



# **Targeted National Sewage Sludge Survey**

## **Overview Report**

**January 2009**

U.S. Environmental Protection Agency  
Office of Water (4301T)

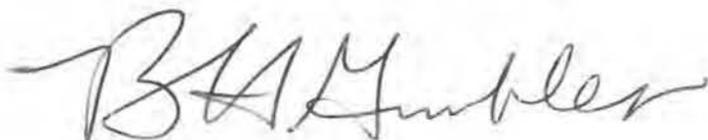
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*EPA-822-R-08-014*

## FOREWORD

The Targeted National Sewage Sludge Survey is a significant step in advancing the understanding of what is present in treated sewage sludge. The information from the survey provides important input for EPA and others to use in evaluating biosolids generated by the nation's publicly owned treatment works. It also fulfills an important commitment under the agency's four pronged strategy for pharmaceuticals and personal care products by providing the first national estimates of which pharmaceuticals, steroids and hormones may be present in sewage sludge and at what concentrations.

EPA is committed to taking action and working with our partners to ensure sewage sludge is managed in a manner that protects human health and the environment.

A handwritten signature in black ink, reading "B. H. Grumbles". The signature is written in a cursive, flowing style.

*Benjamin H. Grumbles*  
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## **Background**

**Introduction** -- Section 405(d) of the Clean Water Act (CWA) requires the U.S. Environmental Protection Agency (EPA) to identify and regulate toxic pollutants that may be present in biosolids at levels of concern for public health and the environment. This report provides an overview of the recently conducted Targeted National Sewage Sludge Survey (TNSSS). The objective of the survey was to determine which analytes (or chemicals) were present in sewage sludge and obtain national estimates of the concentrations of selected analytes. The information will help the Agency in assessing if exposures may be occurring and whether those levels in sewage sludge may be of concern.

The sampling effort collected sewage sludge from 74 randomly selected publicly owned treatment works in 35 states. Samples were collected in 2006 and 2007. The TNSSS Technical Report provides results for 145 analytes, including four anions (nitrite/nitrate, fluoride, water-extractable phosphorus), 28 metals, four polycyclic aromatic hydrocarbons, two semi-volatiles, 11 flame retardants, 72 pharmaceuticals, and 25 steroids and hormones. Some analytes were found in all 84 samples, while others were found in none or only a few of the sewage sludge samples.

The results presented in the TNSSS Technical Report do not imply that the concentrations for any analyte are of particular concern to EPA. EPA will use these results to assess potential exposure to these contaminants from sewage sludge.

**Contents of this Overview Report** -- This document provides an overview of two reports that together make up the TNSSS report: 1) Targeted National Sewage Sludge Survey Sampling and Analysis Technical Report (“Technical Report”), and 2) Targeted National Sewage Sludge Survey Statistical Analysis Report (“Statistical Report”). This overview report addresses the following topics:

- Regulation of Sewage Sludge
- Production and Treatment of Sewage Sludge
- Previous EPA Sewage Sludge Surveys
- Summary of Survey Methodology
- Survey Results
- Next Steps

## **Regulation of Sewage Sludge**

EPA regulations for sewage sludge disposal and use -- the Standards for the Use or Disposal of Sewage Sludge at Section 40 of the Code of Federal Regulations Part 503 -- establish numeric limits, management practices, and operational standards to protect public health and the environment from adverse effects of chemical and microbiological pollutants in sewage sludge. Sewage sludge is the solid, semisolid, or liquid organic material that results from the treatment of domestic wastewater by municipal wastewater treatment plants, also known as publicly owned treatment works or POTWs. The terms sewage sludge and biosolids are used by EPA interchangeably, but others often use the term biosolids to describe sewage sludge that has had additional processing for land application. The Part 503 regulations set national standards for

use or disposal of sewage sludge. Regulatory options include: 1) land application (e.g., to fertilize crops or reclaim mined lands); 2) landfilling or surface disposal; and 3) incineration. States may adopt additional or more stringent requirements for the land application of sewage sludge.

## **Production and Treatment of Sewage Sludge**

Municipal wastewater, or sewage, refers to water that has been used in urban and suburban area homes or businesses for washing, bathing, and flushing toilets. Municipal wastewater also may include water from industrial sources. To remove pollutants resulting from industrial processes, industrial contributors to municipal wastewater systems may treat the wastewater before it is discharged to a wastewater treatment system. The wastewater is usually conveyed via a sewer system to a centralized wastewater treatment plant (e.g., publicly owned treatment works, or POTW). At the POTW, the wastewater passes through a series of treatment steps that may use physical, biological, or chemical processes designed to remove pollutants.

