St. Johnsbury and Hartford/White River Junction), although some Class B land application is performed by private company under contract (e.g. Brattleboro).

Bulk biosolids land application to Vermont farms has declined over the past decade (almost all was land applied in 1987), partly due to public concerns and increased regulatory requirements. The

This feed corn field adjacent to the local WWTF is fertilized with Richmond, VT

1998 decision by Chittenden County--the Burlington area--to truck sewage sludge to southern Quebec to be composted added to the decline of bulk land application.

In 1999, the Vermont Public Interest Research Group released a report condemning biosolids recycling and encouraging landfilling of biosolids. However, their campaign to limit biosolids recycling had minimal effect on actual practice, in part because biosolids management experts refuted many of the inaccurate claims made in the report. Meanwhile, the siting of a regional biosolids compost facility in East Montpelier met with local resistance, and even though all permits were obtained, construction of this facility remains unlikely. Most recently, there has been an increase in exportation of sewage sludges from Vermont to New York and Quebec. In 1999, 48% of Vermont sewage sludge was managed out of state.

Biosolids Recycling in New Hampshire

From 1996 to the present, New Hampshire's rate of recycling has diminished from more than 50% to less than 30%, due mostly to public scrutiny and stricter state and local regulations discouraging land application of bulk Class B biosolids. White Mountain Resource Management is currently the only private company land applying bulk Class B biosolids and does so under contract for the cities of Concord, Franklin, and Nashua. Composting of biosolids is undertaken by public facilities, such as Merrimack, Milford and Plymouth, or under contract with private operations (e.g. Claremont and Hanover).

Since 1995, New Hampshire has seen some public debate regarding biosolids recycling. Concerns grew when the lack of any state regulations in 1994-95 allowed poor local field management of biosolids, resulting in some odor problems and nuisance concerns. Emergency regulations were imposed in November, 1995 and permanent regulations followed. Nonetheless, public pressure continued, strengthened by local environmental groups and concern on the part of the Legislature (where more than 20 biosolids/sewage sludge-related bills were considered in 1998-2001). In 1999, final New Hampshire regulations were passed that are the most stringent in the region with respect to trace metal and chemical quality and testing requirements.

The Nashua "egg," an anaerobic digester, which produces Class B biosolids for land application, was dedicated in May, 2001. It also produces methane for energy.

Many working in the field of biosolids management in New Hampshire expect a continuation of the trend toward more advanced treatment of sewage sludges and the production of Class A products. For example, the capital city of Concord has plans to create an advanced-lime-treated Class A biosolids that will still be used on farm fields. However, the start-up of the new Nashua digester in 2001 represented a new commitment to traditional Class B land application.

See the Appendix case study "Merrimack Biosolids: Nourishing Greener Parks and Fairways."

Concord, NH biosolids are applied to a local field where corn for dairy cow feed is grown.

Biosolids Recycling in Massachusetts

Massachusetts recycles about 20% of the sewage sludge produced in the state--almost all of it as Class A material. The largest recycler is the Boston area Massachusetts Water Resources Authority (MWRA), which produces the only Class A heat dried pellet fertilizer biosolids product in the region. MWRA recycles 100% of its biosolids and accounts for 12% of the state's sewage sludge. Successful compost operations, which treat about 7% of the state's sewage sludge, are found in Amesbury, Billerica, Dartmouth, Holyoke, Mansfield, Marlborough, the Otis Air National Guard Base in Sandwich, Pepperell, Southbridge, and Williamstown. There is virtually no land application of Class B biosolids.

Mixing sewage sludge and sawdust for static pile composting at the Hoosac Water Quality facility in Williamstown, MA.

Massachusetts has strong policy commitments to increasing biosolids recycling rates and reducing the toxicity of the waste-stream to further encourage biosolids recycling. However, investments in infrastructure made during the 1980s have committed many of the Commonwealth's communities (e.g. Worcester) to incineration or landfilling of sewage sludge. In addition, Massachusetts has a dense population and a low percentage of farm land suitable for Class B biosolids land application.

Greater sewage sludge recycling may be possible in Massachusetts with composting and other advanced treatment programs, especially if state regulations can be further adapted to stimulate the development of such programs. New regulations are being considered by the Department of Environmental Protection, but rule-making is a long process and has been delayed. The successful start-up in 2000 of the Marlborough mixed solid waste and biosolids co-composting facility is an encouraging biosolids recycling development.

See the Appendix case study "Massachusetts Water Resources Authority - National Demand for Fertilizer Pellets."

Massachusetts Secretary of Environmental Affairs Robert Durand shows biosolids compost to a photographer at a public event touting the benefits of biosolids recycling for lawn-care at the Harvard Medical

Connecticut and Rhode Island
Connecticut and Rhode Island have biosolids recycling rates below 10%.

Connecticut continues to have a regulatory structure that does not encourage biosolids recycling and 97% of the state's sewage sludge is disposed of. In addition, significant troubles have befallen the Nutmeg State's biosolids recycling efforts. During the 1990s, Hartford Metropolitan District Commission invested millions of dollars in a biosolids composting facility. Odor control at the facility was a problem for several years, but had finally had been addressed at the time of a tragic fire that destroyed the facility in November, 1999. The malodors and smoke from that fire left a strong negative public impression that may make it difficult in the near future to gain support for new biosolids composting programs.

Currently, biosolids recycling accounts for only 3% of sewage sludge management in Connecticut and occurs only at composting operations in a few towns such as Fairfield and Farmington.

In 1998, Rhode Island adopted new regulations that facilitate biosolids composting - including the same trace metals standards as the federal Part 503 regulations. Biosolids recycling accounts for only 8% of sewage sludge management in Rhode Island and occurs only at the biosolids composting operations in Bristol and West Warwick.

2.8. Looking Forward

Biosolids recycling in New England has recently experienced a challenging time, with public concern and stricter regulation. Despite the expressed support for biosolids recycling by state environmental leaders, there have been declines in recycling rates in some states. Even the region's biosolids recycling leader, Maine, has begun to show a small decline in the rate of biosolids recycling. Strong public recognition and support for the benefits of recycling will be required in the near future if this decline is to be reversed.

No one questions the agronomic benefits of recycling biosolids–and demand for biosolids products has been increasing steadily. But, recently, in New England, there have been questions and concerns about biosolids recycling regarding:

- trace chemicals,
- trace metals,
- pathogens,
- odors,
- nuisances such as truck traffic, and
- the level of oversight and enforcement.

There have also been various events that have added to public interest, including:

- a lawsuit alleging harm from biosolids in Greenland, NH;
- claims of harm to farm animals;
- claims of groundwater or well contamination from biosolids (e.g. in Pelham and Sandown, NH);

Such events have been investigated by state experts and biosolids have not been found to be a cause of harm. Nonetheless, these claims have had negative impacts on public perceptions of biosolids, and one result has been bans or severe restrictions on biosolids use adopted by some local communities, especially in New Hampshire.

At the same time, within the agricultural and regulatory communities, biosolids recycling, along with similar practices such as manure management, continually faces technical issues that are being researched and may be addressed with further regulation, including…

- the fact that Class B biosolids that are lime-stabilized can add to calcium saturation of agricultural soils;
- the fact that biosolids recycling, like the recycling of manures, can add phosphorus to soils in amounts that may be of concern in phosphorus-sensitive watersheds;
- the fact that many septage and wastewater solids lagoons in rural parts of the region are filling up with solids that need to be managed, requiring additional biosolids management capacity; and
- the fact that septage processing relies ever more heavily on wastewater treatment facility capacity, thus linking rural septic owners to urban wastewater facilities.

Clearly, biosolids management will continue to be challenging into the future. However, the overall environmental benefits obtained are worth the effort:

- reduced demand for landfill space,
- reduced demand for native soil,
- reduced demand for fertilizer,
- local or regional recycling of nutrients and organic matter,
- soils improved by biosolids organic matter and nutrients.

NEBRA and other professional organizations working in the water quality field are tracking current issues, supporting critical research, and assisting in the development of sound policy based on the best currently available scientific understanding. The rest of this report should provide answers to many of the questions people have about biosolids quality. For detailed information on any of the events or topics noted above, please contact NEBRA or see www.nebiosolids.org.

A notable significant positive development that supports increased biosolids recycling in this region–and will likely continue to do so in the future– is the development of biosolids compost markets. Companies such as Agresource, New England Organics and others are selling biosolids compost into some of the highest quality topsoil and soil amendment markets. Because of its consistency, ease of use, high organic-matter content, and availability, biosolids compost is in increasing demand for golf course, sports field, and park soil-building applications. In addition, several New England states' Departments of Transportation are beginning to include biosolids compost in specifications for restoration of construction sites and for use in highway corridors. This increasing demand for biosolids creates strong economic incentives for improved biosolids product quality and consistency.

In general, the region's biosolids experts note the trend away from Class B bulk biosolids use toward more production of Class A biosolids products, especially compost and heat-dried products. For instance, Middlebury, VT, Keene, NH, and several other smaller wastewater facilities that used to land apply Class B biosolids are now trucking their sewage sludge to composting facilities in New York or Quebec. In Massachusetts, Lowell is developing an advanced lime-stabilized Class A biosolids product for topsoil blending and the Greater Lawrence Sanitary District is planning to build a biosolids heat drying fertilizer facility at its North Andover location. The benefit of Class A products is that, due to reduced regulatory requirements and increased ease of handling, they can be more widely distributed and require little or no special management when used.

An additional development that is likely to further improve the quality of New England biosolids programs is the development of the National Biosolids Partnership (NBP) Environmental Management System (EMS) for biosolids. Currently, three New England facilities that recycle biosolids are part of the trial phase of this new federally-funded program: Brattleboro, VT; Lewiston-Auburn, ME; and Merrimack, NH. The EMS program helps biosolids managers ensure continual improvement in biosolids management. By adopting an EMS, biosolids programs commit to regulatory compliance and to going beyond - ensuring constant improvement with respect to environmental impacts and public communication and participation in biosolids programs.

In summary, the lack of growth, the improvements, and the investments in biosolids recycling that have occurred in New England over the past decade may or may not continue, depending on several factors:

- public acceptance;

- demand for biosolids products;
- results of new research;
- odor management concerns and how well they are further addressed; and
- the states' regulatory response to all of these factors.

As one environmental engineer expert in biosolids management points out (Jager, 2000): "New Englanders receive benefits every day from our wastewater treatment facilities. The quality of our surface and ground water has significantly improved as a result of the investment made in clean water infrastructure. Responsible biosolids management is a logical extension, an integral part, of that clean water system.

Chapter III   The Quality of New England Biosolids

3.1 Biosolids Quality

This report, the first of its kind, focuses on the current state of knowledge of the quality of New England biosolids products. Those working in the field of biosolids recycling are generally familiar with:

1. the agronomic quality of biosolids products and how they work to enhance soils and the growth of plants, and
2. the levels of trace "contaminants" or "pollutants" in New England biosolids products, including test results from biosolids sampling that is conducted as required by federal and state regulations.

However, those outside of the field are not familiar with these experiences and data regarding biosolids quality. In addition, even those within the field tend to have little sense of the "bigger picture," of how one New England biosolids product compares with another New England biosolids product.

While not exhaustive, this report provides enough data from a wide representation of facilities so that the "big picture" becomes clearer.

3.2 Biosolids Agronomic Quality

First and foremost, the quality of any biosolids product is measured by its ability to help plants grow. This is determined by the levels of plant nutrients, the organic matter content, the

Nutrients essential for plant growth include nitrogen, phosphorus, and potassium (the "macro-nutrients") and boron, calcium, chromium, copper, iron, magnesium, molybdenum, selenium, zinc, and many others (the "micro-nutrients"). Unlike most commercial fertilizers, biosolids contain significant quantities of micro-nutrients.

Organic matter refers to masses of complex, biologically-derived molecules of plant matter and animal wastes that can be decomposed by the microbial ecosystem present in soils. The microbial decomposition of organic matter releases component nutrients to soils, while also creating more complex, or humified, organic matter that is more resistant to further decomposition. The
humified organic matter adds to the long-term pool of soil organic matter. Most fertillizers contain little or no organic matter; biosolids products average around 50% organic matter.

Stability refers to the degree of decomposition to which biosolids have been subject. More highly decomposed biosolids, such as a well-cured compost or anaerobically digested biosolids, contain more humified organic matter, and consequently are not as susceptible to the rapid decomposition that occurs in biosolids that have not previously been through a controlled decomposition process. More highly decomposed biosolids, then, are more stable than other biosolids. The more stable a biosolids product, the less likely the biosolids are to create the odors that are associated with the rapid decomposition of organic matter.

stability, and the "handleability" (ease of use) of the biosolids product. Producers of biosolids products are generally required by state laws to test for and report nutrient levels in biosolids products. And, in order to meet market demands, many biosolids management programs test biosolids for organic matter content and other parameters and maintain consistent product appearance and handleability.

Biosolids are processed in many different ways, but one goal is common to all methods: to create a biosolids material that is easily managed for its intended use. Most New England bulk biosolids are processed to Class B standards and are dewatered until they are the consistency of animal manures or damp soil and can be applied with conventional farm machinery. New England Class A, EQ biosolids products that are used by horticulturists, landscapers, and the general public are dried into fertilizer pellets or composted to create a consistent, easily poured and spread material that can be transported in bulk or bagged for distribution.

Hundreds of research studies around the world have determined that biosolids products are effective in enhancing soil quality and plant growth. Biosolids use can result in crop vigor and yields that surpass those achieved with conventional fertilizers. There is little question that a well-managed application of biosolids improves short-term soil and crop health and vigor.

3.3 Assuring Biosolids Quality with Respect to Trace Contaminants

The quality of a biosolids product is also determined by the low levels of potentially harmful contaminants it contains. Biosolids products are monitored for pathogens, trace metals, and potentially harmful chemicals. Because wastewater contains some of these undesirable and potentially harmful contaminants, biosolids treatment and testing are necessary--and required by law--to ensure that the use of biosolids will not create any significant risk to public health and the environment. There are specific quality control methods, required by regulations, to ensure the consistent quality of biosolids products. These quality control processes include:

- the pre-treatment of wastewater at industrial facilities,
- the treatment of wastewater,
- the treatment and periodic testing of wastewater solids and biosolids, and,
- especially for Class B and non-EQ biosolids, the carefully-managed end-use and application of the biosolids products themselves.

Pretreatment — Ensuring Consistent Wastewater Quality

Biosolids generated today are generally low in pollutants, rich in nutrients and organic matter, and beneficial for recycling applications. This is due to the fact that most commercial operations properly dispose of various chemicals and inorganic materials - keeping potential hazards out of the wastewater stream. Hazardous solvents such as inks, dyes, paints, or processing liquids are being used in smaller quantities and are being recycled, rather than being poured down the drain and into wastewater systems. In addition, many industries have shifted away from the use of hazardous materials to the use of benign ones. An example is the shift in the printing industry from metal-based inks to soy-based inks.

Industrial factories and processing plants that discharge wastewater during operations are required to remove contaminants at on-site pretreatment facilities before their wastewater can be discharged into a municipal sewer system.

These pretreatment programs are aided by Pollution Prevention efforts, where local, state, and federal agencies help businesses reduce the use and disposal of potentially harmful materials. As society continues to recognize the need to reduce the use of potentially harmful substances, wastewater will continue to contain even fewer of these substances.

These reductions of harmful substances in wastewater help protect the functioning of wastewater facilities and the health and safety of wastewater workers, while ensuring high quality, recyclable biosolids products.

Wastewater Treatment — Controlling Variability and Reducing Pathogens

The consistent quality of biosolids is further enhanced during the wastewater treatment process. This process reduces pathogens and treats or dilutes many potentially harmful contaminants in the wastewater. Municipal wastewater treatment facilities are designed to remove solids from the wastewater and to disinfect the water before it is discharged back into waterways.

