Smart Guide

On Sludge Use and Food Production

Several million dry tons of sewage sludge, also known as biosolids, are used as fertilizer on agricultural lands and given away or sold for use by homeowners and landscape contractors annually in the U.S.[1] Sewage sludge is the semi-solid to solid matter left over following municipal wastewater treatment. It commonly contains nutrient-rich fecal matter along with bacteria, viruses, parasites, heavy metals, pharmaceuticals and other chemical contaminants—many known to cause health effects.

For farmers, sludge is a less expensive alternative to synthetic fertilizers, but use of sewage sludge as fertilizer for food production increases our risk of exposure to sludge contaminants and their associated health effects. Due to the persistent nature of some of these contaminants, repeated applications to the same piece of land can increase soil contaminant levels and possibly food contaminant levels for centuries to come.

Some European countries including Switzerland,[2] the Netherlands,[3] the United Kingdom[4] and Germany[5] prohibit or significantly limit sludge use on agricultural land. Some companies, including Del Monte,[6] General Mills[7] and H.J. Heinz Company[8] prohibit supplier use of sludge to grow produce. Consumers are encouraged to exercise caution and use the information provided here to make informed food and fertilizer choices.

What's in sludge?

Though the types and levels of contaminants in sludge are variable, sludge contaminants fall into three main groups, including:

- **Disease-causing microbes.** Sewage treatment reduces but does not eliminate disease-causing microbes in sludge.[9] Those commonly found in sludge include: 18 human-excreted **viruses**, including Hepatitis A and Polio; 19 **parasites,** including Cryptosporidium and Giardia; and 31 **bacteria**, including strains causing food poisoning (Salmonella and E. coli 0157:H7), as well as more virulent, antibiotic-resistant strains.[10,11]

- **Synthetic chemicals.** More than 500 synthetic chemical compounds, typically derived from fossil fuels, have been identified to date in various sludges, including chemicals from medicines and consumer products such as antidepressants, steroids, flame retardants, detergents, fragrances, disinfectants and more.[12,13] Other chemicals still detectable in present-day sludge, such as polychlorinated biphenyls (PCBs), have been banned from use for decades.

- **Heavy metals.** Arsenic, cadmium, lead, mercury and other heavy metals are commonly detected in sludge, though concentrations have decreased for some metals over time.[14] Also, radioactive material, both naturally occurring and from human-made sources (such as feces and urine from people undergoing radiation therapy), can be found in sludge.[15]

← In most U.S. cities and towns, almost everything flushed down a toilet, sink or shower drain ends up at a wastewater treatment plant (WWTP). This can also include wastes discharged from manufacturing facilities and hospitals; contaminated water collected from landfills; street runoff; and waste from septic systems. At the WWTP, solids and many other contaminants are separated from wastewater and become sludge, which is then mostly land applied.

2105 FIRST AVENUE SOUTH ■ MINNEAPOLIS MINNESOTA 55404 USA ■ (612) 870-0453 ■ IATP.ORG

How can contaminants from sludge end up in our food?

Animal ingestion

Livestock and dairy animals ingest large quantities of soil when grazing and consequently, sludge contaminants, which can ultimately end up in the food produced from these animals.[16,17,18] Many consider this the primary way that sludge contaminants can enter the food chain.[19] Food animals may also ingest contaminated soil attached to harvested animal feed crops. Many chemical contaminants (including dioxins, PCBs, pesticides and some flame retardants), and a few heavy metals (such as cadmium) found in sludge tend to bio-accumulate in fat tissue and milk fat.[20,21,22,23]

Direct uptake

Food crops grown on sludge-applied lands can absorb some heavy metals present in sludge-treated soil. Heavy metals persist in soils. Plants can continue to take up heavy metals for decades, if not centuries, after sludge is applied.[24,25] Cadmium is of particular concern since it is readily taken up from sludge-amended soils by various food crops, including carrots, potatoes, lettuce, spinach and grains.[26,27] Lead is also taken up by some of the same crops, but to a lesser degree.[28,29]

Some synthetic chemicals found in sludge may also persist in the environment and build up in the food chain. However, plant uptake of these synthetic chemicals is less studied than that of metals. Evidence suggests they are especially likely to be absorbed from soil onto surfaces of root vegetables and tubers, and sometimes into the flesh, depending on the nature of the contaminant.[30]

Various food crops absorb dioxin and dioxin-like compounds from contaminated soil, although cucumbers and related vegetables (e.g. zucchini, pumpkin) take up more dioxins than other plants, and the uptake is related to the level of contamination.[31,32] Carrots can also take up into the interior (and/or the peel) some solvents (chlorobenzenes),[33] chemicals from perfumes and scented products (polycyclic musks),[34] and polycyclic aromatic hydrocarbons (PAHs),[35] a class of chemicals found in dyes and plastics, among other places. Plants can also take up at least one antibiotic from animal manure, a substance similar to sludge.[36]

Air blown

Some synthetic chemicals,[37] arsenic,[38] mercury,[39] and surviving disease-causing microbes and their breakdown products (endotoxins)[40] may also be blown onto plants or vaporize and settle on food crops.