The treatment steps may include preliminary treatment, primary treatment, secondary treatment, and tertiary treatment. Preliminary treatment removes large objects, such as sticks, paper, sand and grit, which are typically landfilled and do not become part of sewage sludge. Primary treatment involves gravity sedimentation for removing solid material that settles out and flotation processes that remove oil, grease, wood, and vegetative matter. Secondary treatment is a biological process in which naturally occurring microorganisms are used to degrade (break down or digest) suspended and dissolved organic material in the wastewater. Tertiary treatment includes steps designed to further reduce plant nutrients (nitrogen and phosphorus), suspended solids, or biological oxygen demand in the wastewater. Preliminary, primary, secondary, and sometimes tertiary treatments are often combined in any given POTW.

## **Previous EPA Sewage Sludge Surveys**

EPA has conducted three previous surveys for purposes of identifying contaminants in sewage sludge. In 1982, EPA conducted the “40 City Study” to develop information on the fate and effects of priority pollutants in wastewater treatment plants and estimates of pollutant concentrations in sewage sludge. In 1988, EPA conducted the National Sewage Sludge Survey to gather information on sewage sludge use and disposal practices and to obtain updated information on the concentration of over 400 pollutants in the Nation’s sewage sludge. This information was used in establishing the Part 503 biosolids use and disposal regulations and in setting numeric standards for ten metals and operational standards for pathogens in biosolids.

In 2001, EPA conducted a survey to obtain updated national estimates of dioxins and dioxin-like compounds in sewage sludge managed by land application. Results from this survey helped EPA conclude that neither numerical standards nor additional management practices are needed to protect human health and the environment from reasonably anticipated adverse effects from dioxin and dioxin-like compounds in sewage sludge that is land-applied. EPA determined that the incremental risk from exposure to dioxins in land-applied biosolids is below levels of concern.

EPA conducted the current TNSSS to obtain updated concentration values for some pollutants previously evaluated and to obtain information on whether certain contaminants of emerging concern may be present in sewage sludge and at what levels. EPA continues to evaluate pollutants that may be present in biosolids to ensure that there are effective and protective management options in place.

## Summary of Survey Methodology

***Selection of Pollutants*** -- Section 405(d) of the CWA requires EPA to review existing sewage sludge regulations at least every two years (i.e., a biennial review). The purpose of such reviews is to identify additional toxic pollutants that may be present in sewage sludge and, if appropriate, to promulgate regulations for those pollutants consistent with the requirements set forth in the CWA. In conducting the biennial review for 2003, EPA identified a subset of 15 pollutants that needed further evaluation [[insert link to 68 FR 75531](#)]. EPA subsequently reduced the list of pollutants to nine – barium, beryllium, manganese, silver, fluoranthene, pyrene, 4-chloroaniline, nitrate, and nitrite -- based on an updated biosolids exposure and hazard assessment. EPA decided that updated concentration data were needed to conduct a more refined risk evaluation and risk characterization for these nine pollutants.

Given the national scope of the survey, EPA expanded the list of analytes to reflect the Agency's interest in collecting concentration data for other chemicals. The expanded list included 24 additional metals that could be analyzed at little extra cost at the same time as the four metals (barium, beryllium, manganese, and silver) included in the list of nine pollutants above; molybdenum because of the Agency's interest in determining the need for a revised numeric standard for it in land-applied biosolids; and other analytes because of their widespread use and emerging concern. The latter category included:

- benzo(a)pyrene (found in coal tar, automobile exhaust fumes, tobacco and wood smoke, charbroiled food, and burnt toast);
- 2-methylnaphthalene (found in nonstructural caulking compounds and sealants, synthetic resins, rubber adhesives, and wall coverings);
- bis (2-ethylhexyl) phthalate (widely used as a plasticizer in manufacturing of items such as cosmetics, toys, tools, and laboratory equipment);
- fluoride (used in topical and systemic therapy for preventing tooth decay, as well as many other uses);
- water-extractable phosphorus (correlated with phosphorus concentration in runoff from soils amended with manure and biosolids and an indicator of loss that may contribute to algae buildup in surface waters);
- 11 polybrominated diphenyl ethers (PBDEs). Four of the PBDEs were of most interest because of available human health information that may be useful for future risk evaluation efforts. PBDEs are used as flame retardants in a wide array of products, including building materials, electronics, furnishings, motor vehicles, plastics, polyurethane foams, and textiles; and
- 97 pharmaceuticals, steroids, and hormones because of broader emerging interest in these analytes.

The table in Appendix A provides a complete list of the analytes included in the TNSSS.

Inclusion of analytes in the TNSSS does not reflect a determination that their presence in sewage sludge adversely affects human health or the environment. Rather, EPA decided that updated or new concentration data were needed to assess exposure and help in evaluating whether the levels of these pollutants in sewage sludge may pose environmental or human health concerns.