Wastewater facilities utilize treatment processes that are based on naturally occurring water purification processes. Natural aeration in streams and lakes helps to purify water, while microorganisms break down solids and dissolved materials. Wastewater treatment uses the same principles: the solids are collected and biologically stabilized by microorganisms that decompose the solids. The wastewater stabilization process destroys most potentially harmful pathogens contained in the solids before the solids are further treated for use as biosolids products. Research has also shown that wastewater treatment destroys or dilutes a majority of trace chemicals that may be present in sewage. Some chemicals are diluted while others are broken down by the micro-organisms in the wastewater treatment facility. Still other chemicals are volatilized – released into the air.

Lastly, biosolids quality may also be protected by the fact that if a high concentration of a toxic substance enters a wastewater treatment facility, the micro-organisms of the wastewater and solids treatment processes can be disrupted. This becomes evident to facility operators who take action to correct the problem. If the resulting sewage sludge is found to be contaminated, it may not be recycled and its proper disposal is required by law.

Finally, it is important to understand that many of the very low levels of pollutants found in biosolids are often there because they are in common household products and the public is exposed to them at similar low, safe levels during common routine activities.

Biosolids Treatment — Addressing the Need for Consistent Quality
To ensure the high quality of biosolids products, producers utilize state-of-the-art technology to convert wastewater solids into biosolids according to regulatory guidelines that have been developed based on extensive research and testing of wastewater and biosolids worldwide. Biosolids managers are required to demonstrate the quality of their biosolids products through regular testing of the product, record keeping, and reporting regarding the biosolids production process. Product quality testing is required for trace metals and, in several New England states, volatile organic compounds, semi-volatile organic compounds, dioxins, PCBs, and other potentially harmful chemicals. Carefully controlled and monitored biosolids treatment and testing in advance of product use is just one more way in which the quality of biosolids products is ensured.

A secondary clarifier at the Windsor, VT, WWTF. Clarifiers mimic the conditions in a still pond, allowing solids to settle to the bottom where they are removed by a slowly-rotating scraper. These solids are then treated to become biosolids.

Agricultural Application
Whether using biosolids, animal wastes, or chemical fertilizers, safe use of agricultural fertilizers and soil amendments requires careful application to ensure that crops receive the proper amount of essential nutrients while, at the same time, ground and surface waters are protected from pollution. Pollution of ground and surface waters around agricultural areas is one of the most significant non-point source pollution problems today.

When using bulk biosolids, whether Class B or large amounts of Class A, farmers and landscapers in New England are required by state and federal laws to manage them in accordance with a "nutrient management plan" and apply only enough biosolids to provide the essential nutrients for the crop being grown. This is called the ***agronomic rate***. Extensive research by the U.S. Department of Agriculture, the U.S. Environmental Protection Agency, and various academic institutions has shown that, when biosolids (or manures) are used in accordance with such regulations, non-point source pollution problems are unlikely.

Agricultural nutrient management requirements vary from state to state in New England, but most states have additional agronomic management restrictions for biosolids land application. In Maine, for instance, a rigorous state nutrient management law ensures that all fertilizers, animal manures, biosolids, composts, and other nutrient-rich materials are managed and land applied in ways that protect surface and ground water quality.

The agronomic rate requirement further protects from any potential harm from biosolids trace contaminants - it limits the amount of biosolids that can be applied each year to any particular field or site. This means that the total amounts of land applied trace metals or other trace contaminants in biosolids are also further limited.

See the appendix for more about the protectiveness provided by agronomic rate applications of biosolids.

3.4. Biosolids Quality Questions

Three questions are commonly asked about biosolids quality:

"What about pathogens?"

"What about the chemicals?"

"What about the heavy metals?"

People have heard about these concerns

Biosolids and other organic residuals are sometimes used to build soil to revegetate barren areas like this central New Hampshire gravel mining site. The slope above the black silt fence was covered with a 6-inch layer mix of sand, paper mill residuals, and biosolids. Then grass seed and mulch were applied. This "manufactured topsoil" will support grass and other vegetation over the long term, stabilizing the soil and reducing erosion and water runoff. The site, once barren, will return to a natural, productive state.

and want to know how they are addressed in the practice of biosolids recycling.

Biosolids managers and government agencies which oversee sewage sludge management around the country generally agree that the biosolids products being recycled in the U.S. are of good quality and that the quality is continually improving over time. While those in the biosolids industry have seen many sets of test results, there has been, and continues to be, a lack of compiled, clearly presented data on biosolids quality.

Members of the New England Biosolids and Residuals Association (NEBRA) wanted to gain a picture of the current quality of biosolids being produced in New England. They also wanted to collect data to support clear and accurate general statements about the biosolids products available for use in the New England region. Finally, they wanted to get a sense of how biosolids quality has changed in recent years, in order to work toward further improvements in biosolids recycling programs.

The data for this report was obtained primarily from state agencies and the EPA Region 1 office. Some data was obtained directly from wastewater treatment facilities. Most biosolids quality data is the result of sampling and testing conducted by wastewater treatment facility operators or biosolids management staff as part of regulatory compliance. These data are submitted, in annual reports, to state and federal regulatory agencies. The accuracy of these biosolids test data is ensured by:

- Federal and state regulatory oversight and enforcement;
- Stiff federal fines and penalties for falsifying any wastewater and biosolids operations protocols or data;
- The fact that most wastewater facilities use independent laboratories to conduct biosolids tests; and
- The verification done by random testing programs, such as in New Hampshire, where regulatory agency staff occasionally visit wastewater treatment facilities or biosolids recycling sites and collect and test random biosolids samples.

The data collected for this report, which includes a representative sampling of biosolids products produced around New England, shows that New England biosolids are of good quality and consistently meet even the strictest federal and state standards. This is exactly why these sewage sludges are are the ones being recycled.

"What About the Pathogens?"

Pathogens in biosolids can be controlled through a variety of treatment methods.

Eliminating virtually all pathogens, to make Class A biosolids, is most often achieved through heating the solids to a high temperature, generally 150 degrees Fahrenheit or more, and maintaining that temperature for a required period of time.

As shown in Chart 2.5, the most common treatment for making Class A biosolids in New England is composting (43,500 dry tons). The Massachusetts Water Resources Authority (MWRA) utilizes heat drying to produce its Class A biosolids fertilizer (32,300 dry tons).

Most bulk Class B biosolids applied to land in New England are treated by lime stabilization or anaerobic digestion and then dewatered and land applied as "cake," manure-like material with the appearance of damp soil, which is distributed on farm fields with typical manure spreaders.

For Class B products, New England facilities generally use temperature, digestion, or pH (alkaline adjustment) controls to regulate pathogens. Class B products have lower pathogen standards than Class A products because they are used in conditions where direct contact with potential receptors (i.e. humans and animals) is controlled. For that reason, there are lower temperature requirements and shorter holding time provisions for Class B products than for Class A products.

Lime stabilization is the most common Class B treatment method used in New England. It involves pathogen reduction through pH control: lime is mixed with the biosolids to elevate the pH to the required threshold and maintain it for the specified time period. As with Class A treatments, documentation of the Class B pH monitoring is required and sufficient, and specific tests for pathogens are usually not required. The other most common method in New England for Class B treatment is anaerobic digestion (see photo of the Nashua anaerobic digester, page 13).

Final destruction of the low levels of remaining pathogens in Class B biosolids is achieved in the soil and environment where the biosolids are applied. Most human and animal pathogens do not survive for long outside of a "warm-blooded" host organism. In addition, competition from soil organisms are effective final pathogen treatments for Class B biosolids. In order to allow time for this natural final pathogen treatment, Class B biosolids products must, by law, be used following specific application guidelines and management practices, including certain time limit restrictions on harvesting crops and allowing general public access.

In summary, any biosolids being applied to land in New England, must, by law, meet the standards set out in strict regulations.

"What About the Chemicals?"

As previously noted, wastewater treatment and biosolids production processes destroy or remove many trace chemicals that may enter a wastewater facility. Research has shown that the greater the amount of treatment of wastewater and biosolids, the more likely that trace chemical contaminants will be removed or destroyed. This is especially true with composting (see Morin and Switzenbaum, 1993).

Additional research has been done to determine the fate and transport of certain potentially harmful chemicals in soils. Such studies, combined with the risk assessment work completed by the U. S. Environmental Protection Agency (EPA) as part of the development of the federal Part 503 regulations, have led experts knowledgeable about biosolids recycling to believe that trace chemicals in biosolids recycled to land are unlikely to cause harm.

For instance, Dr. George O'Connor of the Department of Soil and Water Science at the University of Florida wrote (O'Connor, 1994):

"Numerous man-made organic chemicals with a wide range of chemical properties can occur in sewage sludges…. A review of the pertinent literature… along with risk assessment, suggest that the concern [regarding chemicals] is largely groundless. The vast majority of TOs [toxic organics] are reduced at least 100-fold in typical (agricultural) land application scenarios. Further, most TOs are so strongly sorbed in the sludge-soil matrix as to have low bioavailabilties to plants….The [EPA risk] assessment confirmed the expected low bioavailability of TOs to plants, animals, and humans - especially at the sludge loading rates typical of land application…. These findings, along with other considerations, result in TOs being unregulated in the recently promulgated 503 sludge rule…."

In several New England states, however, public and regulatory interest in the possible impacts of trace chemicals in recycled biosolids has led to additional testing and regulation. Maine has required testing of recycled biosolids for many trace chemicals for several years. And New Hampshire's 1999 rules require testing for more than 150 trace chemicals that are potentially found in biosolids. Boston's MWRA tests its fertilizer product for trace chemicals as well. Therefore, while fewer New England biosolids have been tested for their trace chemical content than for their trace metal content, there is a considerable amount of information

Parts per million (ppm), dry weight is the most common way to describe the amounts of trace contaminants in materials like biosolids. If tests show there is 1 ppm dry weight of a trace contaminant in a biosolids product, it means that one kilogram (kg) of dry biosolids will contain one milligram (mg) of the contaminant (1 ppm = 1 mg/kg) or one ton of dry biosolids (2000 pounds) will contain 0.002 pounds (0.032 ounces) of the contaminant.

Heat dried biosolids are almost all dry--(90+ % solids); a typical land-applied Class B biosolids has 25% solids (it is like damp soil and contains 75% water). Because of this, one wet ton of Class B biosolids with a concentration of a particular contaminant measuring 1 ppm dry weight will only contain 0.0005 pounds (0.008 ounces) of the contaminant. See Appendix Table A-5 for an example of the effect of a certain concentration of a contaminant in biosolids as it is applied to soils.

currently available. Some of this information is reviewed in the Appendix.

More monitoring of biosolids for trace chemicals is being done and will refine our understanding of any potential risks from trace chemicals applied to soils in biosolids. But evidence to date suggests that New England biosolids are like biosolids elsewhere and, because of the absence or very low levels of trace chemicals, meet U.S. EPA risk-based criteria and present little risk.

"What About the Heavy Metals?"

The majority of data collected and compiled in this report focuses on the trace "heavy metals" found in biosolids that have been of particular concern to the general public. This report focuses on these trace metals because they:

- occur routinely in all biosolids products, animal manures, and soils;
- occur at high enough levels in some sewage sludges as to preclude the recycling of such sludges; and
- are regulated and routinely tested for in biosolids products, so there is plenty of data available.

Metals such as arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc occur naturally in the Earth's rocks and soils in varying concentrations. Because these elements are potentially harmful if they are present in large enough concentrations, and because these elements are common in the environment and in wastewater, federal and state laws have set limits on the levels of these metals allowable in biosolids products.

The federal trace metal standards are based on the findings of hundreds of scientific studies into their potential impacts on soils, plants, animals, and human consumers, as well as an extensive risk assessment conducted by EPA. For added assurance, some New England states have adopted even more protective standards.

Testing for trace metals is conducted by all biosolids recycling facilities, and the data is submitted to the U.S. EPA and the appropriate state agency. The frequency of testing varies according to the quantity of biosolids produced by each facility, however, all facilities report testing data at least annually. Usually, grab samples are collected over time and composited into a single sample which ensures that the sample that is submitted for testing is representative of a broad time period for the material processed by the facility. (In addition, the mixing processes involved in treatment result in further distribution and averaging of trace metals.)

3.5 Trace Metals in New England Biosolids

This report looks at biosolids quality data from 1994 to 2000 from ten biosolids recycling facilities in each of the three northern New England states and seven biosolids recycling facilities in Massachusetts. The facilities vary widely in the amount, types, and methods of producing biosolids, from Class A products to Class B products, and from heat drying pelletization to composting and lime stabilization.

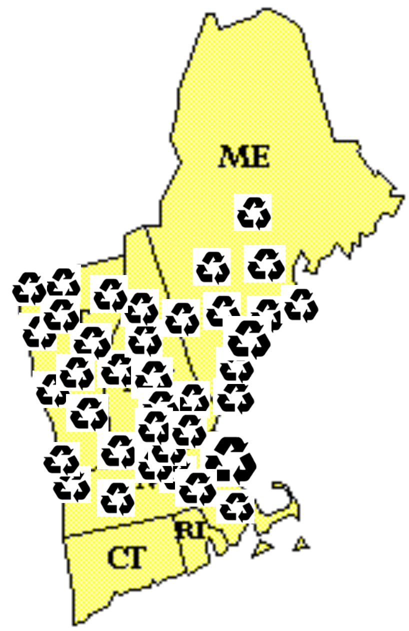


Chart 3.1: Locations of biosolids production facilities for which recycled biosolids trace metal data is included in this report. For a listing of the facilities, see the appendix.

The levels of trace metals in New England biosolids reported below have little meaning unless they are put in context. Interestingly, most of the regulated metals are also important plant and animal micro-nutrients--in small amounts. Only arsenic, cadmium, lead, and mercury are considered to have no value to plants and animals (and, it is important to note that, for instance, the greatest source of cadmium in agricultural soils is traditional phosphorus fertilizers). The other trace metals that are controlled by law in biosolids are found in many multi-vitamin and mineral supplements as well as in expensive chemical fertilizers. Chart 3.2 provides comparative data on the levels of trace metals in other materials, including natural soils, fertilizers, soil amendments, and vitamin supplements.

Landscaping at a private central Massa-chusetts home using biosolids compost from Holyoke.

