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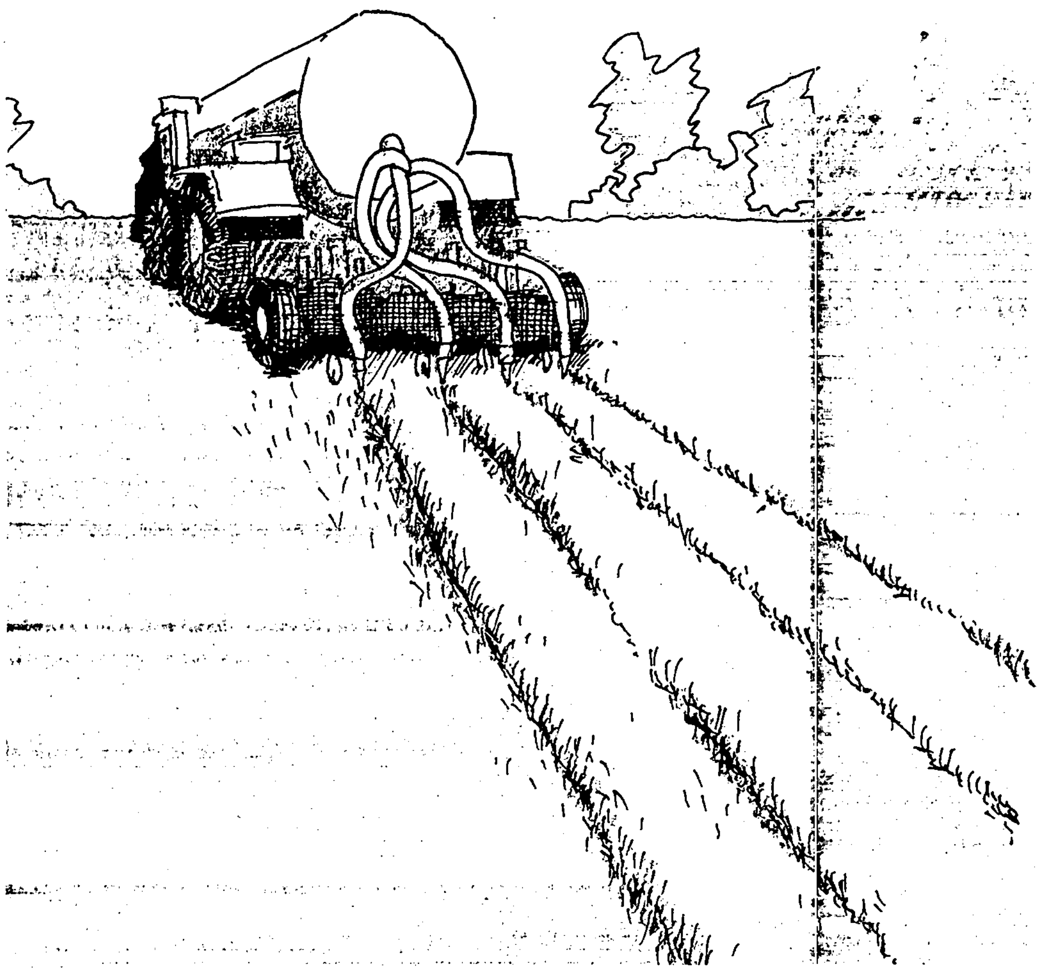
EPA

Biosolids Recycling: Beneficial Technology For A Better Environment



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MUNICIPAL TECHNOLOGY BRANCH

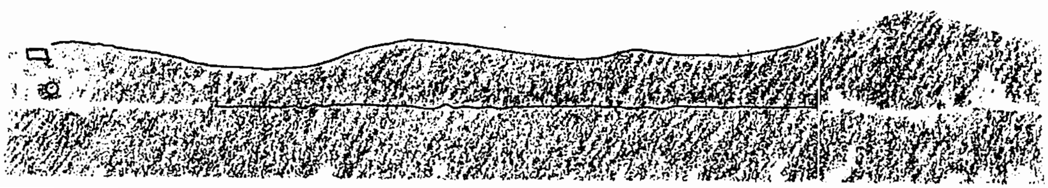
OVERVIEW

- The U.S. Environmental Protection Agency (EPA) will continue to promote practices that provide for the beneficial use of municipal sewage sludge biosolids, while maintaining or improving environmental quality and protecting human health.

- Thousands of municipalities are currently land applying or otherwise recycling their biosolids. Both agricultural and non-agricultural sites benefit from the nutrient and soil conditioning value of biosolids, which is generally worth about $100 to $140 per agricultural application of biosolids. Biosolids have been used successfully in the production of many different food, feed, and horticultural crops; in the production of sod and the maintenance of turf; for improved forest productivity; and for reclaiming and revegetating areas disturbed by mining, construction, and waste disposal activities.

- EPA continues to provide guidance and rules for the safe use of biosolids. Its current rule for the final use or disposal of biosolids (40 CFR Part 503) is the result of nearly 10 years of intensive study and development. This process involved detailed scientific risk assessment with careful evaluation of the available data, and the use of improved models and more realistic assumptions. It benefited greatly by the extensive assistance of biosolids experts.

- The biosolids now being generated are for the most part low in pollutants, rich in nutrients and organic matter, and highly suitable for recycling as a result of EPA's clean water and pretreatment efforts. The Part 503 standards provide for a wide range of different end-use possibilities for these biosolids.



PURPOSE

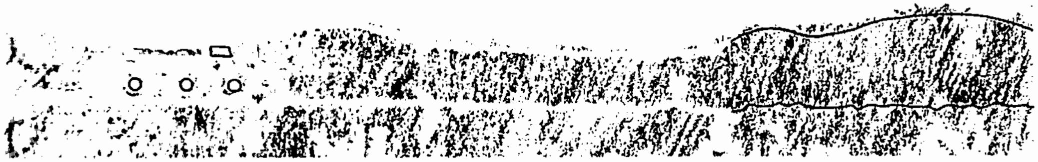
This booklet is written to provide an understanding of the great value that can be derived from the beneficial use of biosolids. In addition, it discusses and reaffirms the U. S. Environmental Protection Agency's policy that encourages the beneficial use of biosolids. This booklet then briefly discusses important aspects of its new regulation (40 Code of Federal Regulations Part 503) that govern the final use or disposal of biosolids. It concludes with a discussion of the scientific basis of the rule and names of people and references to contact for additional information regarding the rule and risk assessment.

EPA Policy on Beneficial Use of Municipal Biosolids

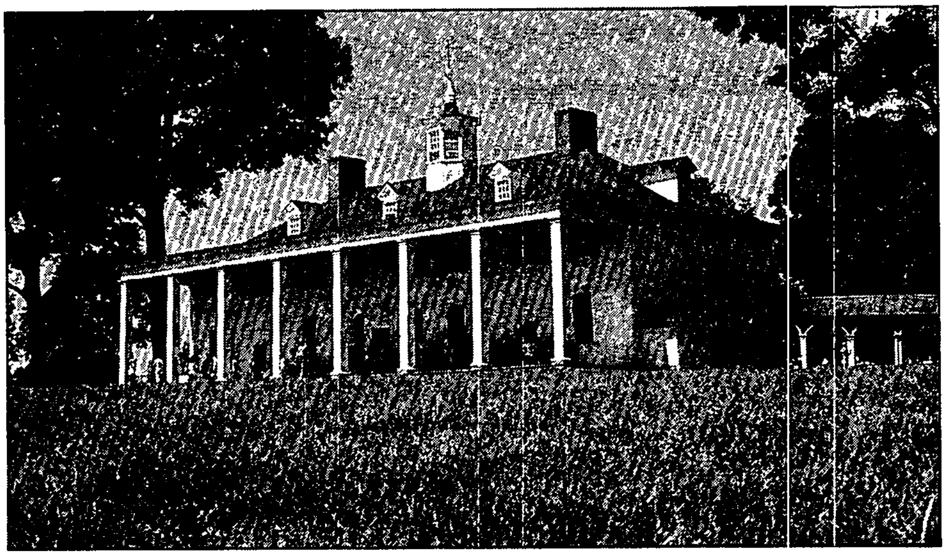
EPA's "Policy on Municipal Sewage Sludge (Biosolids) Management" (49 FR 24358 June 12, 1984) states that:

> *"The U.S. Environmental Protection Agency (EPA) will actively promote those municipal [biosolids] management practices that provide for the beneficial use of [biosolids] while maintaining or improving environmental quality and protecting public health. To implement this policy, EPA will continue to issue regulations that protect public health and other environmental values... Local communities will remain responsible for choosing among alternative programs; for planning, constructing, and operating facilities to meet their needs; and for ensuring the continuing availability of adequate and acceptable disposal or use capacity."*

As noted in the policy statement, EPA prefers well-managed practices that beneficially use municipal biosolids. Such practices include land application of biosolids as a soil amendment or fertilizer supplement and various procedures that derive energy from biosolids or convert them to useful products. These practices can help reduce the volume of biosolids requiring disposal, thus reducing the rate at which the limited capacity of disposal facilities is exhausted. Other benefits derived from recycling biosolids include improved soil fertility and tilth, reduced need for and enhanced response to inorganic fertilizers, better growth and quality of crops, and decreased consumption of energy.



Silvigrow applications vehicle at the University of Washington Pack Forest facility.



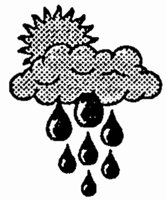
Composted biosolids have enhanced the Mt. Vernon landscape.

Biosolids are a Natural Fertilizer

For many individuals sewage sludge (biosolids) induce a major emotional response. This response is understandable when you realize that ever since infancy, parents teach children that human waste is dirty and is to be avoided and flushed down the toilet. Compare this with the life-long experience of most persons familiar with animal wastes as a material to be managed and used.

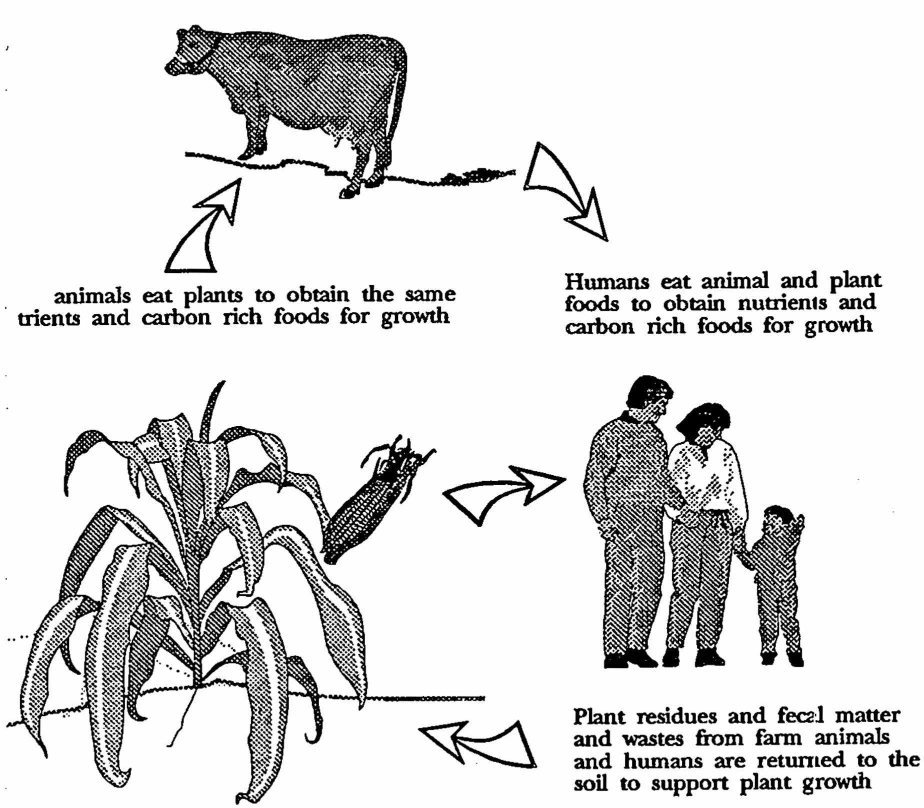
Like animal waste, biosolids are a part of the natural cycle of life (Figure 1). They contain inorganic and organic compounds removed during wastewater treatment. An important perspective on biosolids -- the natural fertilizer -- can be gained from the following closer look:

"Crops that supply our food and animal feed are grown in the soil. To grow, the crops need fertilizer and water. Essential soil fertilizer nutrients include carbon, hydrogen, oxygen, phosphorus, potassium, nitrogen, sulphur, calcium, iron, magnesium, molybdenum, boron, copper and zinc. Plants take up these essential soil-borne nutrients that are necessary for their normal growth. Using these nutrients and sunlight, plants manufacture organic carbon-rich foodstuffs such as carbohydrates, fats, and proteins.



Sun and rain cause crops to make carbon rich foods and provides energy for uptake of nutrients such as nitrogen, potassium, phosphorous, zinc, and molybdenum

The same nutrients that are essential for plant growth also are essential for the growth of humans and other animals. We gain many of these essential nutrients, along with carbohydrates, fats, and proteins, by eating plants. Wastes are excreted from humans and contain these same essential nutrient elements that are in the



igure 1. Natural Cycling of Nutrients

foods we consume. These wastes go into the municipal sewer system along with other household wastes. Municipalities also collect and treat wastewater from industrial and commercial sources. The residual solids generated during wastewater treatment were previously called sewage sludge. Sewage sludges that can be used are now being called biosolids to emphasize the beneficial nature of this valuable recyclable resource. Properly prepared biosolids provide a rich source of the essential fertilizer elements needed by plants to produce food. It seems only natural to return this rich source of nutrients and organic matter back to the soil to perpetuate the cycle of life."