***Selection of POTWs*** -- For this survey, EPA focused its efforts on POTWs that treat more than one million gallons of wastewater per day (MGD). This group of facilities collectively treats approximately 94 percent of the wastewater in the nation. To be eligible for the survey, EPA also required that a POTW be located in the contiguous United States and employ secondary treatment or better. EPA identified POTWs meeting the criteria from information in the 2004 Clean Water Needs Survey and the 2002 version of the Permit Compliance System. From the 3,337 POTWs that met the criteria in either data source, EPA statistically selected 74 facilities for the survey and collected biosolids samples from those facilities. Whether the facility land applies the treated sewage sludge or disposes it via incineration or surface disposal was not a consideration for selecting a facility for inclusion in the survey. By using statistical methods, the concentration measurements can be extrapolated to the entire population of 3,337 POTWs.

***Sampling Methodology*** – As noted above, EPA collected samples of the final sewage sludge produced at each of the 74 POTWs. Final sewage sludge, for purposes of the TNSSS, is defined as the liquid, solid, or semi-solid residue generated during the treatment of domestic sewage in a treatment works, receiving secondary treatment or better, and which may include sewage sludge processed to meet land application standards.

EPA collected a single sewage sludge sample from all but ten facilities. EPA collected two samples at the remaining ten facilities for quality control purposes or because the facility had more than one treatment system.

From an analytical methods standpoint, sewage sludge is a challenging matrix because it is not uniform in its composition or ratio of water to solids. In addition, EPA needed to accurately identify and measure the target chemicals in the presence of the large number and types of chemicals present in the sewage. The preparation of a sewage sample to conduct chemical analysis of its content using highly sophisticated instruments, such as a Liquid Chromatographs in tandem with two Mass Spectrometers (LC/MS/MS), is extremely complex.

The survey used both well-established, multi-laboratory validated EPA procedures as well as three analytical methods that were developed or updated for the survey. The two new methods are single laboratory validated methods for pharmaceuticals (EPA Method 1694), steroids and hormones (EPA Method 1698). The multi-laboratory validated method for flame retardants (EPA Method 1614) was updated for the survey.

## Survey Results

As noted previously, the TNSSS results are described in two EPA reports that together constitute the TNSSS: 1) Targeted National Sewage Sludge Survey Sampling and Analysis Technical Report and 2) Targeted National Sewage Sludge Survey Statistical Analysis Report. The Technical Report includes the number of samples in which each analyte was reported, along with minimum and maximum concentrations for each analyte. To ensure consistency, all sample results are reported on a dry-weight basis.

The Statistical Report describes the survey design and national estimates derived from the concentration data. For 34 analytes measured in the survey, the Statistical Report discusses an in-depth statistical analysis and presents nationally-representative estimates of the 50<sup>th</sup> percentile (i.e., median) of the underlying distribution of measurements across POTWs, as well as the 90<sup>th</sup>, 95<sup>th</sup>, 98<sup>th</sup>, and 99<sup>th</sup> percentiles. The characterization of specific percentiles is useful for EPA's subsequent evaluation of exposure and risk.

Briefly, the survey found:

- The four anions were found in every sample.
- 27 metals were found in virtually every sample, with one metal (antimony) found in no less than 72 samples.
- Of the six semivolatile organics and polycyclic aromatic hydrocarbons, four were found in at least 72 samples, one was found in 63 samples, and one was found in 39 samples.
- Of the 72 pharmaceuticals, three (i.e., ciprofloxacin, diphenhydramine, and triclocarban) were found in all 84 samples and nine were found in at least 80 of the samples. However, 15 pharmaceuticals were not found in any sample and 29 were found in fewer than three samples.
- Of the 25 steroids and hormones, three steroids (i.e., campesterol, cholestanol, and coprostanol) were found in all 84 samples and six steroids were found in at least 80 of the samples. One hormone (i.e., 17 $\alpha$ -ethynyl estradiol) was not found in any sample and five hormones were found in fewer than six samples.
- All of the flame retardants except one (BDE-138) were essentially found in every sample; BDE-138 was found in 54 out of 84 samples.

It is not appropriate to speculate on the significance of the results until a proper evaluation has been completed and reviewed.

## Next Steps

EPA plans to evaluate the pollutants identified by the survey as being present in sewage sludge. As its first priority, using the survey information, EPA has begun assessing the nine pollutants identified from the 2003 biennial review as needing updated concentration information

and molybdenum to determine whether additional action may be necessary. In addition to the survey information, EPA will evaluate other available data and conduct exposure and hazard assessments for these pollutants if sufficient data are available. Some of the information generally needed to conduct exposure and hazard assessment includes:

- Toxicity data for human and ecological receptors (e.g., toxicity defined in terms of reference dose, reference concentrations, cancer slope factor, lethal dose, lethal concentration, or adverse effects, such as reproductive or developmental effects).
- Concentrations for which a pollutant is present in sewage sludge (e.g., data from this survey).
- Chemical and physical properties, including vapor pressure, solubility, and molecular weight.
- Fate and transport data for pollutants that may be present in sewage sludge, including degradation rates in various media and data on the bioconcentration potential of the pollutant.