Chart 3.3 compares statewide averages of metals in biosolids from the most recent testing data available (2000 data for Massachusetts, New Hampshire, and Rhode Island, and 1999 data for Maine and Vermont). The data show that the concentrations of the ten metals for which testing is typically done are remarkably consistent across New England. The most stringent federal

Chart 3.2: Reported Averages (or Ranges) of Trace Metals Levels in Other Materials (ppm or mg/kg)

Trace Metal	Dairy Manure (4)	Dairy Manure (3)	Feedlot Manure (2)	Pig Waste (2)	Swine Manure (3)	Poultry Litter (2)	Chicken Manure (3)
Arsenic (As)	0.26	0.88	NA	3.7	NA	30	0.66
Cadmium (Cd)	0.32	0.03	0.2	ND	0.32	ND	0.59
Chromium (Cr)	5.2	20	NA	61	NA	20	4.9
Copper (Cu)	41	11.6	2.0	501	14.3	1195	13
Lead (Pb)	6.6	2.1	0.2	ND	1	12	11.5
Mercury (Hg)	0.09	0.05	NA	ND	NA	NA	0.04
Molybdenum(Mo)	2.5	22.1	NA	7.9	22.6	NA	95.3
Nickel (Ni)	7.8	3.3	NA	29.3	NA	NA	3.9
Selenium (Se)	0.5	NA	5000	ND	NA	NA	NA
Zinc (Zn)	215	21	8	656	60	631	297

	Phosphorus Fertilizer (5)	Phosphorus Fertilizers (ranges) (6)	MSW Compost (6)	Wood Ash (7)	Agricultural Soils (4)	Silty/Loam Soils (1)	Miracle-Gro® (fertilizer)	Rite-Aid Central Vite® (vitamins)
As	1	2 - 1200	NA	7	6	8.4		
Cd	101	0.1 - 170	7.6	6.3	0.06	0.45		
Cr	320	66 - 245	40	14	100	51		83
Cu	5.9	1 - 300	471	45	20	23	700	1276
Pb	5.6	7 - 225	496	39	10	28		
Hg	0.1	0.01 - 1.2	4.1	0.06	0.03	0.1		
Mo	7.0	40 - 2000	NA	4.7	2		5	102
Ni	303	7	43.4	19	40	26		3.2
Se	NA		NA	0.63	0.2	NA		12.8
Zn	1070	50 - 1450	902	537		60	600	9573

(1) - From Kabata-Pendias and Pendias, as reported in National Biosolids Partnership, 2000.
(2) - From Alpert, 1999
(3) - ASAE Standards, as reported in National Biosolids Partnership, 2000.
(4) - From Estes, University of New Hampshire, as reported by NH Dept. of Env. Svcs.
(5) - From Milwaukee Metropolitan Sewerage Dist, Milorganite Division, as reported by NH Dept. of Environmental Services.
(6) - From. Univ. of MN soil science department, as reported in National Biosolids Partnership, 2000.
(7) - As reported by White Mountian Resource Mgmt, Inc. for ash from electricity generation using only native tree wood chips
NA = Not available; ND = Not detected.

EPA biosolids quality standard - the "EQ Standard" - is included throughout this report for comparison. The scientifically-determined risk based ceiling standards for each trace metal in biosolids are higher.

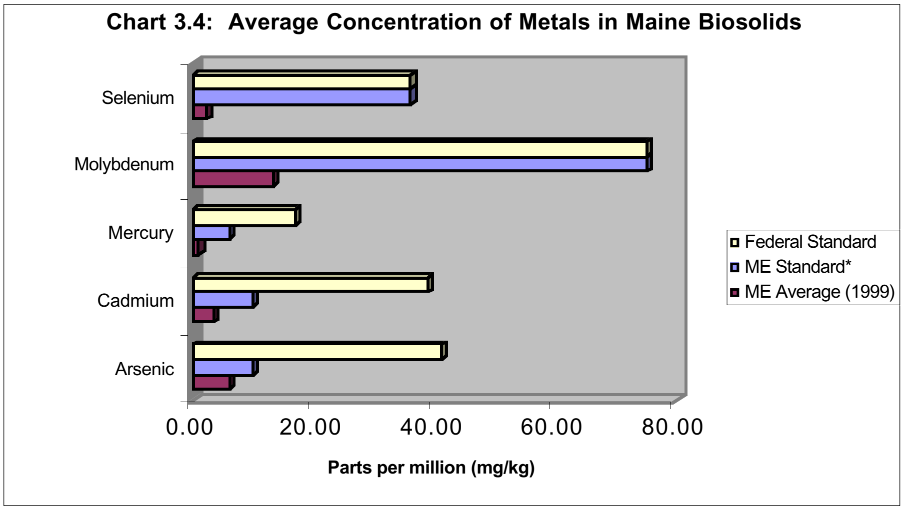
Charts 3.4 through 3.11 graphically compare the most recent average metal concentration sampling data for each New England state to the state and federal standards. Biosolids metal concentration averages are mostly well below the strictest ("EQ") federal standards, as well as below the state's strictest standard.

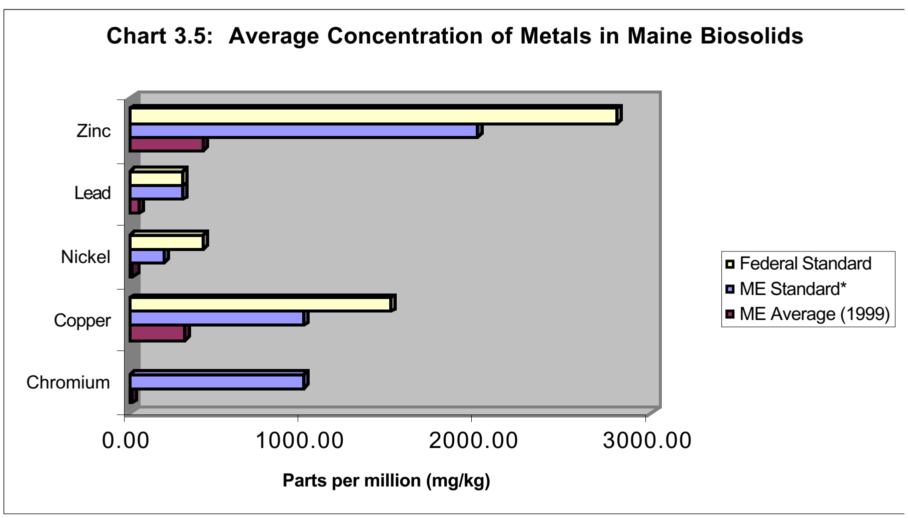
Individual charts showing the yearly average concentration of each of the target trace metals for each of the states are included in the appendix. Most of these charts show a downward trend in trace metals levels over time as improved industrial pretreatment, drinking water corrosion control, pollution prevention, and other programs further reduce the concentrations of metals in wastewater.

Charts 3.12 through 3.15 summarize the average concentrations of arsenic, cadmium, lead, and mercury from 1994 to 2000 in each of the New England states. In general, the data show that the average concentrations of these metals of greatest concern are well below the federal Exceptional Quality (EQ) standards.

Chart 3.3: Trace Metal Concentrations in New England Biosolids (parts per million or mg/kg)

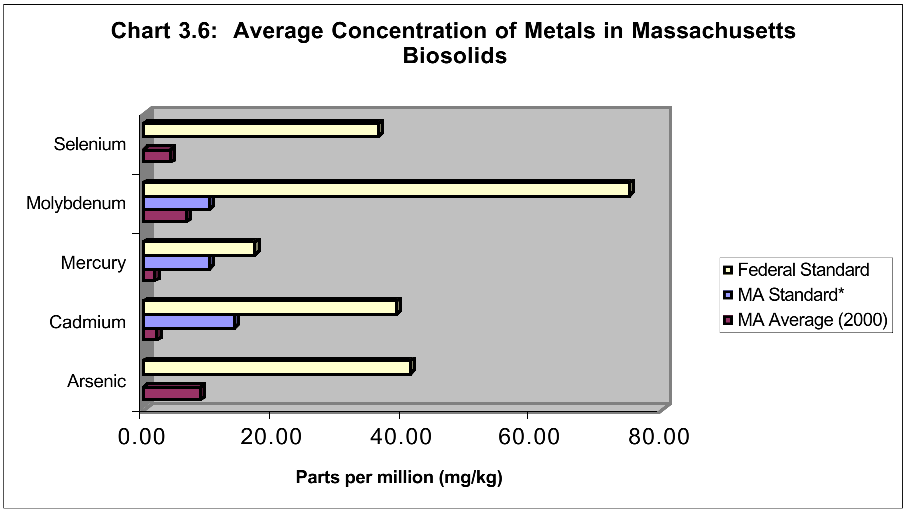
Metal	Federal EQ Standards	Maine (1999 Data)	Massachusetts (2000 Data)	New Hampshire (2000 Data)	Vermont (1999 Data)
Arsenic	41	6	9	2	9
Cadmium	39	3	2	3	3
Chromium	no standard	17	32	20	31
Copper	1500	310	388	433	490
Mercury	17	1	2	2	2
Molybdenum	no standard	13	7	11	9
Nickel	420	19	26	18	22
Lead	300	50	91	49	72
Selenium	36	2	4	2	6
Zinc	2800	419	498	663	649

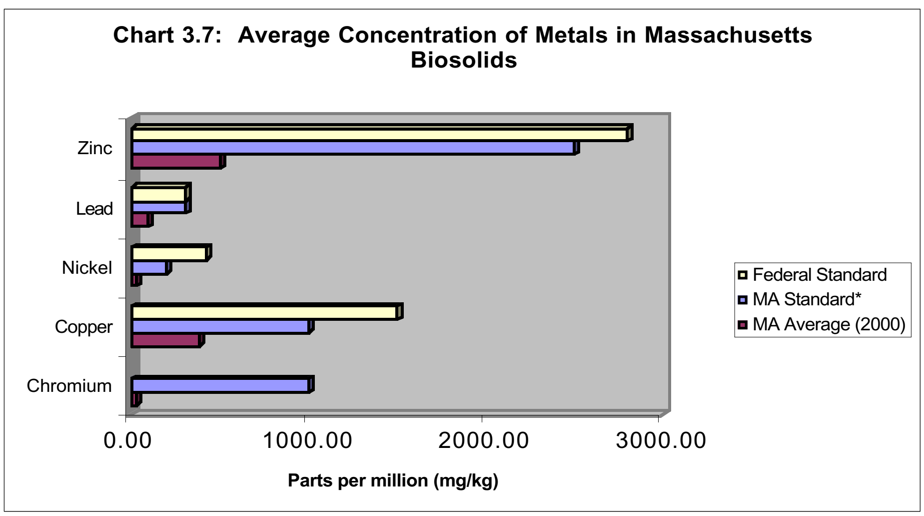




ME lowest "screening concentrations," Chapter 419 regulations, Table 419.3, column A.

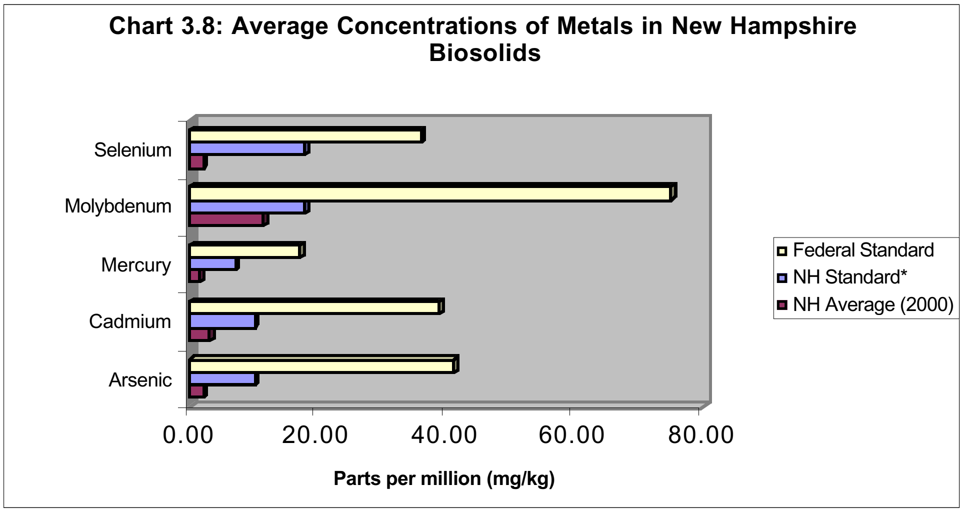
<u>NOTE</u>: The state and federal limits shown for comparison are the strictest standards.

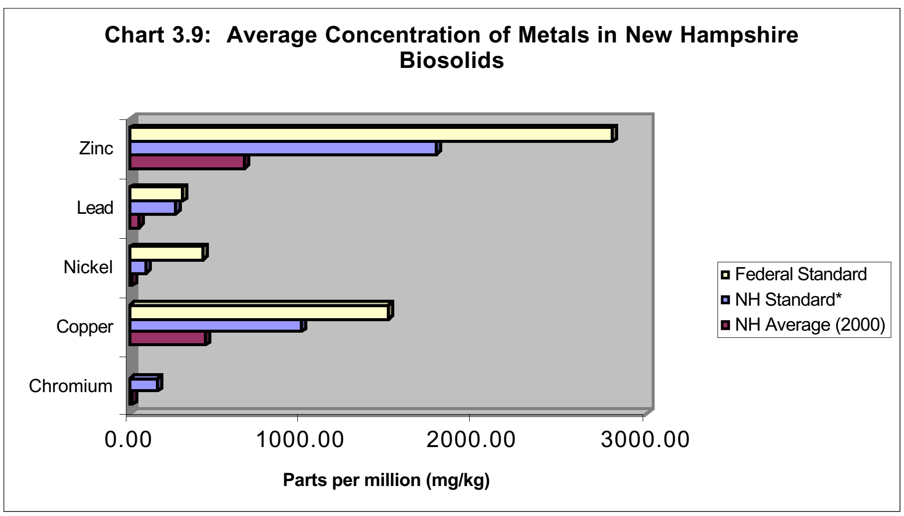




*MA lowest "Type 1 Sludge" standards, regulations Table 32.12(2)(a).

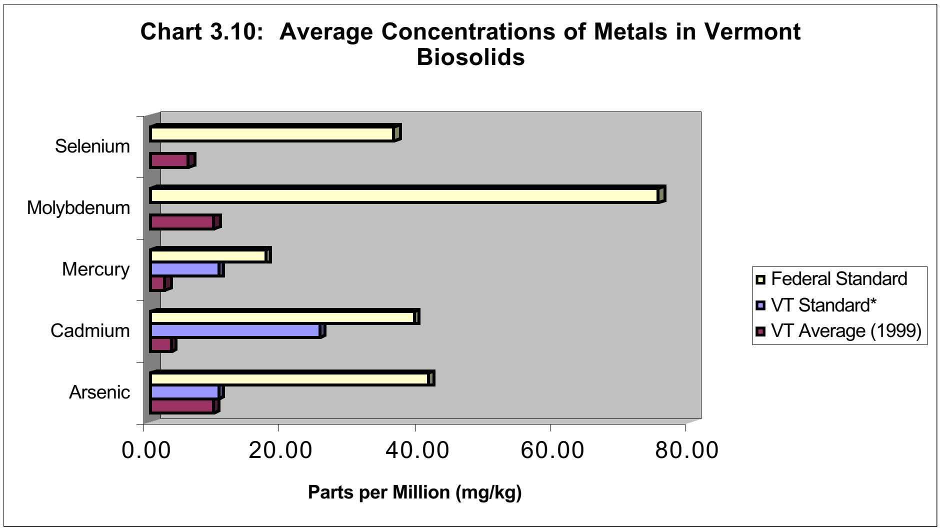
<u>NOTE</u>: The state and federal limits shown for comparison are the strictest standards.

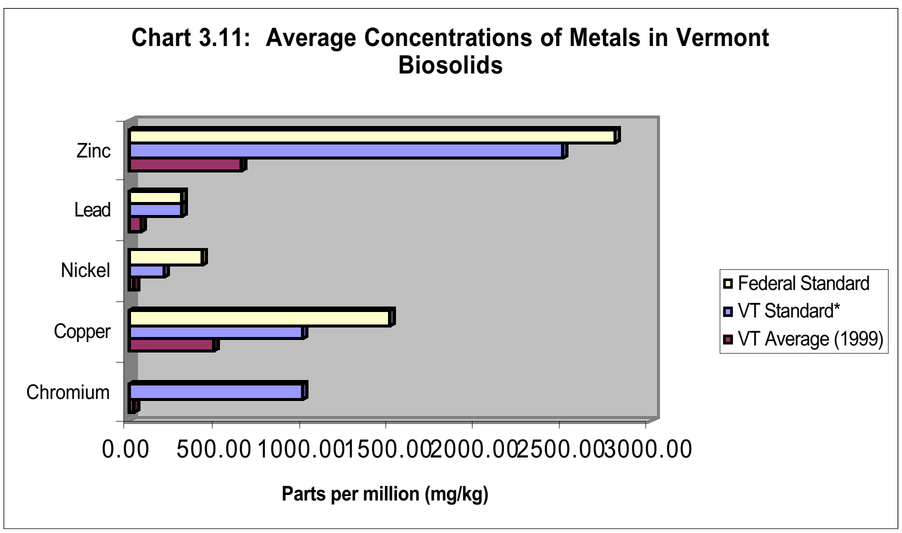




*NH "low metals biosolids" standards, regulations Env-Ws 807.03(h).