What's the concern?

Human exposure to the types of microbes and other contaminants found in sludge is implicated in an array of chronic and acute diseases:

Acute infections

Acute food poisoning accounts for an estimated 76 million illnesses and 5,000 deaths annually in the U.S.; cases of food poisoning are routinely not detected or reported.[41] Scientists are concerned that potentially deadly pathogens surviving in sludge-treated soil may lead to infections, although as yet there is no scientific documentation of cases where this has occurred.[42] The presence in sludge of human antibiotics[43] and heavy metals may also increase the ecological pressures in selecting for bacteria that are antibiotic-resistant.[44] Resistant bacteria can be transferred from sludge-contaminated soil and plants to grazing animals—and then to humans—if meat is not thoroughly cooked or handled properly.[45]

Chronic disease

Dietary exposure to arsenic, cadmium, lead and mercury heightens the risk of cancer.[46,47,48,49] Long-term dietary exposure to arsenic may result in lower IQ scores in children, early death in young adults, reproductive problems in women and hormone-disruption.[50,51] Long-term exposure to cadmium is linked to intestinal and kidney damage in both children and adults.[52] For fetuses and young children, there is no "safe" level of exposure to environmental lead[53] or mercury.[54]

More than 330 of the synthetic chemical contaminants detected in sludge to date have been found to contribute to chronic diseases.[55] Some of these chemicals, such as dioxin and PCBs, are part of a group of contaminants referred to as persistent, bioaccumulative toxins (PBTs) because they do not break down easily in the environment, build up in the food chain and can negatively impact human health. Some PBTs and other chemical sludge contaminants are also known or suspected endocrine disrupting chemicals (EDCs). EDCs, even at low levels, may disrupt growth, brain and reproductive development, cause cancer and more.[56] A chart containing some of the known or suspected PBTs and EDCs found in sludge, along with other potential heath effects, can be found at www.healthobservatory.org.

Chronic diseases including cancer, learning disabilities, neurologic and reproductive problems, are typically caused by multiple, mutually interacting factors. These include not only exposure to toxic chemicals, but also genetics, diet, stress, poverty and other influences. Thus, it is impossible to predict whether any individual eating food from sludge-amended soil will definitively suffer health impacts.

For more on other health impacts related to agricultural use of sludge, see the Cornell Waste Management Institute Web site at http://cwmi.css.cornell.edu/sewagesludge.htm.

Governments' role

The Environmental Protection Agency (EPA) has set minimum standards (40 CFR Part 503)[57] for sludge contaminant content and application, including how soon fields can be grazed or harvested after spreading, and the additional treatment required to allow home/public use. Some of the key problems with these standards include:

- **No restriction of use based on synthetic chemical content.** Despite the routine presence of these chemicals in sludge, their ability to persist in soils, and their potential health impacts alone or in combination (even at low levels of exposure), federal sludge standards do not require testing for the presence of, or restrict use of, sludge based on synthetic chemical content.
- **Weak limits on heavy metals.** The standards make it acceptable to contaminate farms (and other lands) up to a certain point with heavy metals, and have the weakest restrictions of any industrialized country on agricultural use of heavy metal contaminated sludge.[58] Dietary exposure to cadmium was not considered by the EPA when setting the cadmium sludge pollutant limits.[59] For some contaminants, e.g. lead,[60] presumed "safe" thresholds have dropped significantly over time. For others, such as chromium, the EPA chose not to establish a pollutant limit.
- **Inadequate pathogen protections.** Sludge end products are divided into two categories based predominantly on pathogen content: Class B and Class A/EQ.
  - **Class B.** Most sludge used on agricultural land is Class B,[61] and likely contains detectable levels of pathogens. In addition to minimal treatment, waiting periods are used to allow environmental conditions to reduce pathogen levels before harvesting or grazing. However, field testing is not required to assure that bug concentrations have been adequately reduced;[62] established waiting periods may not be long enough since some disease-causing microbes have been shown to live three times longer than the established waiting period for grazing animals;[63] and breakdown products of certain bacteria may cause illness even after destruction of the microbes themselves.[64]
  - **Class A.** Sludge has to meet Class A or Class A Exceptional Quality standards before public distribution in bulk or sale as a bagged fertilizer product. Heat treatment and other methods are used to reduce indicator micro-organisms to non-detectable levels before distribution;[65] however, some microbes are known to be heat resistant;[66] pathogen regrowth can occur in sewage sludge that is heated or otherwise treated to kill pathogens once it has been applied and rewet;[67] and current indicator microbes are now thought to be inadequate for determining safe use of sludge.[68]
- **Exposures from multiple pathways, contaminant mixtures, not considered.** Neither exposure from multiple routes[69] nor the potential for toxic synergies between sludge contaminants were considered by regulators when setting "safe" levels or practices.
- **No labeling requirement.** Food produced on land treated with sewage sludge does not have to be labeled as such.