Later this year, EPA expects to initiate evaluations of other pollutants in the survey that may warrant further consideration. The evaluations will depend on the availability of data needed to conduct the evaluations.

## APPENDIX A: Analytes Included in the TNSSS

### Analytes Included in the TNSSS, by Analyte Group

Analyte Group	Analyte	
Metals	Aluminum	<b>Manganese</b>
	Antimony Mercury	*
	Arsenic* Mol	ybdenum*
	<b>Barium</b>	Nickel *
	<b>Beryllium</b>	Phosphorus
	Boron Selenium	*
	Cadmium*	<b>Silver</b>
	Calcium Sodium	
	Chromium* Thallium	
	Cobalt Tin	
	Copper* Titanium	
	Iron Vanadiu	m
	Lead* Yttriu	m
	Magnesium Zinc*	
Polycyclic aromatic hydrocarbons (PAHs)	Benzo(a)pyrene 2-Methy	Inaphthalene
	<b>Fluoranthene</b>	<b>Pyrene</b>
Semivolatile organics	Bis (2-Ethylhexyl) phthalate	<b>4-Chloroaniline</b>
Inorganic anions	Fluoride Water-extractable	phosphorus
	<b>Nitrate</b>	<b>Nitrite</b>
Polybrominated diphenyl ethers (PBDEs), including the Tetra, Hexa, Penta, and Deca congeners	2,2',4,4'-TeBDE (BDE-47)	2,2',4,4',5,5'-HxBDE (BDE-153)
	2,2',4,4',5-PeBDE (BDE-99)	2,2',3,3',4,4',5,5',6,6'-DeBDE (BDE-209)
Antibiotics and their degradation products, disinfectants, and other antimicrobials	Anhydrochlortetracycline Ofloxacin	
	Anhydrotetracycline Or	metoprim
	Azithromycin Oxacillin	
	Carbadox Oxolinic	acid
	Cefotaxime Oxy	tetracycline
	Chlortetracycline Penicillin	G
	Ciprofloxacin Penicillin	V
	Clarithromycin Roxithrom	ycin
	Clinafloxacin Sarafloxacin	
	Cloxacillin Sulfachloropy	ridazine
	Demeclocycline Sulfadiazine	
	Doxycycline Sulfadimethoxine	
	Enrofloxacin Sulfa	merazine
	4-Epianhydrochlortetracycline Sulfam	ethazine

### Analytes Included in the TNSSS, by Analyte Group

Analyte Group	Analyte	
	4-Epianhydrotetracycline Sulfa	methizole
	4-Epichlortetracycline	Sulfamethoxazole
	4-Epioxytetracycline Sulfanilam	ide
	4-Epitetracycline Sulfathiazole	
	Erythromycin Tetracy	cline
	Flumequine Triclocarban	
	Isochlortetracycline Triclosan	
	Lincomycin Trim	ethoprim
	Lomefloxacin Ty	losin
	Minocycline Virginiam	ycin
	Norfloxacin	
Other drugs	1,7-Dimethylxanthine Diphenh	ydramine
	Acetaminophen Fluoxetine	
	Albuterol Gem	fibrozil
	Caffeine Ibuprofen	
	Carbamazepine Metfor	min
	Cimetidine Miconazole	
	Codeine Naproxen	
	Cotinine Norgesti	mate
	Dehydronifedipine Ranitidine	
	Digoxigenin Thiabendazole	
	Digoxin Warfarin	
Diltiazem		
Steroids	Campesterol Epi-coprostanol	
	Cholestanol Ergosterol	
	Cholesterol	$\beta$ -Sitosterol
	Coprostanol	$\beta$ -Stigmastanol
	Desmosterol Stigm	asterol
Hormones	Androstenedione Estriol	
	Androsterone Estrone	
	17 $\alpha$ -Dihydroequilin 17	$\alpha$ -Ethyngyl estradiol
	Equilenin Norethindron	e
	Equilin Norgestrel	
	17 $\alpha$ -Estradiol Progesterone	
	17 $\beta$ -Estradiol Testosterone	
$\beta$ -Estradiol-3-benzoate		
The 9 pollutants in <b>bold</b> are those selected in the December 2003 Biennial Review		
* Metals currently regulated at 40 CFR 503		