<u>NOTE</u>: The state and federal limits shown for comparison are the strictest standards.





*VT solid waste regulations subchapter 7, 6-702(a)(10)(B)

<u>NOTE</u>: The state and federal limits shown for comparison are the strictest standards.

Chart 3.12: Average Concentrations of Arsenic in New England Biosolids

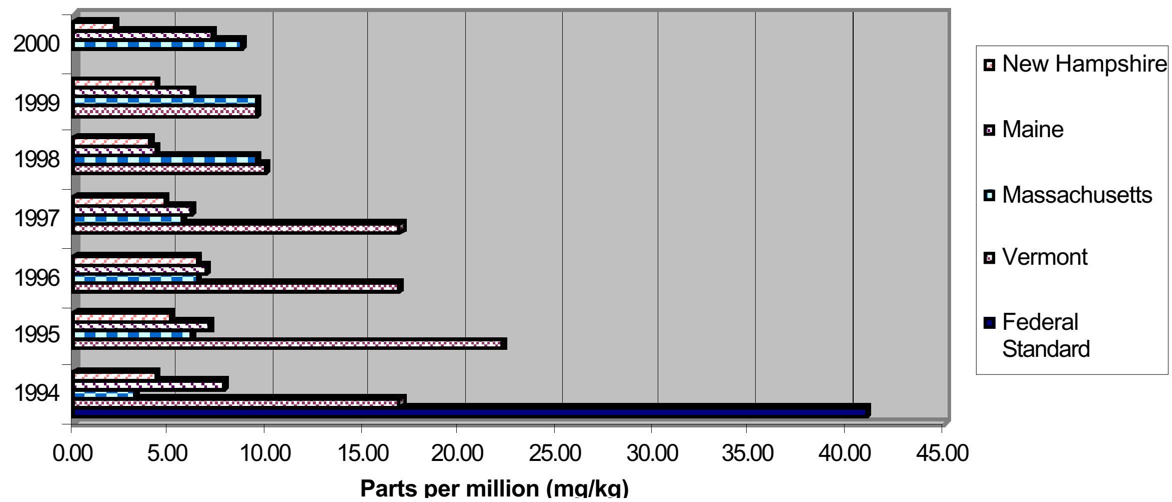
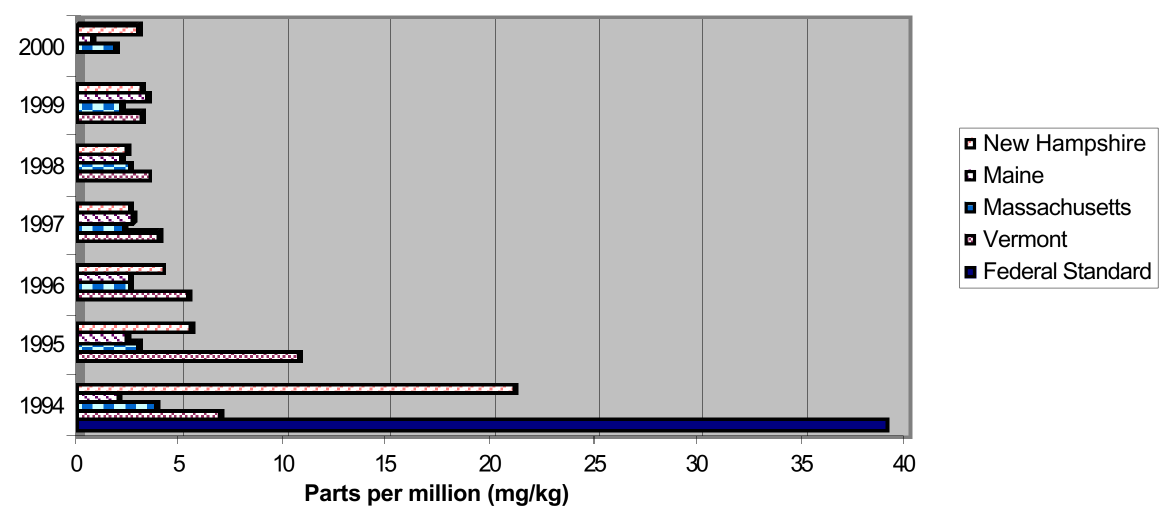
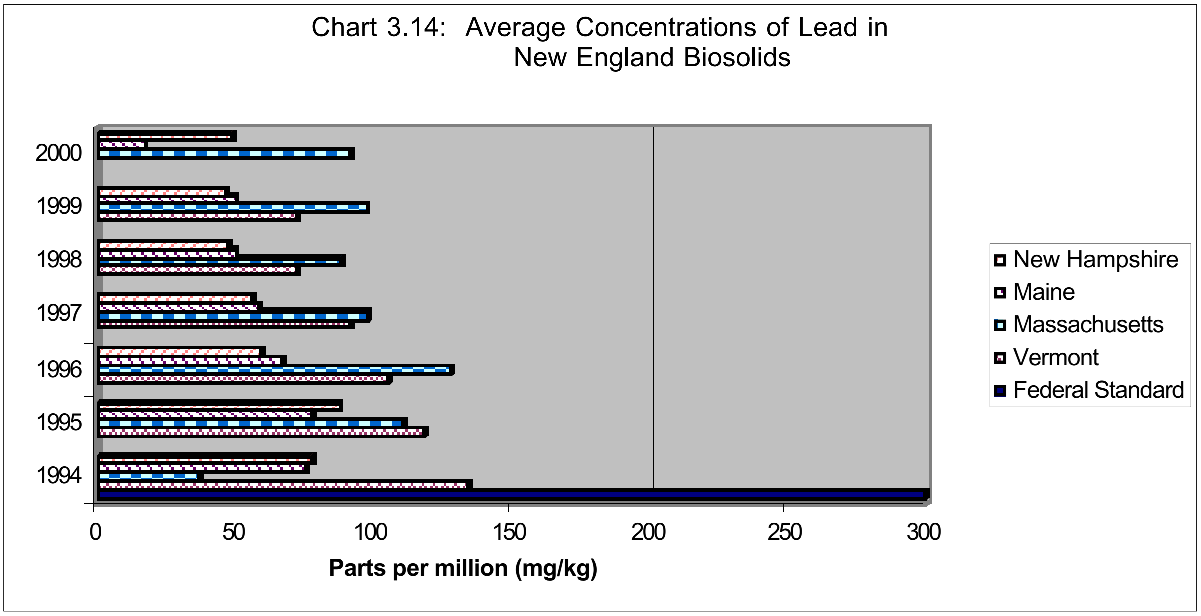
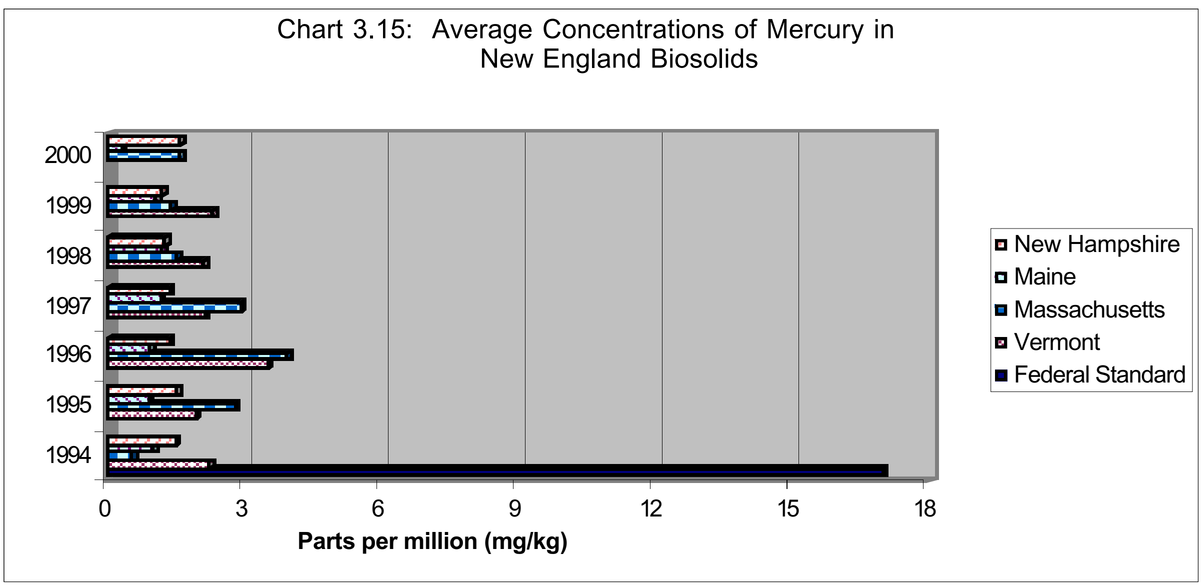


Chart 3.13: Average Concentrations of Cadmium in New England Biosolids



NOTE: Federal standards shown for comparison are the strictest (EQ) standards.





NOTE: Federal standards shown for comparison are the strictest (EQ) standards.

3.6 More About the Trace Metals Data

Note that trace metals data–like any test data–is influenced over time by changes in test methods, especially when such very small traces of metals are being tested for. Thus, for instance, the apparent decline in recent years, in arsenic in Vermont biosolids (Chart 3.12) is likely due to the ability of laboratories to detect smaller amounts.

Why are *averages* presented in this report? Mostly because of the volume of data. But also because averages are what biosolids recycling involves:

- The wastewater and sewage sludge treatment processes create *average* materials through constant mixing of a continuous flow of wastewater and biosolids.
- The process for collecting biosolids samples for testing involves creating an *average* composite sample representative of biosolids from one day to a few months, depending on the size of the facility.
- And, over time, *average* biosolids are what are applied to soils: in practice, in the marketplace, over many years, any one particular site will most likely receive biosolids from different facilities and different times. Thus, the application of trace contaminants to the soil will be an *average*.

The averaging processes involved in biosolids production and distribution help ensure that trace contaminants are unlikely to accumulate rapidly at any particular end-use site.

More information about the compilation and presentation of trace metals data is provided in the appendix.

IV. Conclusions

The data compiled and reviewed for this report indicate that the biosolids being recycled in New England are of relatively high quality with regard to trace metals and (based on limited data) trace chemicals (see also the appendix).

Clearly, it will be useful for biosolids managers and the public to continue to have ever greater access to this kind of data and summary information.

This report is only one piece in the process of improving the availability of information about biosolids recycling in New England. Future efforts may include on-line data availability and improved access to individual facility records. These are the kinds of open communications that some of those critical of the biosolids management industry have requested. As *public* utilities, wastewater and biosolids facilities are responding.

Given the data collected in this report, and given what is currently known about the potential impacts of trace contaminants on soils, plants, animals, and humans, it is reasonable to conclude that biosolids currently in use throughout New England present very low risk to public health and the environment.

Additionally, based on the fact that demand is increasing for biosolids products in the marketplace, it seems that farmers, growers, and landscapers are finding that biosolids products are of value and are beneficial.

But this report does not intend to make decisions for its readers. This is a presentation of information--and then it is up to the public to decide how well New England's biosolids programs are doing. Because each facility and program is somewhat different, it may also be helpful to get to know your local biosolids management program. In general, these public facilities are glad to have visitors and share additional information.

The ultimate quality of biosolids products, and the programs that recycle biosolids back to the land, depend on the care and professionalism of those managing their production and end-use. Wastewater operators are certified water quality professionals with continuing education requirements in all six New England states. They follow strict, science-based protocols. They are public servants who have chosen to work in one of the most important environmental professions.

Many water quality and biosolids professionals recognize that improvement needs to be constant. Over the past few years, the wastewater treatment and biosolids management industry nationwide has recognized this fact and that the most successful biosolids management programs have been aided, in part, by constant attention to detail and continual improvement. The Environmental Management System (EMS) program for biosolids mentioned in Chapter 2 will help encourage more wastewater and biosolids management programs to recognize the importance of continual improvement. (For more about the EMS program for biosolids, see the National Biosolids Partnership website at www.biosolids.org).

As the biosolids management industry focuses more and more on the quality of biosolids products and biosolids programs, it is hoped that the kind of information included in this report will be that much more available and "user-friendly." Information is a powerful tool for understanding. The public has every right to as much information about the biosolids programs in their communities as possible. NEBRA will continue to work to provide such information.

For questions, other information, or additional details, contact the NEBRA office by phone at 603-323-7654 or by email at info@nebiosolids.org.

APPENDIX

APPENDIX CONTENTS

CASE STUDIES

A.1 Trace Chemical Data for New England Biosolids

The U.S. EPA reviewed the potential risks posed by traces of chemicals (organic pollutants) found in sewage sludges and did not set regulatory standards for them, because one or more of the following applied to the trace chemicals identified in sewage sludges:

- "The pollutant has been banned for use…; has restricted use…; or is not manufactured for use in the United States.

- Based on the results of the National Sewage Sludge Survey (NSSS), the pollutant has a low percent detect in sewage sludge.
- Based on data from the NSSS, the limit for an organic pollutant in the Part 503 exposure assessment by use or disposal practice is not expected to be exceeded in sewage sludge that is used or disposed" (U.S. EPA Technical Support Document, Vol. 2, Appendix B).

U.S. EPA is currently developing numerical regulatory standards for dioxins and co-planar PCBs in land-applied biosolids because they are found in low levels in more than 5% of sewage sludges and they persist in the environment (they do not readily degrade in soils, as do many chemical compounds).

Because EPA does not require testing for trace chemicals, in New England, as elsewhere, there is less data on the levels of trace chemicals in biosolids than there is data for trace metals. However, several states (e.g. Maine and New Hampshire) require testing for trace chemicals, and several other large wastewater treatment facilities test for them routinely (e.g. Massachusetts Water Resources Authority).

In 1993, Morin and Switzenbaum of the Civil Engineering Department at the University of Massachusetts at Amherst reviewed the literature regarding levels of trace organic chemicals in sewage sludges around the U.S. They found "the concentrations of individual trace organics measured in the EPA [e.g. the 1988 National Sewage Sludge Survey] and other studies exhibit wide variability between sludges from different municipalities but are consistently very low."

Morin and Switzenbaum also completed testing for about 160 organic chemical compounds on several biosolids compost products from western Massachusetts. Testing included volatile organics, semi-volatile organics, and pesticides. Their report stated: "It is evident from the results that very few trace organic compounds were detected in either the parent sludge (raw compost) or finished compost samples." The only chemicals detected, and the levels found, are listed in Chart A-1.

In its 1998 publication "Target Organic Compounds in Maine Biosolids," the Maine Wastewater Control Association noted that "in the State of Maine, biosolids from larger public wastewater treatment facilities have been tested for organic priority pollutants for many years. The data generated has generally shown either very low levels of or no organic priority pollutants…. Over the course of four years of testing from thirteen treatment plants in Maine, only twelve organic priority pollutants were detected more than once" (Maine Wastewater Control Association, 1998).

Chart A-1: Only a few trace chemicals were detected, at low levels, out of about 160 tested for in several western Massachusetts biosolids composts.