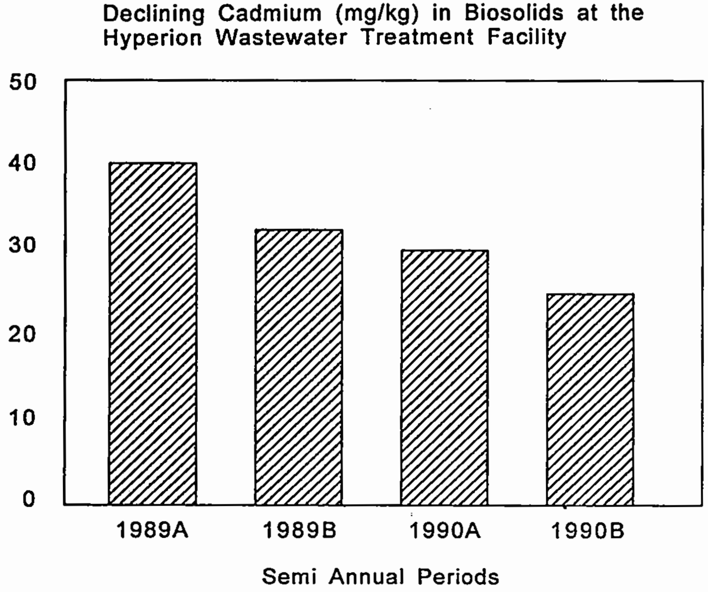


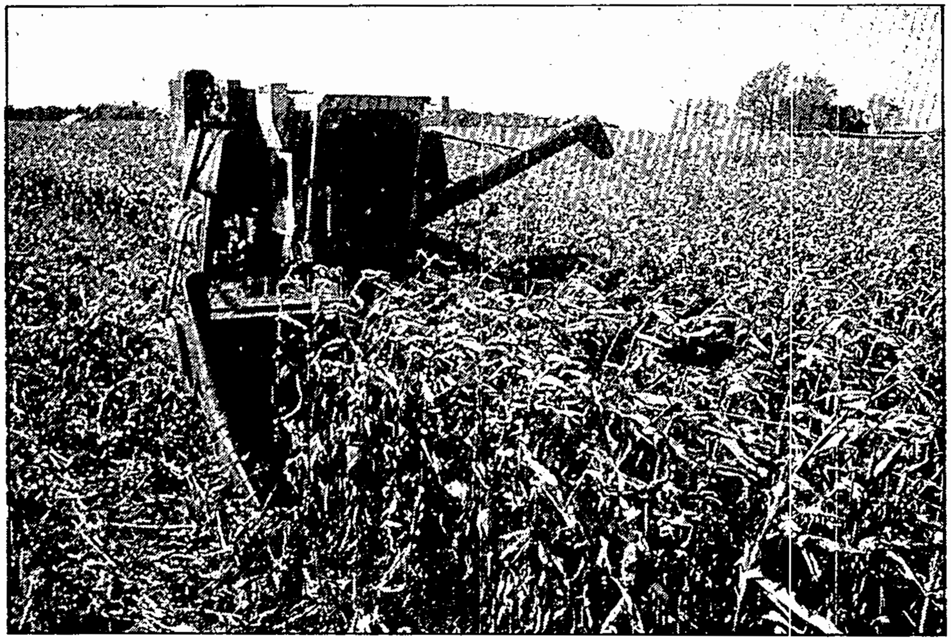
Figure 2. Pretreatment and source control have been very successful in reducing pollutant levels in biosolids.

Appropriate control is needed for the safe agricultural use of all fertilizers and soil conditioners -- whether in the form of biosolids, other organic amendments, or chemically-based fertilizers -- to insure that the proper amount of essential elements are provided. Controls also are needed with all fertilizers and soil conditioners to avoid contamination of groundwater with leachable excess nitrogen. Controls are needed with biosolids and animal wastes, because, depending upon the level of treatment, disease-causing organisms (pathogens) may be present and vectors such as flies and rodents can be attracted that may transmit disease. These controls come from many sources. Some control comes from following State fertilizer recommendations and sound agricultural practices. Additional control is obtained by required wastewater treatment to reduce pathogens to levels that are not harmful. Pretreatment by industry, mandated by law, is another primary control that prevents excessive levels of unwanted pollutants in wastewater and the resultant biosolids. Figure 2 shows that pretreatment and source control have been very successful in reducing the levels of pollutants in biosolids. And finally, compliance with the new Federal as well as existing State regulations requires the careful implementation of management practices and the use of biosolids application rates based on crop needs.

Agricultural Use of Biosolids

EPA's policy that promotes the beneficial use of municipal biosolids is based on years of extensive study and experience. Hundreds of studies have been conducted as a basis for the safe use of biosolids. Moreover, thousands of publicly owned treatment works (POTWs) are currently using their biosolids as an organic fertilizer and soil conditioner on land throughout the United States. For example, over 55% and 90%, respectively, of all biosolids produced in Ohio and Maryland are used on land.

Examples of communities recycling their biosolids include Hannibal, MO (19,000 population), Madison, WI (250,000 population), and Seattle, WA (1.1 million population). Each of these municipal authorities have been winners in EPA's National Beneficial Use of Biosolids Awards Program. Hannibal, MO and Madison, WI charge farmers for using their biosolids. Hannibal recovers 100% of the costs of hauling and spreading biosolids from its sales to farmers,



This corn crop benefitted from the use of biosolids as a fertilizer.

Table 1. Value of 5 to 10 Dry Tons per Acre of a Typical Anaerobically Digested Dewatered Biosolids Applied to Farmland

Nutrient	lbs/Acre Applied	Value/Acre
Nitrogen	150	$ 30.00
Phosphorus (P_2O_5)	150	$ 30.00
Potassium (K_2O)	10	$ 1.00
Copper (Cu)	7	$ 14.00
Zinc (Zn)	10	$ 12.50
Sulfur	20	$ 10.00
Lime	1 ton	$ 28.00
Spreading		$ 15.00
Total Value*		**$140.00**

* Value of organic matter is in addition to this total

Madison receives $12 per acre for applying their biosolids. Madison fertilizes 3,000 to 4,000 acres of farmland with biosolids each year and has farmers waiting with a total of 22,000 acres of farmland available for application. Seattle applies biosolids to forest as well as agricultural land.

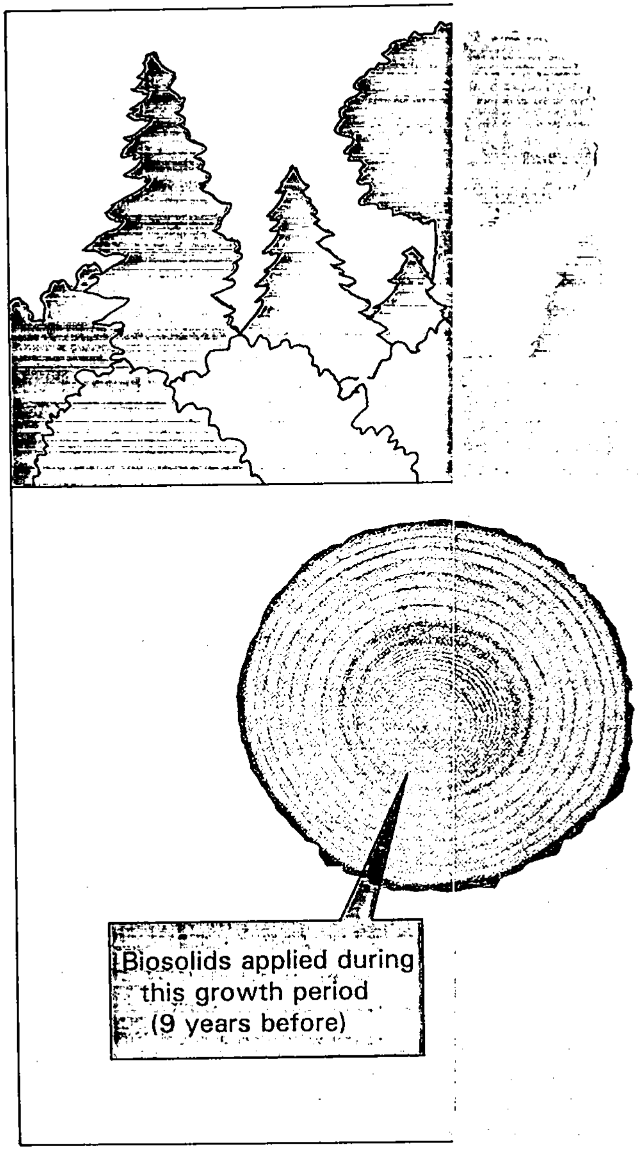
Since 1974, all the biosolids from metropolitan Washington, DC (3 million population) have been used on land. In 1993 about 75% (87,000 dry tons) of the dewatered biosolids produced was used on agricultural land in Maryland (4,000 acres) and Virginia (4,000 acres). The remaining 25% was composted for use by landscapers, horticulturalists, and the general public. The dewatered biosolids were applied to private farmland by private contractors at no charge to the farmers. The farmers received $100 to $140 worth of needed nitrogen, phosphorus, trace nutrients, lime, and organic matter per acre from each 5 to 10 dry ton per acre application of biosolids (Table 1).

An additional benefit of biosolids is its suppression of pathogenic soil organisms such as nematodes that damage plant roots as well as specific plant root diseases that otherwise cause damage to commercially grown potted plants.