Some localities have banned agricultural use of sludge.[70] Also, many states have adopted more protective heavy metal standards (16) and/or management practices (37), and a few are testing sludge for one or more synthetic chemicals—primarily PCBs.[71] However, this patchwork of regulation lacks uniformity and falls short of what is needed to assure safety of sludge use in agriculture. Also, 26 states allow sewage sludge/biosolid generators to pass legal liability over to the landowner. [72]

What can I do?

1. **Think upstream.** Keep chemicals out of sludge by choosing safer household and personal care products. Learn more at www.healthylegacy.org/consumerpower.cfm.
2. **Buy "certified organic"** when possible—especially meat and dairy—and vegetables known to take up sludge contaminants, including roots and tubers such as potatoes, sweet potatoes and carrots, and leafy vegetables such as lettuce and spinach. Federal organic standards prohibit sewage sludge application to crop- or pastureland for a minimum period of three years immediately preceding harvest.
3. **Support local growers who don't use sludge.** Absent labeling requirements, check with the farmer about their practices.
4. **Wash and peel produce** to help reduce (but not eliminate) exposure to disease-causing organisms and chemicals.
5. **Avoid home use of sludge-based fertilizers.** Some products are made entirely from sludge. Others are a blend of sludge with materials such as leaves, sawdust and food waste. Most sludge products are only marketed locally or regionally. Others, such as Milorganite®, are sold in home and garden stores nationwide. Find the names of known sludge-based fertilizer products at www.healthobservatory.org.
6. **Choose landscapers wisely.** Screen landscape/lawn care companies before hiring to make sure they will not use sludge-based fertilizer products on your lawn or garden.
7. **Encourage elected officials** to ban use of sewage sludge on agricultural land and home gardens; in the absence of a ban, require labeling of food produced from sludge-amended soil and promote policies that incentivize manufacturers to create safer products using clean, innovative technologies that do not put toxic chemicals into the waste stream.

References:

1. North East Biosolids and Residuals Association (NEBRA). *A National Biosolids Regulation, Quality, End Use & Disposal Survey. Final Report*. 2007, p.1. June 14, 2008. <http://www.nebiosolids.org>.

2. "Ban on the use of sludge as fertilizer." *Federal Office for the Environment FOEN*. 26 Mar. 2003. 2 Sep. 2008 < http://www.bafu.admin.ch/dokumentation/medieninformation/00962/index.html?lang=en&msg-id=1673>.

3. Philippe Aubain et. al. "Disposal and Recycling Routes for Sewage Sludge". European Commission 22 Feb. 2002, 16-17. 2 Sep. 2008 < http://ec.europa.eu/environment/waste/sludge/pdf/synthesisreport020222.pdf>.

4. European Commission, Joint Research Centre Institute for Environment and Sustainability, Soil and Waste Unit. "Organic Contaminants in Sewage Sludge for Agricultural Use" Oct. 18, 2001, p.14. Feb 1, 2007 <http://ec.europa.eu/environment/waste/sludge/index.htm>.

5. *Ibid*.

6. Del Monte Foods Consumer Affairs. "In Response to your Website Comments-Ref #004593069A PDELUCA/JCONSTAN." E-mail to the author. 10 Jun. 2008.

7. Alexandria Richards. "General Mills Web 2008/06/13-2580 AMR." E-mail to author. 16 Jun. 2008.

8. Andrea Cartwright."00284045A (NR): Marie Kulick HZ REQMAT." E-mail to the author. 12 Jun. 2008. Heinz North America Growers Handbook Good Agricultural Practices GAP's. Organic Soil Amendment Policy (Attachment). 11 Jun. 2008.

9. David K. Gattie and David B. Lewis. "A High-Level Disinfection Standard for Land-Applied Sewage Sludges (Biosolids)." *Environmental Health Perspectives* 112 (2004): 126-131. *See also* Stefano Dumonet, et al. "The Importance of Pathogenic Organisms in Sewage and Sewage Sludge." *Journal of the Air & Waste Management Association* 51 (2001): 848-860.

10. Dumontet, *op. cit.,* pp.852-854, 857. *See also* Shivi Selvaratnam and J. David Kunberger. "Increased frequency of drug-resistant bacteria and fecal coliforms in an Indiana Creek adjacent to farmland amended with treated sludge." *Canadian Journal of Microbiology* 50 (2004) 653-656.