(adapted from Morin & Switzenbaum Table 5-1)

Sample location and date	Compounds detected in finished compost	Concentration (mg/kg) dry wt.
1) Holyoke, 10/1/92	Dimethyl disulfide	0.05
2) Springfield, 10/1/92	Lindane	1.1
	Bis (2-ethylhexyl) phthalate	*51
	Benzoic acid	58
	Acetone	*2.8
	Methylethyl ketone (MEK)	2.6
	Dimethyl disulfide	1.8
3) Williamstown, 10/8/92	Bis (2-ethylhexyl) phthalate	*0.86
	4-Methylphenol	0.73
	Methylethyl ketone (MEK)	0.26
	Acetone	*1.5
	Toluene	0.015

(adapted from Morin & Switzenbaum Table 5-2)

Sample location and date	Raw/Final compost	Compounds detected in compost	Concentration (mg/kg) dry wt.
4) Holyoke 11/19/92	Raw	Bis (2-ethylhexyl) phthalate	11
		Acetone	82
		Methylethyl ketone (MEK)	79
		Toluene	0.34
		Total xylenes	0.15
		Dimethyl disulfide	0.64
	Final	Bis (2-ethylhexyl) phthalate	37
		Pyrene	3.2
5) Holyoke 1/7/93	Raw	Bis (2-ethylhexyl) phthalate	*18
		Acetone	73
		Methylethyl ketone (MEK)	220
		Chloroform	0.084
		Ethylbenzene	0.031
		Toluene	0.42
		Total xylenes	0.18
	Final	Bis (2-ethylhexyl) phthalate	*39
		Dimethyl disulfide	0.72
6) Holyoke 3/18/93	Raw	Bis (2-ethylhexyl) phthalate	51
	Final	Bis (2-ethylhexyl) phthalate	59
		Dimethyl disulfide	0.36
7) Holyoke 6/23/93	Raw	Bis (2-ethylhexyl) phthalate	36
		Acetone	19
		Methylethyl ketone (MEK)	15
	Final	Bis (2-ethylhexyl) phthalate	46

*-Also detected in laboratory blank at a similar level.

During the period 1995 - 1998, the state of New Hampshire collected data and tested Lowell, MA biosolids for over 100 priority pollutant chemicals. Lowell's biosolids, at the time, were treated to Class B standards (Lowell is now developing a Class A process). Fourteen separate testing events occurred, spread over the three year period. Only about 20 chemicals were detected, some of them only once. Chart A-2 includes those chemicals most often detected.

Chart A-2: Trace chemicals found most often in tests of 14 different Lowell, MA biosolids samples, 1995 - 1998 (from NH-DES, May 19, 1998 memo).

Chemical compound name (and how many times out of 14 it was detected)	Range of levels detected (mg/kg)
Acetone (7)	0.14 - 18.92
Bis (2-ethylhexyl) pthalate (14)	1.593 -62.37
2-Butanone (5)	0.06 - 8.62
Chloroform (5)	0.026 - 0.625
p-Isopropyltoluene (6)	0.046 - 0.816
4-Methylphenol (5)	0.878 - 47.52
Toluene (12)	0.052 - 4.25
Total Cresol (6)	8.1 - 50

Since 1999, New Hampshire regulations have required four separate tests for 168 trace chemicals in any biosolids that are to be recycled in the state. This testing requirement has created more data, which is summarized in Chart A-4 (from Carpenter, 2000).

Finally, to put trace levels of chemicals--some of which are naturally-occurring and some of which are common in the environment--in perspective, it is useful to compare them to levels found in other materials. Chart A-3 provides such a comparison for two chemicals that show up in biosolids occasionally: acetone and methly-ethyl ketone (MEK or 2-Butanone), two chemicals that were of public concern when found in groundwater in New Hampshire.

Chart A-3: Comparing the levels of two chemical contaminants in New England biosolids to natural levels in other materials (from Carpenter, 2000).

Material	**Acetone**	**Methyl Ethyl Ketone**
	Median values mg/kg (dry weight)	
Biosolids	1.5	0.60
Dairy Manure (1 sample)	0.65	0.68
Dried beans	0.88	0.15
Split peas	0.53	0.11

Chart A-4: Trace chemicals found in New Hampshire biosolids from NH-DES Sludge Quality Testing for 168 compounds (from Carpenter, 2000).

Compound	% detection	Average (mg/kg)	Median (mg/kg)	possible sources
bis(2-Ethylhexyl)phthalate	88%	28.6	20	plasticizer, plastic pipes
3/4-Methylphenol	65%	41.6	8	decomposition by-product
Toluene	61%	1.5	0.19	vehicle exhaust, gas stations
4-Chloroaniline	53%	5.1	3.2	Dyes, biosynthesis?
2-Butanone(MEK)	52%	3.2	0.60	decomposition by-product
Acetone	49%	9.7	1.50	decomposition by-product
1,2,4-Trimethylbenzene	40%	0.09	0.05	
p-isopropyltoluene	37%	0.24	0.05	
1,4-Dichlorobenzene	37%	0.23	0.05	disinfectant
Phenol	34%	7.5	4.5	decomposition by-product
Chloroform	23%	0.05	0.03	by-product of water chlorination
1,3,5-Trimethylbenzene	23%	0.08	0.03	
mp-Xylene	21%	0.05	0.03	Engine exhaust, forest fires

Dioxins--a group of organic chemicals that are potentially harmful in very small amounts--are detectable in biosolids. Dioxins and related compounds (e.g. co-planar PCBs) are of environmental concern because of their resistance to decay or biodegradation in the environment. Most dioxins found in biosolids are likely there because of the fact that the largest source of dioxins is from aerial deposition and runoff carries dioxin from the environment into wastewater treatment systems. Some may also enter wastewater from industrial and domestic sources. The greatest human exposure to dioxins is through meat and dairy consumption: dioxin accumulates in animal fats. The U. S. EPA is currently assessing the potential risks of dioxins in biosolids. A U.S. EPA regulatory limit for dioxins in land applied biosolids is due to be finalized in December, 2001. Maine and New Hampshire already have strict limits on dioxins in biosolids.

What is known about dioxins in New England biosolids is (see Chart A-5, below):

- from recent test data, New England biosolids have low to average levels of dioxins in comparison to U. S. averages, and

- average levels of dioxins in New England biosolids are similar to dioxin levels currently found in background soils and other materials (e.g. yard and leaf waste composts).

In summary, the data that exists regarding the levels and potential risks of trace chemicals in New England (and other) biosolids is similar to that found in other parts of the country and the data reviewed in the U.S. EPA risk assessment process. Although additional research regarding a few chemicals is recommended (e.g. see R.V. Anderson), current scientific knowledge indicates that biosolids use does not create any significant risk from the trace chemicals they may contain.

Chart A-5: Levels of dioxins found in New England biosolids (from Carpenter, 2000). The group of chemicals called "dioxins" actually includes several individual chemicals of similar nature that are commonly reported with one summary value--the "TEQ." As is typical for dioxin reporting, the measurements here are parts per trillion (ppt - 1 ppt = 1 second in 30,000 years).

	Sampling years	Number of samples	Mean ppt (dry weight) TEQ	Median ppt (dry weight) TEQ
Maine	1995-1997	31	6.3	5.4
New Hampshire	1999/2000	95	5.2	3.5
Vermont	1997	28	11.2	8.6
NSSS	1988	208	83[1]	37[1]

1 Data taken from Jones, K.C. and A.P. Stewart 1996. *Dioxins and furans in sewage sludges*. Non-detects were reported as 1/2 the detection limit when calculating TEQ values.

Source	Concentration (ppt TEQ dry weight)
U.S. soils average	8
rural average	4
urban average	19
Leaf and yard waste compost	5 - 91 (29 samples)
Cow manure compost	3.4 (4 samples)
Fish	0.59
Human body burden	28

A.2 Trace Metal Data Sources

Biosolids use and disposal figures were obtained from state regulatory staff David Wright (ME), Cathy Jamieson (VT), Larry Polese (MA), Alex Pinto (RI), and Robert Norwood (CT) and checked against other published numbers (e.g. *Biocycle* magazine).

Biosolids production facilities nationwide are required to submit the results of their trace metals testing to their individual state departments of environmental protection and the U.S. Environmental Protection Agency. For this report, NEBRA collected and reviewed metals testing data from these archives.

Prior to retrieving the testing data from state and federal sources, NEBRA chose approximately 10 facilities in each state that were representative of the common types of biosolids recycling and final products in that state. An attempt was also made to choose facilities of varying sizes, serving both rural and urban areas, in each state. The chosen facilities, listed by the name of the communities they serve, were:

Chart A-6: Biosolids Trace Metal Data Sources

Maine	Massachusetts	New Hampshire	Vermont
Bath	Boston	Allenstown	Barre
Bethel	Holyoke	Claremont	Bennington
Brunswick	Lowell	Concord	Chelsea
Gardiner	Mansfield	Dover	Johnson
Jay	Marlborough	Franklin	Middlebury
Kennebec Sanitary Dist. - Waterville	Pepperell	Hooksett	Randolph
Lewiston-Auburn	Williamstown	Keene	Richmond
Ogunquit		Milford	St. Albans
Portland		Nashua	St. Johnsbury
York		Plymouth	Stowe

All of the data in this report is compared to the strictest federal (Exceptional Quality or "EQ") and state standards. U. S. EPA and state limits were determined based on studies of potential receptors and are designed to be fully protective of the environment and public health and safety.

A.3 Trace Metal Data Quality Control

To create graphs and determine state averages, the collected trace metal data was transcribed into Microsoft Excel workbooks and reviewed for accuracy. Specific quality control checks were performed on any data points that deviated from the state averages by more than 20%. All of the data were linked electronically to create the state averages and graphs, thus reducing the chance of error due to incorrect data transfer.

Data quality is also provided by comparing data from different sources, compiled and reported by different people. A few data points do not say much, but when there is a large amount of consistent data, collected over time and involving many different people, it begins to be possible to have a great deal of confidence in the accuracy of the data. Such is the case with biosolids trace metal data for New England.

For example, Chart A-7 was compiled in 2000 from data collected from random samples taken from biosolids products in New Hampshire. The samples were collected by regulatory personnel at random times and sites. The New Hampshire trace metal averages reported in Chart 3.5 of this NEBRA report are provided at the bottom of the Chart A-7, for comparison. Note that while there is some variability, as expected, the random sampling data confirms the general accuracy of the data collected and reported by facility personnel.

Chart A-7: New Hampshire Quality Control Data
(from NH Dept. of Environmental Svcs.)

Lab #	Arsenic (32)	Cadmium (14)	Copper (1500)	Chromium (1000)	Lead (300)	Mercury (10)	Molybdenum (35)	Nickel (200)	Selenium (28)	Zinc (2500)
A2980-1	7.5	3.86	534	171	87.9	NT	10.1	162	3	628
A4326-1	7.2	2.36	268	43.9	90.2	3.06	<10	19.9	3.6	643
A4326-2	7.4	6.36	1300	51.6	134	2.35	18.9	39.2	6.2	2020
A4326-3	6.4	1.27	282	14.4	23.5	2.51	20.7	5.8	2.7	358
A4558-1	8.1	<1.98	249	34.7	50.7	1.68	<10	12.7	3.6	511
A4786-1	4.3	<1.96	182	44.2	45.1	0.11	<19.6	13	2.4	395
A4786-2	<3	<3.46	1320	17.4	42.9	0.16	<34.6	21	3.5	2230
A4786-3	7.4	5.94	916	47.4	125	1.75	<41.2	45.4	5.8	1430
A5816-1	6.3	4.89	860	46	123	4.42	<28.8	43	4.9	1360
A5816-2	3.6	<1.79	123	18.4	38	1.09	<17.9	10	<1.8	320
A5999-1	2.8	<1.64	NT	NT	18	0.451	NT	NT	<1.6	NT
A6718-2	7.9	3.95	212	35.8	41.5	1.55	<20.4	18	2	479
A6718-3	6.1	2.92	803	34.2	84.2	1.63	11	28.6	4	45.5
A13395-4	***34***	5.6	***1500***	63	170	3.7	23	56	<18	2100
Standard Deviation*	7.79	2.04	489.52	39.64	46.95	1.32	6.09	40.77	2.19	763.11
Mean	7.89	3.04	657.62	47.85	76.71	1.88	13.46	36.51	3.74	963.04
Average from NEBRA-compiled data, for comparison (from Chart 3.5)	**2**	**3**	**433**	**20**	**49**	**2**	**11**	**18**	**2**	**663**

< - Indicates that the metal concentration is below the minimum detection level shown
NT – not tested

A 1997 analysis of Vermont biosolids quality data conducted by the Vermont Department of Environmental Conservation (VT DEC) provides another independent confirmation of the accuracy of the data compiled by NEBRA in this report (see Chart A-8, below). Some variation exists due to the fact that the data analyzed by VT DEC was from a different year.

A.4 Trace Metal Detection Limits

Laboratories report concentrations of the targeted metals compounds in milligrams per kilogram. If a metal is not detected, the laboratory reports that the concentration of that metal was "less than X", where X represents the lowest detection limit of the analytical machinery. To be conservative, in those cases where laboratory analysis failed to detect a metal, for purposes of averaging, NEBRA chose to assign the detection limit as the concentration of that metal, even though the actual concentration may have been below that level. Therefore, even though the stated average concentrations of most metals are well below the strictest federal and state standards, the actual average concentrations may be even lower than that.

Chart A-8: Comparison of Vermont Biosolids Quality Data Reported Here and by VT DEC (parts per million or mg/kg)		
	***Saving Soil* Report - VT 1999 data**[1]	**VT DEC Data - 1997 study**[2]
Arsenic	9	10.47
Cadmium	3	6.08
Chromium	31	58.69
Copper	490	783.8
Mercury	2	2.58
Molybdenum	9	N/A
Nickel	22	34.82
Lead	72	112.14
Selenium	6	5.07
Zinc	649	994.52

1 - see Chart 3.3
2 - from a 1997 study by VT DEC, reported in Vermont Final Proposed Revised Solid Waste Master Plan, July 2001.

A.5 Variability of Trace Metal Levels

This question sometimes comes up: "Couldn't there be an elevated level of a trace contaminant that goes through the system undetected and could negatively impact the site where biosolids are put to use?"

There are several checks and balances that provide assurance that any particular truckload of biosolids is unlikely to cause significant negative impact. Indeed, because of the amount of scrutiny applied to biosolids recycling, it presents fewer "unknowns" than many other commonly accepted practices, such as land applying animal manures that may contain antibiotics, trace metals, excessive nutrients, and other potential pollutants.

First, remember that biosolids are produced by wastewater treatment facilities that are living systems. Any high level of toxic material entering the system would disrupt the facility's operations and lead to additional testing and monitoring of biosolids coming from the facility at that time.

Secondly, the wastewater treatment process is a long, continuous process, that mixes, dilutes, and spreads out any variability in the quality of the wastewater entering it.

Thirdly, statistical analyses are occasionally conducted on biosolids testing data. Because it is impossible or excessively expensive to test every cubic yard of biosolids, or even every truckload, assessments of biosolids quality often rely on statistical analysis. Statistics can help answer the question, "How likely is it that a given truckload of biosolids will contain some trace contaminant at a level that exceeds the regulatory standard?"

For example, during the past two years, New Hampshire Department of Environmental Services (NHDES) scientists asked Professor Thomas Ballestero of the University of New Hampshire's

Department of Civil Engineering to conduct a statistical analysis of the trace metals data for New Hampshire biosolids. According to the report compiled by NHDES,

> "A review of the metals data obtained in the 2000 field season shows that, except for copper and zinc, the probability of exceeding a state standard is less than 1% (less than 1 in 100). For copper and zinc, the probability of a violation is approximately 5% (5 times in 100)."

Dr. Ballestero is continuing this work and will be delivering another report to NHDES in the fall of 2001.

And, finally, it is helpful just to review the data from one facility and look at the high and low test results along with the calculated average concentrations. Chart A-9 below shows the variability in concentrations of selected metals from individual samples collected and analyzed at one facility (Lewiston-Auburn, ME) between 1994 and 1999. All of the test data for arsenic, cadmium, mercury, and lead--the trace metals of greatest concern--are presented.