Non-Agricultural Use of Biosolids

The beneficial uses of biosolids are not limited to farmland application. Biosolids are used in silviculture to increase forest productivity and to revegetate and stabilize lands that have been harvested or disturbed by mining, construction, fires, land slides, or other natural disasters.

The application of biosolids to forest land can shorten pulp wood and lumber production cycles by accelerating tree growth, especially on marginally productive soils. Studies by the University of Washington in the Northwest, and the U. S. Forest Service in the Southeast, on the use of biosolids as a fertilizer in silviculture have shown as much as a three-fold increase in tree growth compared to controls for certain tree species.



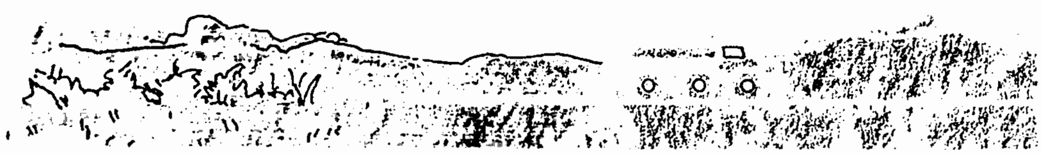
A cross-section of a Douglas fir tree demonstrates how biosolids increase tree growth.

Biosolids are used productively to stabilize and revegetate areas destroyed by mining, dredging, and construction activities. Alkaline-stabilized, digested, air-dried, and composted biosolids are frequently used to help revegetate mine spoil, highway embankments and median strips, and other construction sites.

Alkaline-stabilized biosolids are also used as a soil substitute for intermediate and final landfill cover. The use of biosolids in land reclamation efforts has proved very successful and comparable in cost to other commercial methods in both large- and small-scale projects. For example, in a strip-mined area in Fulton County, IL, reclamation using municipal biosolids costs about $3,700 per acre, as compared with a range of $3,400 to $6,300 per acre using commercial methods.

Studies in New Mexico have shown sustained improved growth and nutritional quality of desirable native vegetation on rangeland and reduced run-off of rain water from a one-time, 10 to 20 dry tons per acre surface application of biosolids. Studies in Colorado, with 1 to 15 dry tons per acre of biosolids applied, are being conducted to determine optimum rates to improve range quality and minimize public health and environmental risks. Early results from these studies show similar improvements in range quality and reduced water runoff proportional to the rate of biosolids application.

Biosolids have been used to reclaim over 3,000 acres of lands devastated by mining and smelting activities in Pennsylvania. Biosolids are being used in combination with fly ash to revegetate soils at that Palmerton, PA, site which has been included on EPA's list of Superfund Sites. The Palmerton site was so highly contaminated from 90 years of smelting zinc that all vegetation in the surrounding area was destroyed. The research team members from Allentown, PA, and the Pennsylvania State University, who were responsible for demonstrating the viability of the reclamation procedures, were recognized as winners in EPA's first National Beneficial Use of Biosolids Awards Program (1988).



Above, truck spraying biosolids/fly ash mixture for revegetation at the Palmerton, Pennsylvania, hazardous waste site. Right, the same area after being reclaimed.

Biosolids may be used separately or in conjunction with chemical fertilizers. Figure 3A shows the comparative use of chemical fertilizers with and without 8 dry tons per acre of biosolids applied to sandy irrigated soils near Yuma, AZ. Figure 3A shows the comparative usage during the first year after biosolids application where only about one-fourth as much chemical fertilizer was needed. By the third year of biosolids application, no supplemental chemical fertilizer was required.

Figure 3B shows that the yield of three crops was greatly enhanced compared with their yields on both chemically fertilized and unfertilized controls.

Particularly in soils that are low in organic matter, biosolids provide benefits that are not available from chemical fertilization. The biosolids' organic matter content enhances the soil

Fewer Pounds per Acre of Chemical Fertilizer Nutrients Were Needed When Biosolids Were Used

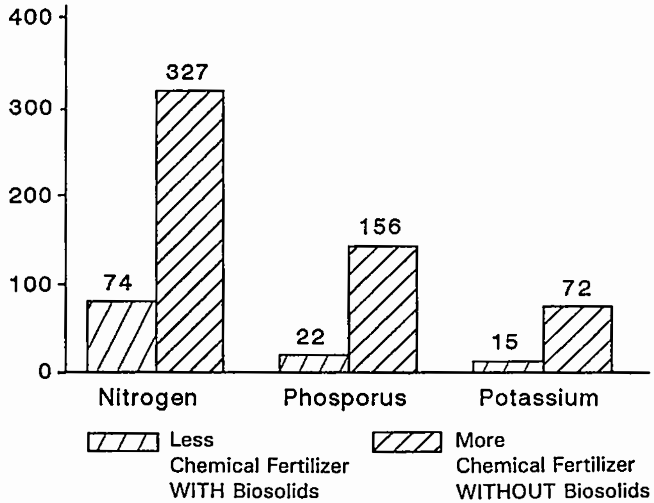


Figure 3A

Comparative Yield of Crops Due to Chemical Fertilizers vs. Biosolids

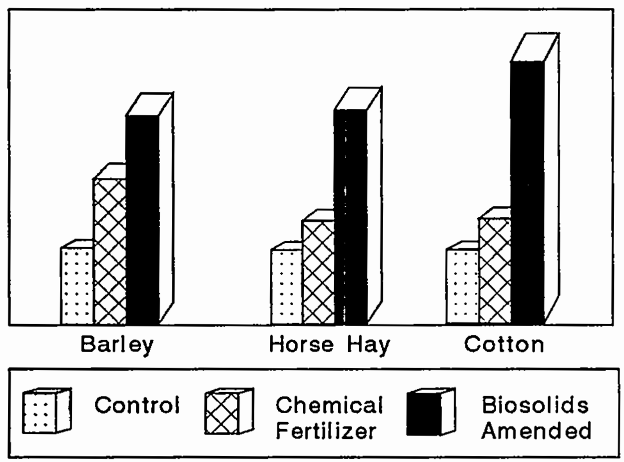


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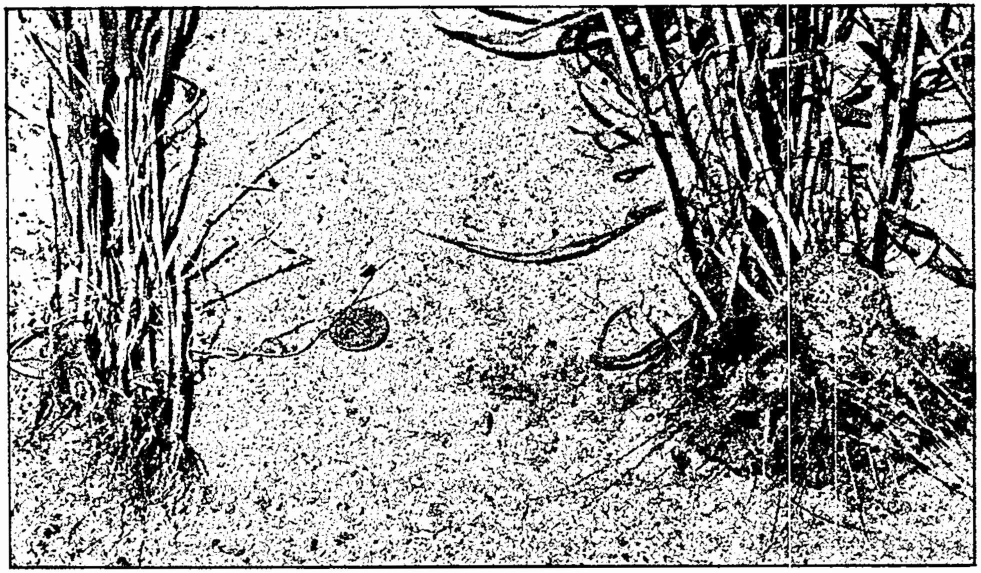
Figure 3B

