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

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.

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.

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.)