A-6: Accumulation of Trace Metals in Agricultural Soils

For many years, one of the greatest concerns with the practice of biosolids recycling has been the potential long-term impacts of accumulation of trace metals--especially arsenic, cadmium, mercury, and lead--in soils to which biosolids are applied for many years. U. S. Department of Agriculture and other researchers have extensively studied this concern (see Chaney, 1999).

Chart A-10 shows how biosolids managers and farmers calculate the *agronomic rate* --the rate at which biosolids may be applied so that only enough nitrogen is supplied to grow the crop. Using the agronomic rate ensures little risk of excess nitrogen negatively impacting groundwater.

Agronomic rate applications determine how much biosolids is applied to each acre of soil for each crop cycle. Chart A-10 also shows how biosolids managers and farmers can calculate approximately how much of each trace metal is applied to the land with the biosolids application. In this example, a typical application rate of 3.1 dry tons of biosolids per acre results in, for instance, 3 pounds of zinc being applied per acre (see Chart A-10).

U. S. EPA and other scientists assessed the risks of trace metals levels in soils and established regulatory standards for cumulative soil metals levels as part of the federal Part 503 rule. In order to give a sense of how small is each annual addition of trace metals from a typical New England biosolids application, Chart A-10 shows how many years a typical application of biosolids could be made before the U. S. EPA limit is reached. In this example, a typical biosolids application could occur for more than two hundred years before any of the trace metals begin to reach the current regulatory maximum. And this is a conservative figure; given current biosolids management practices, the actual period of time might be two or three times greater, because

- many farmers use biosolids on a particular field only every few years, and
- the first-year agronomic rate of application is higher than in future years.

Chart A-11 shows a similar calculation, using an average Vermont biosolids for an example.

Charts A-10 and A-11 include comparisons to Washington state and Canadian limits for annual additions of metals to soils applied in fertilizers (biosolids are not covered by these laws, unless they are sold with fertilizer claims; biosolids have been shown to make metals less bioavailable, which is not the case with fertilizers).   And Charts A-10 and A-11 include comparisons to the very conservative recommendations of the Cornell Waste Management Institute (see Harrison et. al., 1999)

Additional Charts

- Chart A-12 provides data on the Use and Disposal of Biosolids in each New England state. This data is graphed in Chart 2.4.
- The last set of charts shows the averages, by state, of trace metals levels over time.

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Chart A-9: Assessing Variability--High, Low, and Average Concentrations for Arsenic, Cadmium, Mercury, and Lead in a Typical Biosolids Recycling Facility in New England

Year	Metal	Number of Samples Tested *	Average	Lowest Concentration	Highest Concentration	State and (Federal EQ) Standards
1994	Arsenic	6	9.25	7.00	10.60	41 (41)
	Cadmium		2.27	0.90	4.30	10 (39)
	Mercury		0.66	0.52	0.82	10 (17)
	Lead		84.67	58.00	109.00	300 (300)
1995	Arsenic	12	14.31	3.40	67.00	41 (41)
	Cadmium		3.58	2.00	5.00	10 (39)
	Mercury		0.16	0.10	0.78	10 (17)
	Lead		87.92	72.00	132.00	300 (300)
1996	Arsenic	12	10.71	0.90	57.00	41 (41)
	Cadmium		3.50	1.00	7.00	10 (39)
	Mercury		0.10	0.10	0.10	10 (17)
	Lead		73.58	53.00	100.00	300 (300)
1997	Arsenic	12	4.12	1.00	11.00	41 (41)
	Cadmium		3.75	2.00	7.00	10 (39)
	Mercury		0.17	0.10	0.40	10 (17)
	Lead		60.58	10.00	86.00	300 (300)
1998	Arsenic	12	2.59	1.00	14.00	41 (41)
	Cadmium		1.75	1.00	4.00	10 (39)
	Mercury		1.00	0.50	1.80	10 (17)
	Lead		56.92	39.00	76.00	300 (300)
1999	Arsenic	12	4.38	2.60	6.10	41 (41)
	Cadmium		2.79	1.00	6.30	10 (39)
	Mercury		0.55	0.04	0.97	10 (17)
	Lead		40.48	27.00	78.30	300 (300)

* Number of samples tested – composite samples submitted during the year by the facility for laboratory analysis for trace

Chart A-10: Calculating Accumulation of Metals in Soils From a Typical Bulk Biosolids Application

Chart: CALCULATING ACCUMULATION OF METALS IN SOILS FROM A TYPICAL BULK BIOSOLIDS APPLICATION

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For this example, the highest Concord NH annual average for each trace metal during 1994-2000 was used. Using averages, rather than maximums, makes sense for this example, because, over many years of repeat applications, average concentrations of each trace metal are applied. Note that this biosolids application meets even the strict limits on annual soil additions of Canadian and Washington state fertilizer laws (which do not apply to biosolids in those jurisdictions unless they are sold with specific nutrient value claims).

DATA FROM KNOWN REQUIREMENTS AND BIOSOLIDS TESTING:

biosolids source:	Concord WWTF
crop:	feed corn
nitrogen (N) needed by crop (lb./acre):	150
residual N in soil (lb/acre):	30
additional N needed (lb/acre):	120
biosolids plant-available N (PAN), 1st yr. (lb./dry ton)*:	38.26
application rate (dry tons/acre):	**3.1**

trace elements measured in biosolids (mg/kg):

Arsenic (As):	7.0
Cadmium (Cd):	4.0
Chromium (Cr):	164
Copper Cu);	256
Lead (Pb):	191
Mercury (Hg):	2.4
Molybdenum (Mo):	8.5
Nickel (Ni):	36
Selenium (Se):	17
Zinc (Zn):	491

* To calculate plant available N, enter N test data here:

TKN (mg/kg)	48600
NH4 (mg/kg)	4400
NO3 (mg/kg)	2100
Organic N (mg/kg)	42100
TKN (lb/dry ton)	97.2
NH4 (lb/dry ton)	8.8
NO3 (lb/dry ton)	4.2
Organic N (lb/dry ton)	84.2
% organic N available first year	30
plant availabe N (PAN), first year	38.26

	Column A Total trace element applied with biosolids (application rate x element level x 2000 lbs. / 1000000) (pounds/acre - usually applied once/year)	*Column B* Average NH agricultural soils or Northeast forage soils* from Holmgren et. al. (pounds/acre)	Total soil level of trace element after application Col. A + Col. B (pounds/acre)	WA & Canada Fertilizer Annual Addition to Soil Limit (lbs./acre/yr.)	USEPA "503" cumulative metal loading limits (pounds/acre)	1997 CWMI "Case for Caution" soil standards (pounds/acre)	**Years of biosolids application at the same annual rate to reach USEPA cumulative limit (years)**	Years of biosolids application at the same annual rate to reach CWMI cumulative limit (years)
As	0.04	12.0	* 12.04	0.297	37	1 to 10	**567**	*avg. soil over limit*
Cd	0.03	0.35	0.38	0.079	35	2	**1377**	66
Cr	1.03	200	* 201.03	N/A	N/A	N/A	**N/A**	N/A
Cu	1.61	68.0	* 69.61	N/A	1338	40 to 100	**791**	20
Pb	1.20	16.0	17.20	1.981	268	300	**210**	237
Hg	0.02	0.06	0.08	0.019	15	1	**976**	61
Mo	0.05	3.2	* 3.25	0.079	16	4	**241**	15
Ni	0.23	56.2	56.43	0.713	375	25 to 50	**1412**	*avg. soil over limit*
Se	0.11	0.4	* 0.51	0.055	32	5	**296**	43
Zn	3.08	141.6	144.68	7.329	2498	200	**765**	19

Chart A-11: Calculating Accumulation of Metals in Soils From a Typical Bulk Biosolids Application

Chart: CALCULATING ACCUMULATION OF METALS IN SOILS FROM A TYPICAL BULK BIOSOLIDS APPLICATION

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For this example, the Vermont 1999 average for each trace metal was used. Using averages, rather than maximums, makes sense for this example, because, over many years of repeat applications, average concentrations of each trace metal are applied. Vermont averages were chosen because they are the highest reported (see Chart 3.3). Note that this biosolids application meets even the strict limits on annual soil additions of Canadian and Washington state fertilizer laws (which do not apply to biosolids in those jurisdictions unless they are sold with specific nutrient value claims).

DATA FROM KNOWN REQUIREMENTS AND BIOSOLIDS TESTING:

biosolids source:	***assume the***
crop:	***same***
nitrogen (N) needed by crop (lb./acre):	***application***
residual N in soil (lb/acre):	***rate as***
additional N needed (lb/acre):	***previous***
biosolids plant-available N (PAN), 1st yr. (lb./dry ton)*:	***example***
application rate (dry tons/acre):	**3.1**

trace elements measured in biosolids (mg/kg):

Arsenic (As):	9.0
Cadmium (Cd):	3.0
Chromium (Cr):	31
Copper Cu);	490
Lead (Pb):	72
Mercury (Hg):	2.0
Molybdenum (Mo):	9.0
Nickel (Ni):	22
Selenium (Se):	6
Zinc (Zn):	649

* To calculate plant available N, enter N test data here:

TKN (mg/kg)	48600
NH4 (mg/kg)	4400
NO3 (mg/kg)	2100
Organic N (mg/kg)	42100
TKN (lb/dry ton)	97.2
NH4 (lb/dry ton)	8.8
NO3 (lb/dry ton)	4.2
Organic N (lb/dry ton)	84.2
% organic N available first year	30
plant availabe N (PAN), first year	38.26

When applied at a typical annual agronomic rate (3.1 dry tons/acre), the average 1999 Vermont biosolids could be applied for hundreds of years before the metals levels in soils reach EPA maximums.

	Column A Total trace element applied with biosolids (application rate x element level x 2000 lbs. / 1000000) (pounds/acre)	***Column B*** Average NH agricultural soils or Northeast forage soils* from Holmgren et. al. (pounds/acre)		Total soil level of trace element after application Col. A + Col. B (pounds/acre)	WA & Canada Fertilizer Annual Addition to Soil Limit (lbs./acre/yr.)	USEPA "503" cumulative metal loading limits (pounds/acre)	1997 CWMI "Case for Caution" soil standards (pounds/acre)	**Years of biosolids application at the same annual rate to reach USEPA cumulative limit (years)**	Years of biosolids application at the same annual rate to reach CWMI cumulative limit (years)
As	0.06	12.0	*	12.06	0.297	37	1 to 10	**448**	*avg. soil over limit*
Cd	0.02	0.35		0.37	0.079	35	2	**1863**	89
Cr	0.19	200	*	200.19	N/A	N/A	N/A	**N/A**	N/A
Cu	3.04	68.0	*	71.04	N/A	1338	40 to 100	**418**	11
Pb	0.45	16.0		16.45	1.981	268	300	**565**	636
Hg	0.01	0.06		0.07	0.019	15	1	**1205**	76
Mo	0.06	3.2	*	3.26	0.079	16	4	**229**	14
Ni	0.14	56.2		56.34	0.713	375	25 to 50	**2337**	*avg. soil over limit*
Se	0.04	0.4	*	0.44	0.055	32	5	**849**	124
Zn	4.02	141.6		145.62	7.329	2498	200	**586**	15

Chart A-12: New England Biosolids - Use and Disposal Methods (2000 - *updated**)

(This data is depicted in Chart 2.4.)

		Beneficial Use			Disposal			
Location	**Units**	**Land App.**	**Compost**	**Heat Dried**	**Landfill**	**Incin.**	**Other**	**Total**
Maine	dry tons	10,431	15,651		7,769		126	33,977
	% of Total	30.7%	46.1%		22.9%		0.4%	100.0%
Vermont	dry tons	2,086	3,957		1,766	384		8,193
	% of Total	25.5%	48.3%		21.6%	4.7%		100.0%
New Hampshire	dry tons	1,980	3,600		8,460	3,960		18,000
	% of Total	11.0%	20.0%		47.0%	22.0%		100.0%
Massachusetts	dry tons	2,690	18,830	32,280	53,800	145,260	13,450	266,310
	% of Total	1.0%	7.1%	12.1%	20.2%	54.5%	5.1%	100.0%
Rhode Island	dry tons		2,174		1,053	24,795		28,022
	% of Total		7.8%		3.8%	88.5%		100.0%
Connecticut	dry tons		2,385		3,180	73,935		79,500
	% of Total		3.0%		4.0%	93.0%		100.0%
New England	dry tons	17,187	46,597	32,280	76,028	248,334	13,576	434,002
	% of Total	4.0%	10.7%	7.4%	17.5%	57.2%	3.1%	100.0%

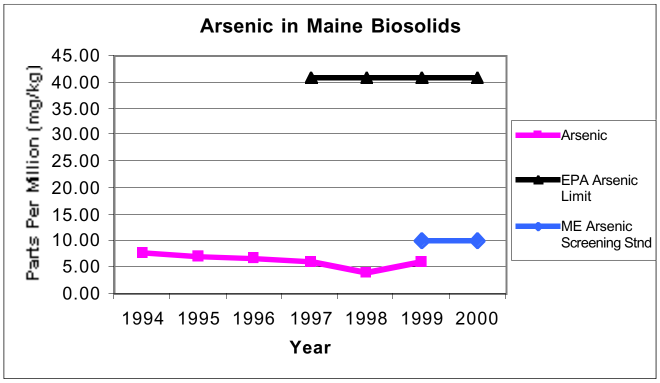
Regional Totals

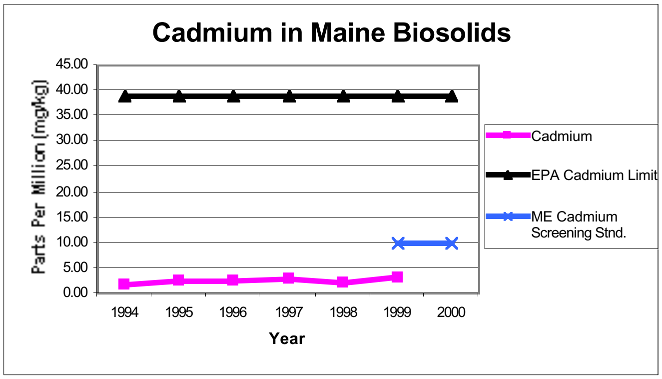
			Land App	**Compost**	**Heat Dried**	**general use-Class A**
Total Beneficial Use in New England	dry tons	96,064	17,187	46,597	32,280	78,877
	% of Recycled	22.1%	17.9%	48.5%	33.6%	82.1%
			landfill	**incin**	**other**	
Total Disposal in New England	dry tons	337,938	76,028	248,334	13,576	
	% of Disposed	77.9%	22.5%	73.5%	4.0%	

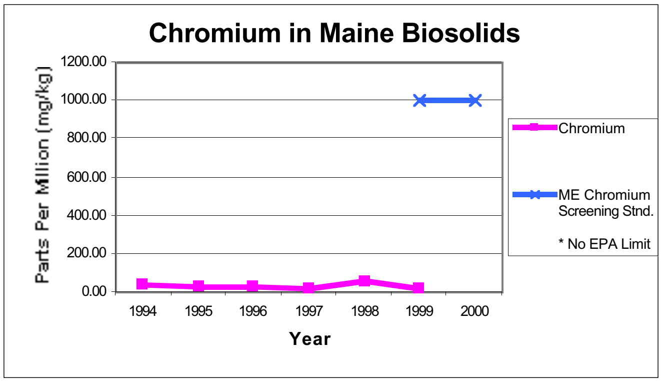
*NOTE: This table includes updated Maine numbers received at the time of publication that are not included in Chart 2.4--the difference is not great, but is significant: Maine's 2000 recycling rate was actually 77% and the total sewage sludge produced and recycled are slightly higher than reported in Chapter 2 of this report.