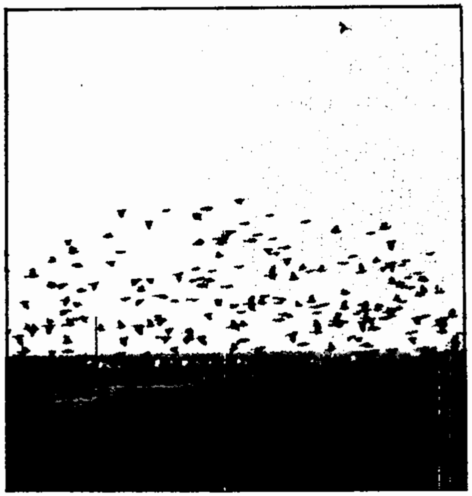
rooting media thus providing for better water retention, improved air exchange around plant roots, and increased ability of the soil to hold nutrients in a plant-available state (increased cation exchange capacity). In sandy, highly leachable soils, the tendency for biosolids' organic nitrogen to be released at a rate that is consistent with plant uptake, mitigates the loss of excess nitrogen into groundwater.

The biosolids' organic matter had other impacts on the same Yuma, AZ farm that initially might have seemed undesirable. Herbicides became less effective because of their interaction with the changing sandy soil and organic biosolids matrix. Those fields, previously weed-free, now contained more weeds. On the other hand, the plants became more vigorous and better able to compete with weeds and withstand damage from insect pests. The changes that occurred because of biosolids usage allowed the farmer to decrease his costs for fertilizer, herbicides, and pesticides by approximately $170 on each acre of his 12,000 acre farm.



Comparative plant vigor on sandy Yuma, AZ, soil without (left) and with (right) biosolids amendments.

In some instances the total yield decreased compared to weed-free fields. However, the farmer's net return per acre increased (more dollars per acre profit). The same Yuma, AZ farmer, because of his enhanced yield and lowered costs from use of biosolids, decided to dedicate 10% of his land each year to producing grains for wildlife. Because of the farming changes that left more cover from weeds on all 12,000 acres and the 1,200 acres left each year with unharvested grain for wildlife, the dove and other wildlife population increased so substantially in 6 years that the Yuma region began to realize an unexpected $3.5 million increased annual benefit from hunting-related activities.



Increased populations of birds over biosolids-amended farm fields in Yuma.

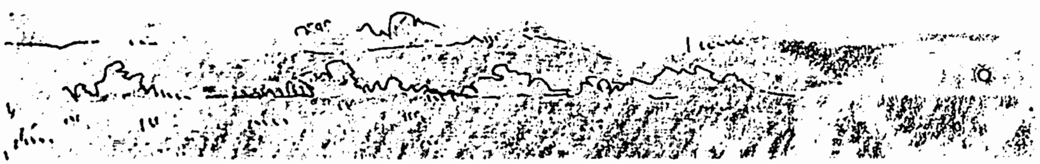
Other Uses for Biosolids

The sale of biosolids products to the public for many kinds of garden, nursery, household, and lawn uses continues to increase. Treatment such as heat-drying, composting, and treatment with alkaline materials convert biosolids into useful products that can be considered "exceptional quality" if pollutant concentrations in the biosolids do not exceed the minimum levels specified in Table 3 of the Part 503 rule. These products are safe for unrestricted use by the general public. Generators of these products are required to have an ongoing monitoring program to ensure that the biosolids continually meet the "exceptional quality" requirements.

Examples of these stabilized products include Milwaukee's heat-dried biosolids product, "MILORGANITE,"* which it has been producing and selling throughout the United States since the 1920's.

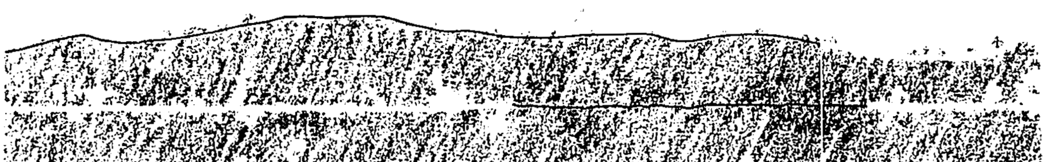
Products of this nature have sold in bulk for as for as much as $190 per ton if high in nitrogen content and aesthetically pleasing. Kellogg Supply Company (a private firm in California) has been producing and marketing composted biosolid products

* Vendor and trade names are included for the benefit of the reader and do not imply endorsement by EPA.



(e.g., NITROHUMUS, TOPPER, GRO-MULCH) mostly in California, Arizona, and Nevada for a similar period of time. Their products include composted biosolids that have come predominantly from Los Angeles County, CA, wastewater treatment facilities. Both MILORGANITE and NITROHUMUS have been used to establish and maintain grass playing fields in sports stadiums across the country -- including the Rose Bowl. A composted biosolids product from Philadelphia called EARTHGRO has been used with great success for growing container plants and chrysanthemums. Even the White House has used composted biosolids to reestablish its lawns. Several years ago, 825 tons of composted biosolids (COMPRO) were used in this highly successful project. Similarly, the lawns at Mount Vernon, the Washington Monument Grounds and the Governor's Mansion in Annapolis, MD, were renewed with COMPRO. The first use of composted biosolids on the Washington, DC Mall (nearly 6,000 tons) was in 1976 to establish the Constitution Gardens in time for the United States Bicentennial Birthday celebration. COMPRO is currently being sold for $10 to $50 per cubic yard in bulk depending on quantity

Research projects have yielded impressive results. Corn plants on the left were grown in biosolids-amended soil.



delivery. The cost for their bagged product is $5 to $6 per cubic foot.

Current research by Heneghan, et.al. regarding the potential use of biosolids to remediate soils containing high levels of lead by reducing the soil lead bioavailability shows promise. The research is indicating that appropriately produced and applied biosolids may help protect child health because the biosolids matrix reacts with the lead in contaminated soils to reduce the bioavailability of the soil lead. The research involved the feeding of laboratory animals an otherwise completely balanced diet that also containing 9% of either a low or high-lead containing urban soil mixed with 1% of different biosolids products.

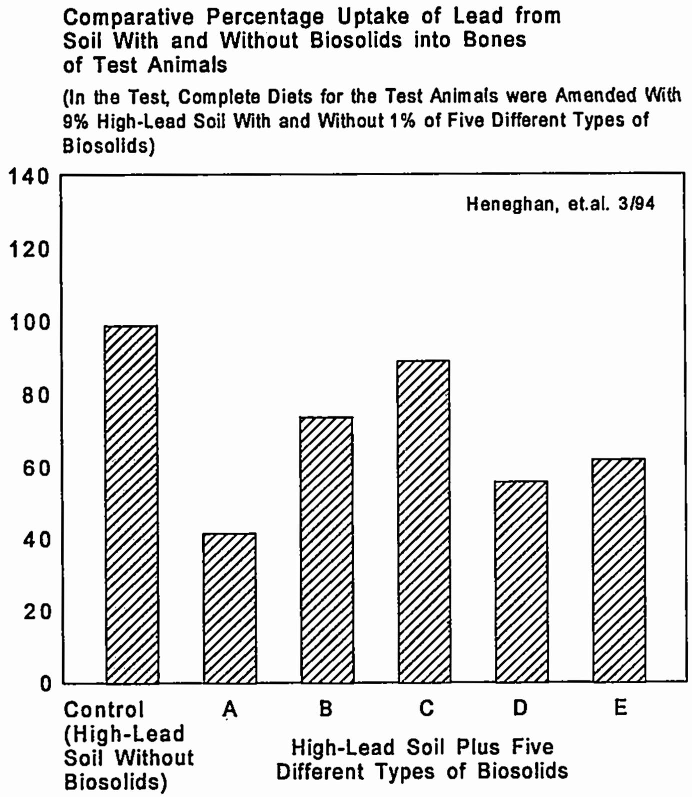


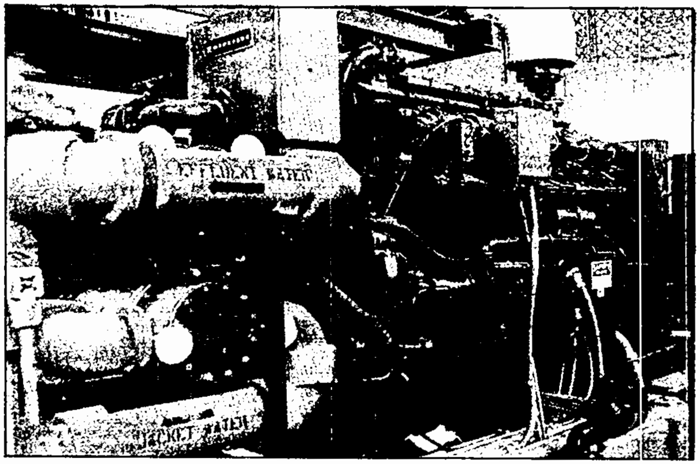
Figure 4. Biosolids can reduce the bioavailability of soil lead

The preliminary results from these animal feeding studies, depicted in Figure 4, show up to 50% reduced bioavailability of ingested lead, (i.e., reduced absorption of ingested soil lead into the blood and body tissues reflected by bone levels). Such data suggest that children ingesting biosolid-treated soil and dust may have a decreased absorption of lead into the blood stream, thus lessening the potential for lead-induced nerve and brain damage. Additional research is needed with laboratory animals to determine the best form of biosolids to use and the reduction of bioavailability that is possible.

Another stabilization method that is

commonly used by many wastewater treatment works is anaerobic digestion. This stabilization process generally yields a Class B biosolids product as defined in EPA's Part 503 rule that has been spread for years on agricultural land in liquid form and as a dewatered product. One of the most economical and agriculturally beneficial methods for using biosolids is the land application of this type of stabilized product.

Methane gas is generated during the anaerobic digestion process and has considerable value. For example, the Tampa, FL, treatment works recovers about $700,000 worth of electricity each year from methane it produces during anaerobic digestion. This is equivalent to approximately $65 worth of net electricity being produced per dry ton of volatile biosolids removed from the digester. Tampa also uses the heat removed from the electrical generators to provide more than 95% of the warmth needed for the digesters. All but 10 to 15% of Tampa's anaerobically digested biosolids are being heat-dried and marketed for between $85 to $120 per dry ton. The balance is being land applied in dewatered form. Tampa was recognized for this highly efficient operation in EPA's 1992 Beneficial Use of Biosolids Awards Program.



A 500-kilowatt engine and generator using biosolids digester gas to produce electricity.

Expert Opinions Regarding Biosolids Useability

In 1981, Del Monte Corporation, along with other food processors, announced that they would no longer accept fruit and vegetables for processing that had been grown on biosolids treated soils. Officials from the U.S. Department of Agriculture (USDA), the Food and Drug Administration (FDA), and EPA met with representatives of the National Food Processors Association to address the food processor's concerns.

After analyzing the available health and safety information pertaining to these practices, the USDA, FDA, and EPA issued guidance and a joint policy statement in 1981 that was signed by the Administrators of each Agency. The Agencies endorsed using biosolids on land for producing fruits and vegetables, and concluded:

> *"that the use of high quality [biosolids], coupled with proper management procedures, should safeguard the consumer from contaminated crops, minimize any potential adverse effect on the environment,"* and

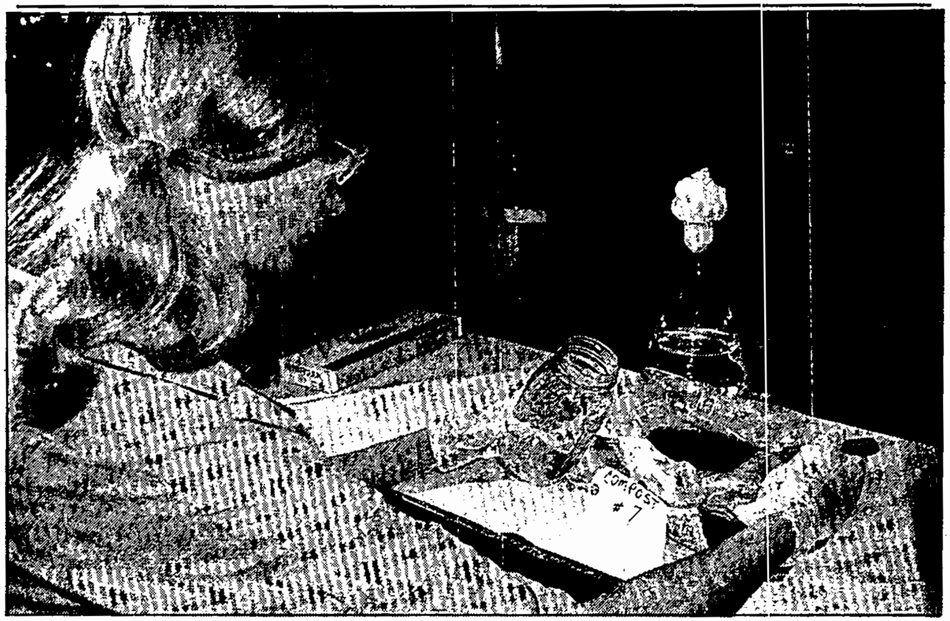
> *"that, with the adherence to the guidance contained in this document, the safety and wholesomeness of the fruit and vegetable crops grown on [biosolids]-amended soils will be assured."*

In 1983, over 200 health and environmental experts from the United States, Canada, and Europe met in Denver, CO, to assess the state of the art for biosolids use and disposal (ten years after a similar meeting in Champaign, IL). These experts arrived at a published consensus that the existing guidance and regulations were adequately protective of public health and the environment, provided that biosolids were used in accordance with those provisions. They concluded:

> *"Guidelines have been developed to enable the environmentally safe use of [biosolids] containing median concentrations of metals and organics when the [biosolids] are applied at agronomic rates based upon nitrogen or phosphorus utilization by crops."*

> *"Groundwater monitoring for nitrate-nitrogen is not needed where [biosolids] nitrogen additions do not exceed fertilizer nitrogen recommendations for the crop grown."*

> *"Using [biosolids] for reclamation of disturbed land*



Sampling composted biosolids for pathogen analysis. Studies show that properly composted biosolids are safe for use.

at rates higher than those for agricultural land, when properly implemented and managed, improve the quality of soils, groundwater or vegetation."

"With proper management and safety allowances based on research data, land application is a safe, beneficial and acceptable alternative for treatment of municipal wastewater and [biosolids]."

Some concern has been expressed about the possibility that land-applied biosolids might damage crops, livestock, or the land itself resulting in possible financial loss to the farmer or his mortgage lender. Some concern has also been expressed about possible future loss that might occur if new discoveries were to show unanticipated hazards from previous biosolids use.

While there can be no guarantees, past experiences with agronomic use of biosolids have been very reassuring. Where biosolids have been applied in accordance with regulations, problems that have occurred are rare and are generally related to inadequate field management and not biosolids quality -- virtually the same type of problems which have occurred from other normal farming practices. All research to date leads to the conclusion that the agronomic use of high quality biosolids is sustainable and very safe.