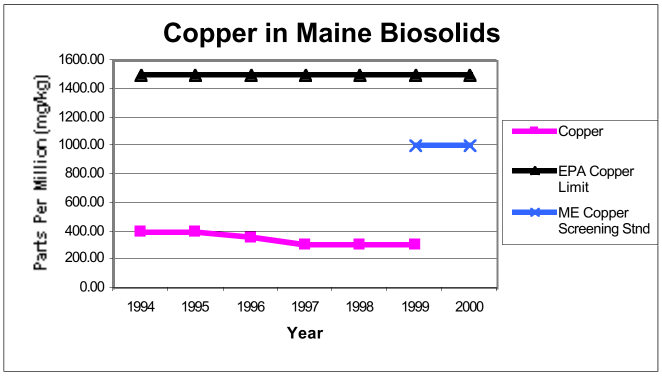
Averages by State of Trace Metals Levels Over Time: MAINE

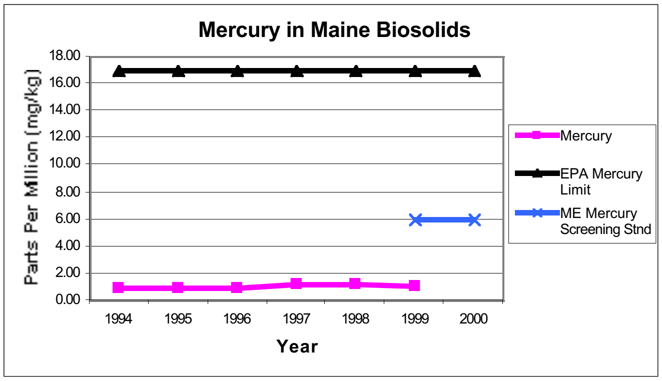
(Maine's lowest "screening" standards, Chapter 419: Table 419.3, col. A, are used for comparison.)

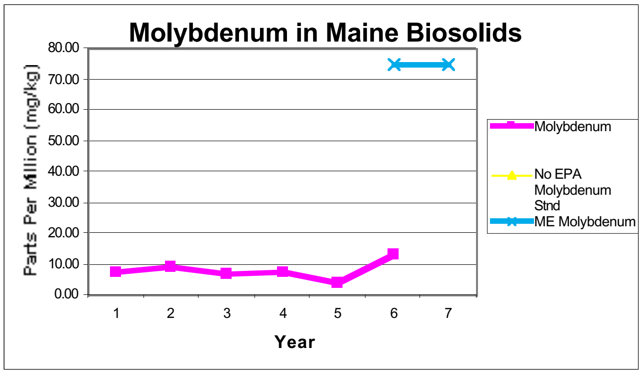


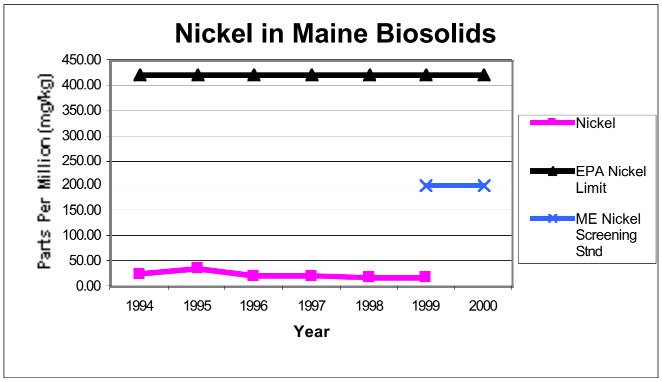


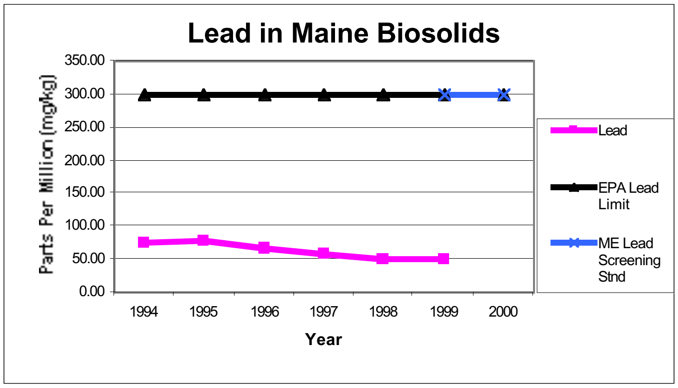


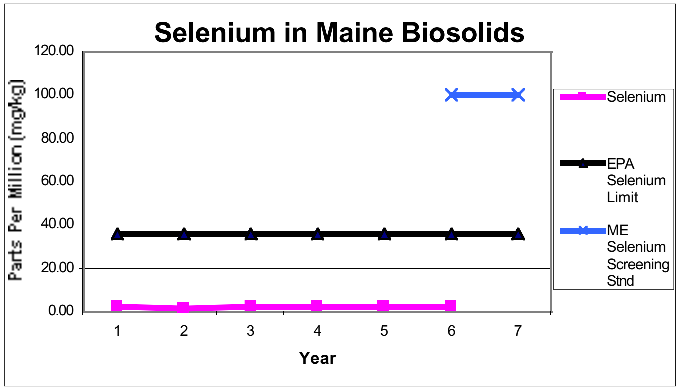


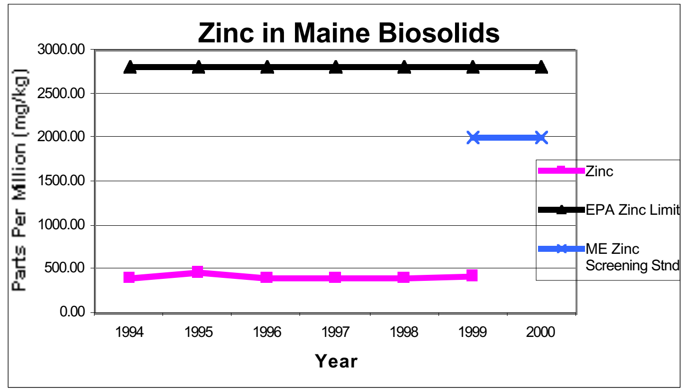






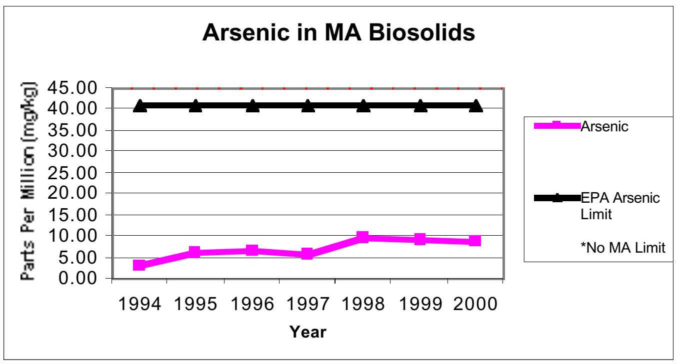


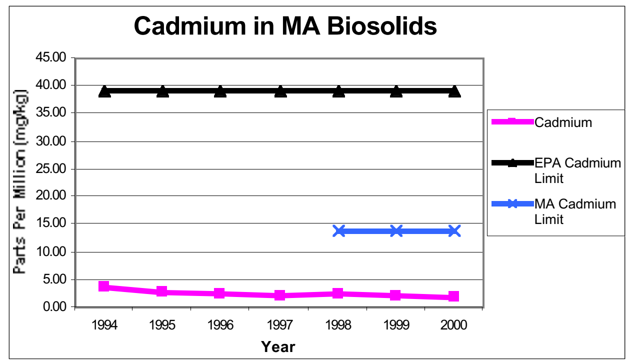


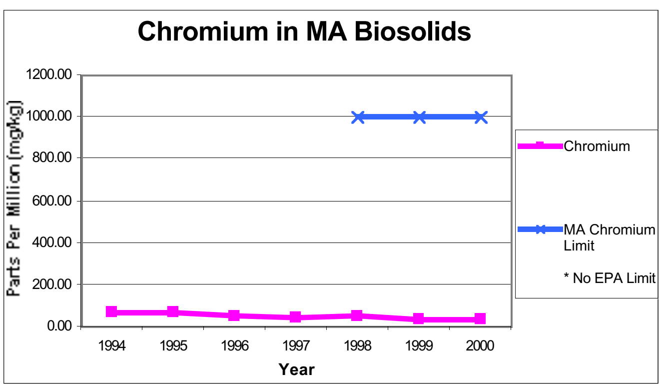


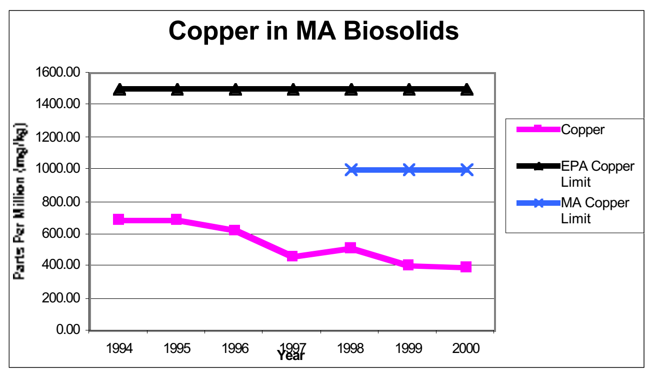
Averages by State of Trace Metals Levels Over Time: MASSACHUSETTS

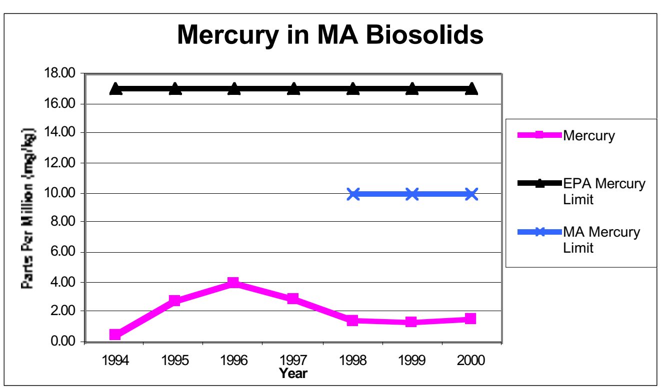
(MA lowest "Type 1 Sludge" standards, regulations Table 32.12(2)(a) are used for comparison.)

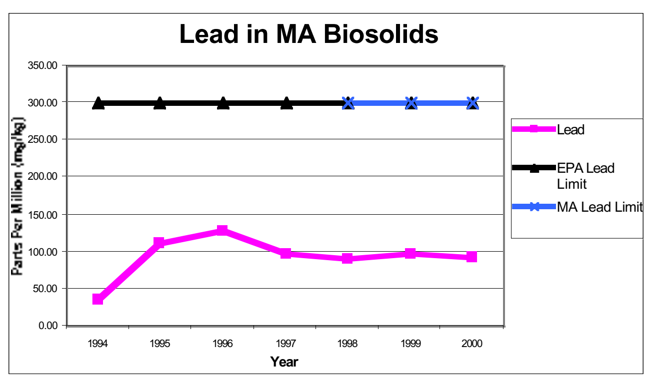


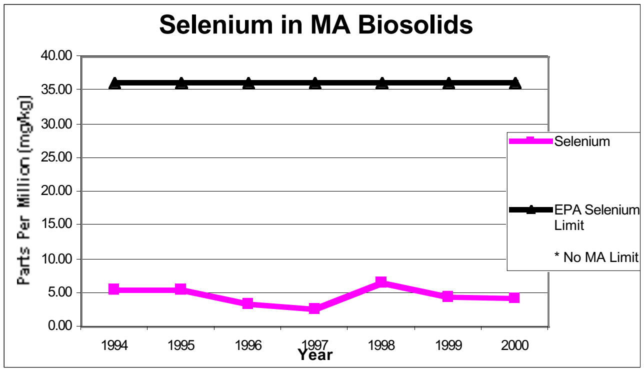


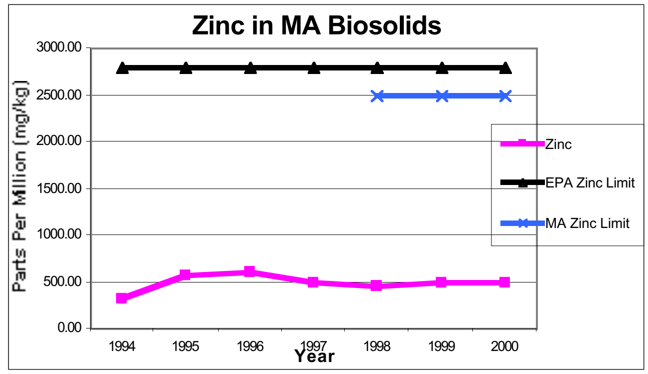






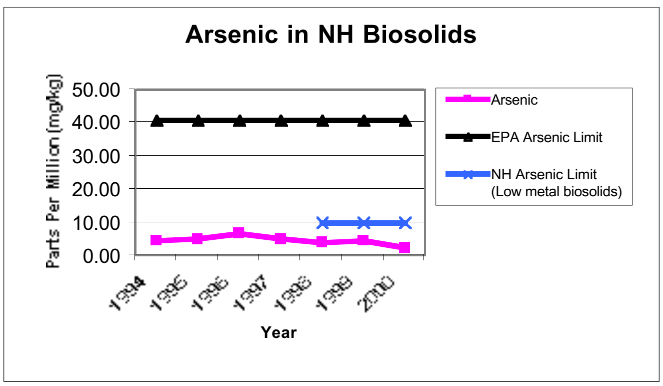


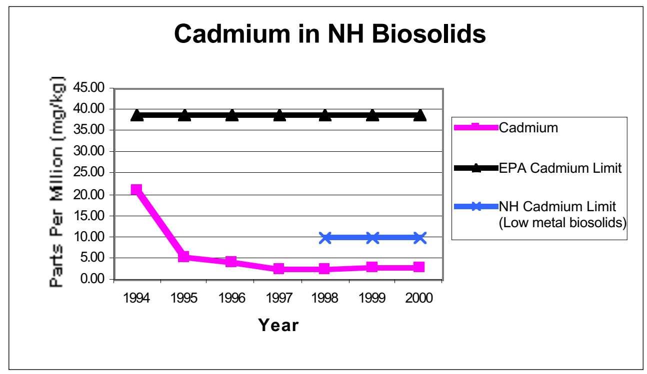


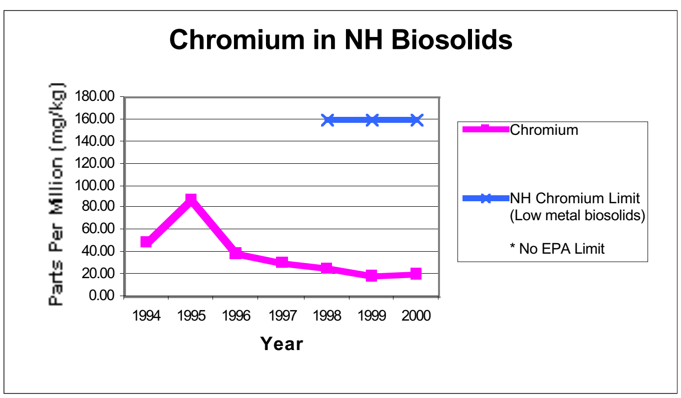


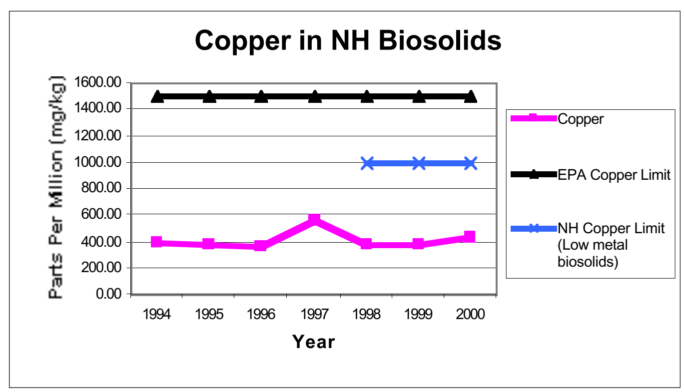
Averages by State of Trace Metals Levels Over Time: NEW HAMPSHIRE

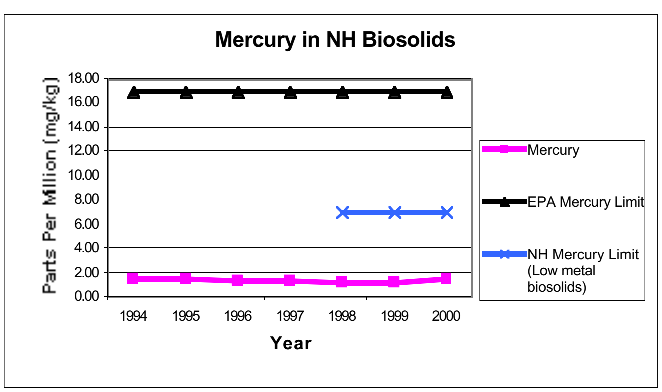
(NH "low metals biosolids" standards, regulations Env-Ws 807.03(h), are used for comparison.)