Final Part 503 Standards for the Use or Disposal of Biosolids

Overview of the Development of the Rule

Each series of biosolids guidance and regulations, developed by EPA since the mid 1970's, has been based upon the most recent knowledge about the risks and benefits of disposing and using biosolids. Over time, the amount of information and understanding obtained from research and operational experience upon which these efforts were based has continued to increase. The EPA effort to determine what would be permissible increases in soil and crop pollutant contents as a result of biosolids additions to land has been scientific and conservative and has involved the expert assistance of USDA and other cooperating institutions. This EPA approach contrasts with the policy-based approach taken by some other countries to limit increases of pollutants in soils to some small fraction of "background environmental

Table 2A. Most Limiting Pathway for Each Biosolids Pollutant Remaining in the Final Part 503 Rule*

Sludge Pollutant	Highly Exposed Individual	Most Limiting Pathway
Arsenic	Biosolids eaten by child	3
Cadmium	Biosolids eaten by child	3
Chromium	Phytotoxic plant	8
Copper	Phytotoxic plant	8
Lead	Biosolids eaten by child	3
Mercury	Biosolids eaten by child	3
Molybdenum	Animal eating feed	6
Nickel	Phytotoxic plant	8
Selenium	Biosolids eaten by child	3
Zinc	Phytotoxic plant	8

* The regulatory limit for each pollutant was based on the exposure pathway found to be the most limiting for that pollutant.

Table 2B. Most Limiting Pathway for Each Biosolids Pollutant Deleted from the Final Part 503 Rule **

Biosolids Pollutant	Highly Exposed Individual	Most Limiting Pathway
Aldrin	Eating animal fat/milk	5
Dieldrin	Eating animal fat/milk	5
Benzo(A)Pyrene	Biosolids eaten by child	3
Chlordane	Biosolids eaten by child	3
DDT/DDD/DDE	Eating fish	12
DimethylNitrosamine	Biosolids eaten by child	3
Heptachlor	Eating animal fat/milk	5
Hexachlorobenzene	Eating animal fat/milk	5
Hexachlorobutadiene	Eating animal fat/milk	5
Lindane	Biosolids eaten by child	3
PCB's	Eating animal fat/milk	5
Toxaphene	Eating animal fat/milk	5
Trichloroethylene	Biosolids eaten by child	3

** Pollutant deleted because (1) it was not present in NSSS studied biosolids, (2) it was only present in biosolids at levels about 10 to 100 times below the pollutant limits calculated by risk assessment for biosolids to be protective of human health and the environment, or (3) the pollutant has been banned by EPA and is no longer being manufactured or used in the United States.

levels" without careful assessment of positive or negative impact.

As a result of the statutory directive in Section 405 of the Clean Water Act, EPA has expanded its regulatory efforts by developing a new comprehensive risk-based rule for biosolids. In this expanded effort, which began in 1984, EPA increased the number of pollutants considered to over 50. However, after careful screening and analysis, the Agency reduced this to a list of 25 crucial pollutants (Tables 2A/2B).

Risk from exposure to these 25 pollutants was evaluated via 14 different public health and environmental pathways (Table 3). The new method, which was established for conducting this multimedia risk assessment, was reviewed and approved by EPA's Science Advisory Board.

Many careful decisions were made during this intensive effort to select data that was more representative, assumptions that were more realistic, and models that were more appropriate. This effort has resulted in a final rule with many of the proposed standards becoming less restrictive and complex than previously believed necessary because of the more comprehensive and appropriate research data base, assumptions, and modeling.

Rule development will continue. Additional pollutants may be added to or deleted from the Part 503 rule, and restrictiveness may change. One example of change in the Part 503 rule was the elimination from the regulation, after initial proposal and subsequent evaluation, of 14 toxic organic pollutants. The basis for elimination is discussed in a later section of this document entitled "Features of the Risk Assessment Process" and are also listed in a footnote to Table 2.

Table 3

	PATHWAY
1	Biosolids-Soil-Plant-Human
2	Biosolids-Soil-Plant-Human
3	Biosolids-Soil-Human
4	Biosolids-Soil-Plant-Animal-Human
5	Biosolids-Soil-Plant-Human
6	Biosolids-Soil-Plant-Animal
7	Biosolids-Soil-Animal
8	Biosolids-Soil-Plant
9	Biosolids-Soil-Soil Biota
10	Biosolids-Soil-Soil Biota-Biota Predator
11	Biosolids-Soil-Airborne Dust-Human
12	Biosolids-Soil-Surface Water/Fish-Humans
13	Biosolids-Soil-Air-Human
14	Biosolids-Soil-Groundwater-Human

athways of Exposure from Land Application of Biosolids

DESCRIPTION

Consumers in regions heavily affected by landspreading of biosolids

Farmland converted to residential home garden five years after reaching maximum biosolids application

Farmland converted to residential use five years after reaching maximum biosolids application with children ingesting biosolids-amended soil

Households producing a major portion of their dietary consumption of animal products on biosolids-amended soil

Households consuming livestock that ingest biosolids-amended soil while grazing

Livestock ingesting food or feed crop grown in biosolids-amended soil

Grazing livestock ingesting biosolids/soil

Crops grown on biosolids-amended soil

Soil biota living in biosolids-amended soil

Animals eating soil biota living in biosolids-amended soil

Tractor operator exposed to dust from biosolids-amended soil

Humans eating fish and drinking water from watersheds draining biosolids-amended soils

Humans breathing fumes from any volatile pollutants in biosolids

Humans drinking water from wells surrounded by biosolids-amended soils

Expert Assistance with the Rule and Risk Assessment

The best scientific talent and data were assembled and used to structure the final Part 503 rule. Twelve experts (Table 4) with extensive experience in the field of evaluating the benefits and risks of using biosolids assisted in its formulation. These experts, who collectively had over 300 years of training and research experience, were from Universities, EPA, and other Federal

Table 4. Expert Cooperators in the Part 503 Risk Assessment

Dr. Rufus Chaney USDA-ARS Beltsville, MD	Dr. Andrew Chang Dept. of Soil & Environmental Science University of California Riverside
Dr. Willard Chappell Center for Environmental Science University of Colorado Denver	Dr. Lawrence Gratt IWG Corporation San Diego, CA
Dr. Robert Griffin Dept. of Chemical Engineering University of Alabama Birmingham	Charles Henry College of Forestry Resources University of Washington Seattle
Dr. Terry Logan Dept. of Agronomy Ohio State University Columbus	Dr. George O'Connor Dept. of Soil Science University of Florida Gainesville
Dr. Al Page Dept. of Soil & Environmental Science University of California Riverside	Dr. Jim Ryan Risk Reduction Engineering Lab US EPA Cincinnati
Dr. Robert Wagenett College of Agriculture & Life Science Cornell University Ithaca	Dr. John Walker OWEC US EPA Washington, DC

Agencies. The carefully reasoned science and policy decisions which occurred have provided the best rule ever developed for governing the use or disposal of biosolids. EPA believes that this Part 503 rule fully meets the Congressional mandate to be protective of public health and the environment and allows for the safe and effective recycling of biosolids -- indeed providing beneficial technology for a better environment.

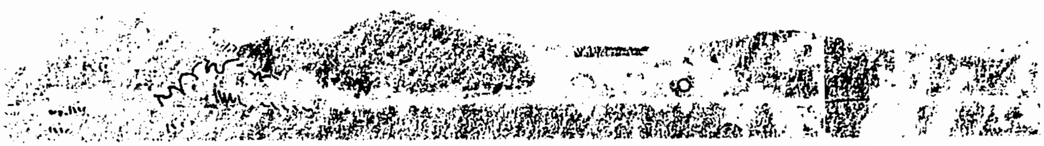
Features of the Risk Assessment Process

The following brief examples describe some of the valuable information that has come from extensive research by EPA and others on the safe and continuing use of biosolids. The examples show how this information was used in the scientific risk assessment that resulted in a comprehensive, sometimes less restrictive, and simplified final Part 503 rule.