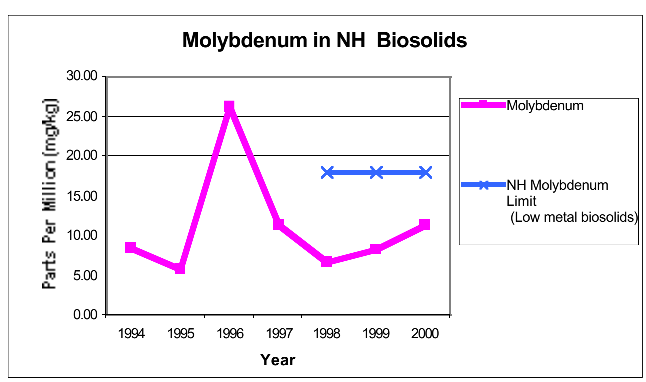


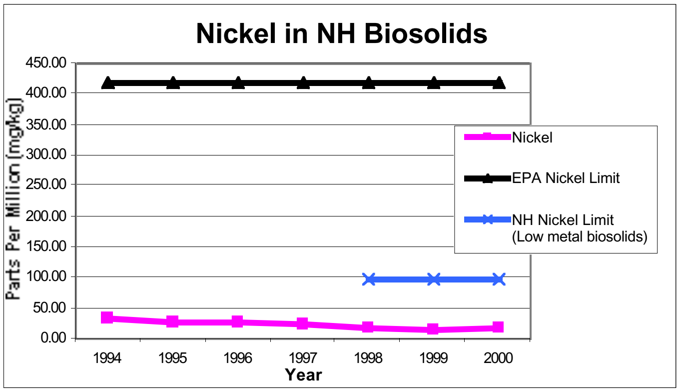


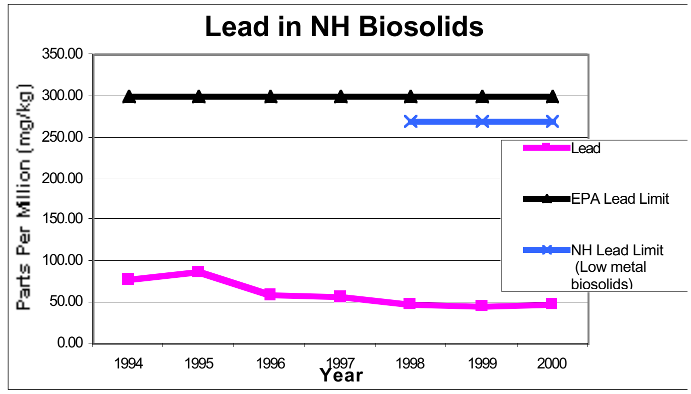


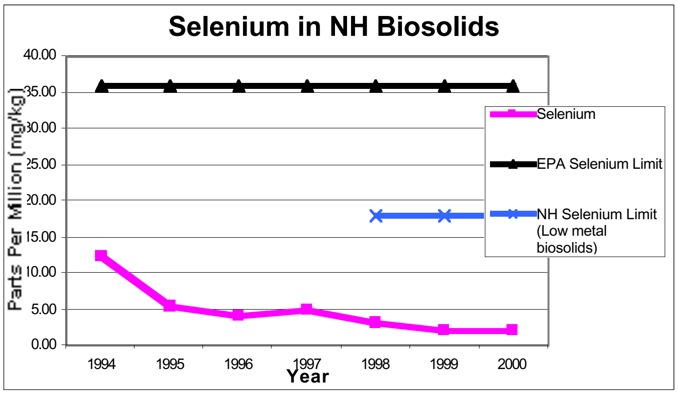


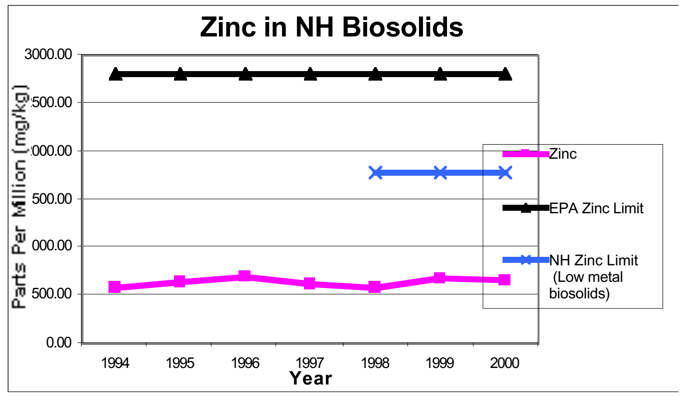






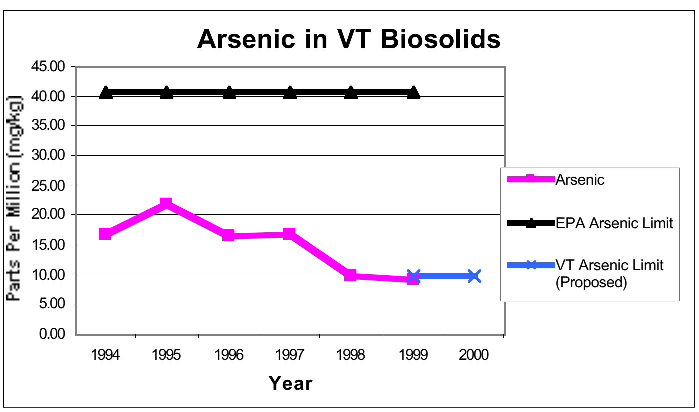


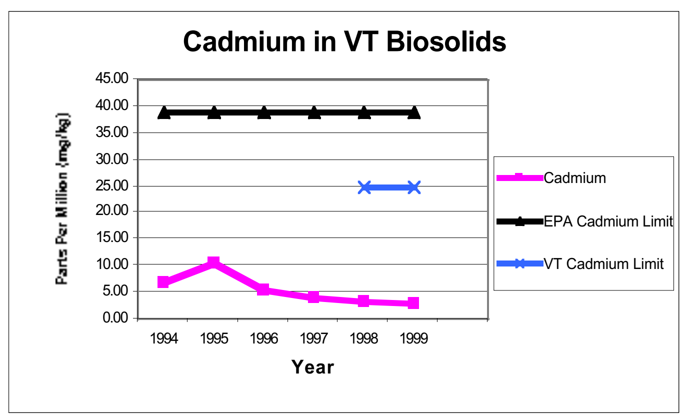


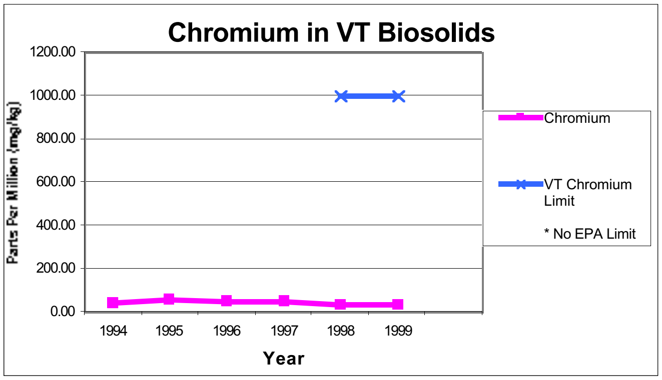


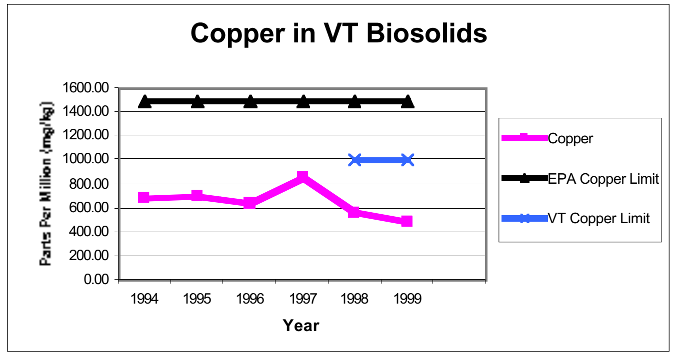
Averages by State of Trace Metals Levels Over Time: VERMONT

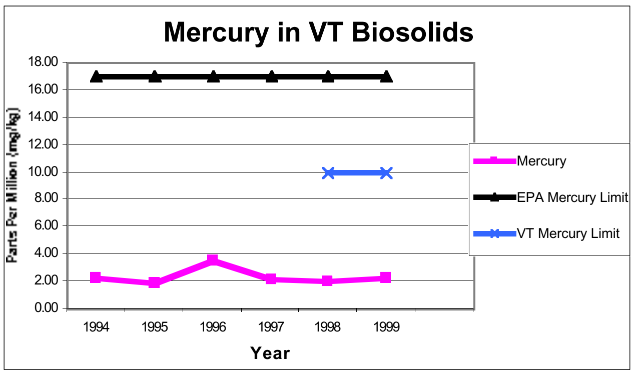
(VT standards, solid waste regulations subchapter 7, 6-702()(10)(B), are used for comparison.)

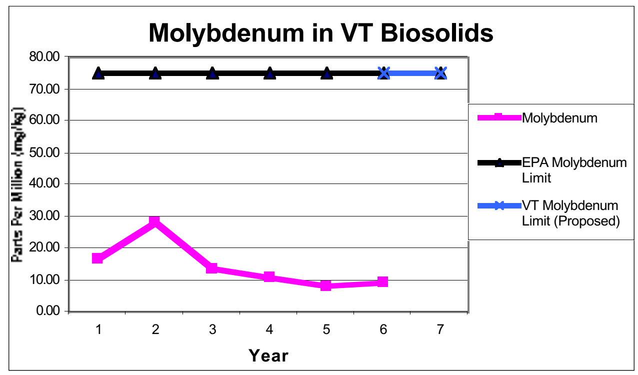


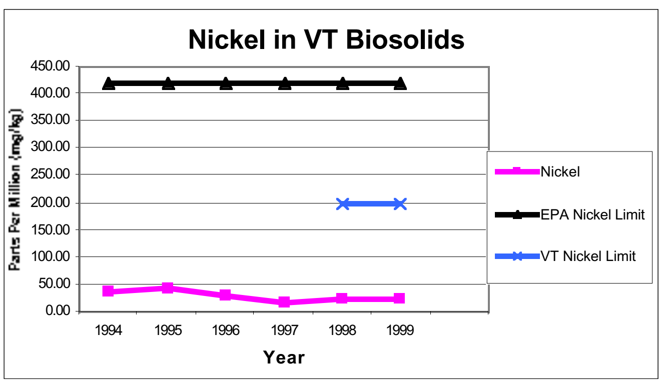


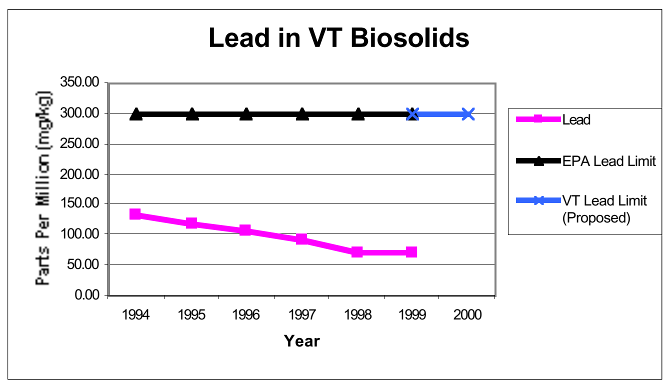

Chromium in VT Biosolids
Parts Per Million (mg/kg)
Year
Chromium
VT Chromium Limit
* No EPA Limit

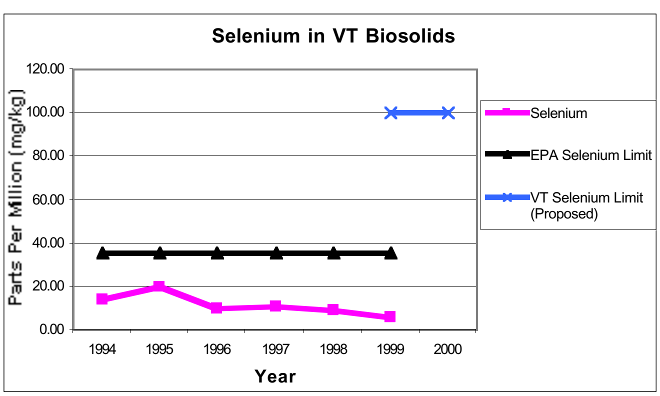

Copper in VT Biosolids
Parts Per Million (mg/kg)
Year
Copper
EPA Copper Limit
VT Copper Limit

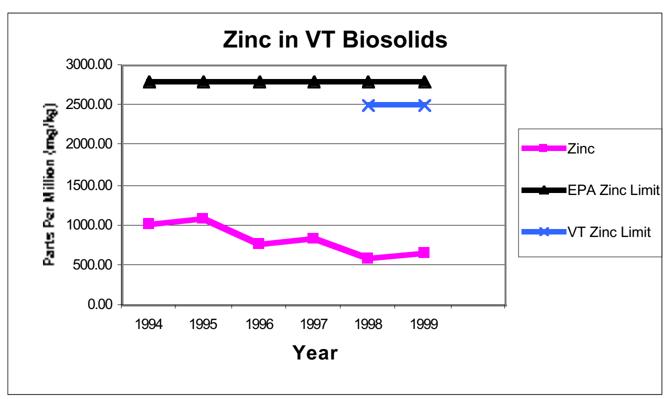

Mercury in VT Biosolids
Parts Per Million (mg/kg)
Year
Mercury
EPA Mercury Limit
VT Mercury Limit


Molybdenum in VT Biosolids
Parts Per Million (mg/kg)
Year
Molybdenum
EPA Molybdenum Limit
VT Molybdenum Limit (Proposed)


Nickel in VT Biosolids
Parts Per Million (mg/kg)
Year
Nickel
EPA Nickel Limit
VT Nickel Limit


Lead in VT Biosolids
Parts Per Million (mg/kg)
Year
Lead
EPA Lead Limit
VT Lead Limit (Proposed)


Selenium in VT Biosolids
Parts Per Million (mg/kg)
Year
Selenium
EPA Selenium Limit
VT Selenium Limit (Proposed)


Zinc in VT Biosolids
Parts Per Million (mg/kg)
Year
Zinc
EPA Zinc Limit
VT Zinc Limit