Research has shown that the biosolids-organic-chemical matrix greatly impacts the plant uptake/bioavailability of pollutants, even after the biosolids have been mixed with soil. This means that certain pollutants cannot be drawn into the plant because they are bound in a form that is unavailable to the plant. Data from sites that are nearly 100 years old show that this binding effect does not change over time. Hence, only data from field experiments where biosolids had been applied were used, not data from chemical salts applied to soils.

Another area of intensive study and data review centered on the issue of potential cadmium toxicity. It was found that most crops grown in biosolids-amended soils do not take up high levels of cadmium. Those sensitive crops that do accumulate cadmium (generally vegetables) also accumulate calcium, iron and zinc, other elements that are contained in biosolids. Hence, persons eating "sensitive" accumulator crops will simultaneously ingest all those elements. Studies have shown that calcium, iron and zinc inhibit cadmium absorption in the intestine of individuals -- thus preventing levels of this metal from accumulating. Hence, the use of this information in the risk assessment process led to a Part 503 cadmium limit being less restrictive than when the rule was proposed.

Another example of how information was developed to formulate the final rule came from the National Sewage Sludge Survey (NSSS) conducted in 1988. In this survey, biosolids analytical data from about 200 statistically representative treatment plants across the United States were reviewed for the prevalence of more than 400 toxic organic pollutants. The scientific review of this data revealed that a



majority of the toxic organic pollutants were not present in biosolids at detectable levels and that risk assessment for the various toxic organic pollutants under consideration showed no anticipated adverse effects at the levels that were detected. This information, coupled with the fact that many of these toxic organic pollutants were no longer manufactured or in use, led to the decision not to include these pollutants in the final rule.

Part 503 Rule Has Conservative Elements

Even though research has shown that pollutant uptake by crops grown in biosolids-amended soils is less than linear (i.e., less than directly proportional to the amount of biosolids-contained pollutant that was added to the soil), the assumption used for the Part 503 risk assessment was that pollutant uptake by crops is linear (Figure 5). This means that the risk assessment assumes greater uptake of pollutants into plants and hence exposure to the humans and the environment than actually occurs.

EPA has also continued to use the conservatively established risk-reference-doses in the risk assessment for the final rule to estimate the lowest amount of pollutant that the highly exposed individual in each pathway can safely tolerate. The toxicological studies that were used to establish many of the risk-reference-doses often

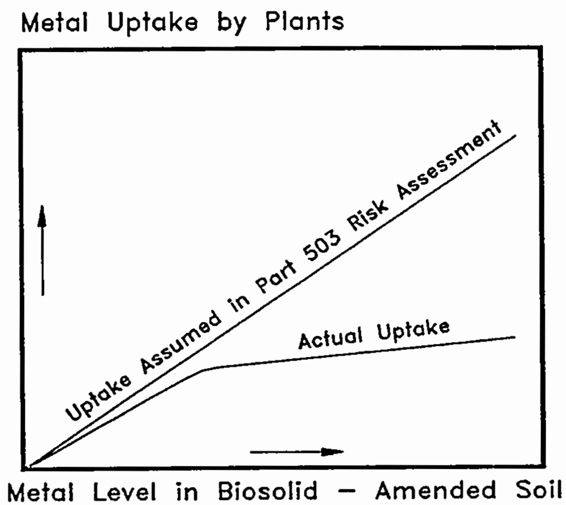


Figure 5. Conservative Assumption of Metal Bioavailability to Plants

were based on studies in which pure chemical doses of the pollutants were fed directly to the test animal without food or injected directly into the animal. These procedures overestimate risks because the actual bioavailability and toxicity of pollutants are much less when the pollutants are in a biosolids- or food-borne matrix than when the pure chemical form is placed directly in the stomach or injected directly into blood stream of the test animal.

High Quality Biosolids as a Product

A major simplification of the rule resulted because additional research and risk analyses showed that an exceptional quality (EQ) biosolids product with low levels of pollutants and highly reduced pathogen and vector attractiveness can be safely used by the general public in a manner similar to any other commercial fertilizer/soil conditioner product. Once the Part 503 requirements for EQ biosolids are met (this includes continued demonstration of EQ quality by periodic monitoring, record keeping, and reporting), there is no further regulation by the Part 503 rule. EQ biosolids are generally produced by composting, heat-drying, or stabilization with alkaline materials.

Equally Protective Regulatory Options

The Part 503 rule includes several options for regulating the uses of biosolids -- each with different levels of control. Each of the options is equally safe and protective of public health and the environment. The safety is ensured by the combination of pollutant limits and management practices imposed by each option.

The most simple option from a regulatory perspective is the EQ biosolids option just described. Here, safety is assured by imposition of stringent pollutant, pathogen and vector attraction reduction limits. Such EQ biosolids materials are marketed to, and used by, the general public without tracking. A more detailed, equally protective option is the one in which less stringent pollutant, pathogen and vector attraction reduction alternatives are coupled with site and crop controls and operational standards to ensure safe large-scale agricultural use.

Conclusion

We hope that this discussion of the rule and risk assessment process helps you to understand and be more comfortable with EPA's new standard for beneficial use of biosolids. More detailed discussions of the data, assumptions, and models used in the risk assessment process can be found by reading the Technical Support Documents that were issued along with the final rule and EPA's "Guide to the Biosolids Risk Assessment Methodology for the EPA 503 Rule," EPA/832-B-93-005, which should be completed by the end of 1994.

Additional understanding can be gained from the preamble to the rule and the papers written by the experts who have assisted EPA in selecting appropriate data, assumptions, and models. The rule itself is described in greater detail in EPA's "Plain English Guide to the EPA 503 Biosolids Rule," EPA/832-R-93-003. To help address remaining concerns, EPA has sponsored and will continue to sponsor and foster research and information sharing events, as well as provide technical assistance and written publications.

Strip-mined land in Pennsylvania reclaimed with the use of biosolids.

Sources of Information

EPA Materials Available From:

Office of Water Resource Center (OWRC)
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National Technical Information Service (NTIS)
800-553-6847 (phone)
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5285 Port Royal Road
Springfield, VA 22161

Education Resource Information Center (ERIC)
614-292-6717 (phone)
614-292-0263 (fax)
C/O West Virginia University
P.O. Box 6064
Morgantown, WV 26506

EPA Materials

A Plain English Guide to the EPA 503 Biosolids Rule. USEPA Office of Wastewater Enforcement and Compliance. EPA/832-R-93-003. June 1994. To be available in 1994 from OWRC.

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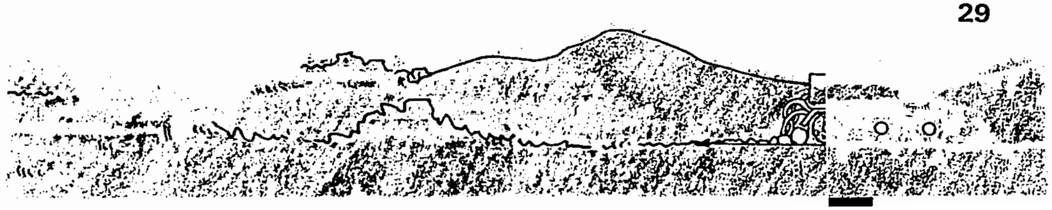

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Land Application of Sewage Sludge: A Guide for Land Appliers on the Record Keeping and Reporting Requirements of the Federal Standards for the Use or Disposal of Sewage Sludge, 40 CFR Part 503. USEPA Office of Wastewater Enforcement and Compliance. EPA/831-B-93-002b. May 1994 Available from NTIS, ERIC, and OWRC.

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