11. F.F. Reinthaler et al. "Antibiotic resistance of E. coli in sewage and sludge." *Water Research* 37 (2003) 1685-90.

12. Ellen Z. Harrison, Summer Rayne Oakes, Matthew Hysell and Anthony Hay. "Organic chemicals in sewage sludges." *Science of the Total Environment* 367 (2006) 481-497.

13. Chad A. Kinney et al. "Survey of Organic Wastewater Contaminants in Biosolids Destined for Land Application." *Environmental Science and Technology* 40 (2006) 7207-7215.

14. Murray B. McBride. "Growing Food Crops on Sludge-Amended Soils: Problems with the U.S. Environmental Protection Agency Method of Estimating Toxic Metal Transfer. *Environmental Toxicology and Chemistry* 17 (1998) 2274-2281. *See also* National Research Council of the National Academies. *Biosolids Applied to Land-Advancing Standards and Practices.* Washington DC: The National Academies Press, 2002, p. 2.

15. R. K. Bastian et al. "Radioactive Materials in Biosolids." Journal of Environmental Quality 34 (2005) 64-74.

16. European Commission, *op. cit.,* p.44.

17. Karen Rideout and Kay Teschke. "Potential for Increased Human Foodborne Exposure to PCDD/F When Recycling Sewage Sludge on Agricultural Land." *Environmental Health Perspectives* 112 (2004) 959-969.

18. S. M. Rhind et al. "Effects of exposure of ewes to sewage sludge-treated pasture on phthalate and alkyl phenol concentrations in their milk (Abstract)." *Science of the Total Environment* 383 (2007) 70-80.

19. D. Schowanek et al. "A risk-based methodology for deriving quality standards for organic contaminants in sewage sludge for use in agriculture-Conceptual Framework". *Regulatory Toxicology and Pharmacology* 40 (2004) 227-251.

20. S. M. Rhind. "Endocrine disrupting compounds and farm animals: their properties, actions and routes of exposure (Abstract)." *Domestic Animal Endocrinology* 23 (2002) 179-187.

21. Clifford L. Heffron et al. "Cadmium and Zinc in Growing Sheep Fed Silage Corn Grown on Municipal Sludge Amended Soil." Journal of Agriculture and Food Chemistry 28 (1980) 58-61.

22. Larry G. Hansen et al. "Polychlorinated Biphenyl, Pesticide, and Heavy Metal Residues in Swine Foraging on Sewage Sludge Amended Soils." *Journal of Agriculture and Food Chemistry* 29 (1981) 1012-1017.

23. Schowanek, *op. cit*., p. 234.

24. M.B. McBride and B. Hale. "Molybdenum Extractability in Soils and Uptake by Alfalfa 20 Years After Sewage Sludge Application (Abstract)." *Soil Science* 169 (2004): 505-514.

25. P.S. Hooda, et.al. "Plant Availability of Heavy Metals in Soils Previously Amended with Heavy Applications of Sewage Sludge." *Journal Science Food and Agriculture* 73 (1997): 446-454.

26. McBride, op.cit., Growing, pp. 2276-2277.

27. Hooda, *op.cit.,* pp. 448-449.

28. Jorge de las Heras, Pilar Mañas and Juana Labrador. "Effects of Several Applications of Digested Sewage Sludge on Soil and Plants." *Journal of Environmental Science and Health* A40 (2005):437-451.

29. Hooda, *op. cit.*

30. European Commission, *op. cit.,* p.43.

31. Rideout, *op. cit.* pp. 962, 966-967.

32. Schowanek, *op. cit.* pp. 232, 241.

33. Min-Jian Wang and Kevin C. Jones. "Uptake of Chlorobenzenes by Carrots from Spiked and Sewage Sludge-Amended Soil." *Environmental Science & Technology* 28 (1994) 1260-1267. *See also* Schowanek, *op. cit.* p. 234.

34. Norbert Th. Litz, Josef Müller and Walter Böhmer. "Occurrence of Polycyclic Musks in Sewage Sludge and their Behavior in Soils and Plants. Part 2: Investigation if Polycyclic Musks in Soils and Plants (Abstract)." *Journal of Soils and Sediments* 7 (2007) 36-44. (1992) 217-225 (Abstract). *See also* European Commission, *op. cit.*

35. S.R. Wild and K.C. Jones. "Polynuclear Aromatic Hydrocarbon Uptake by Carrots Grown in Sludge-Amended Soil." *Journal of Environmental Quality* 21 (1992) 217-225 (Abstract). *See also* European Commission, *op. cit.*

36. Kumar et al. "Antibiotic Uptake by Plants from Soil Fertilized with Animal Manure." *Journal of Environmental Quality* 34 (2005) 2082-2085.

37. European Commission, *op. cit.* p. 43.

38. S. Dudka and W.P. Miller. "Accumulation of potentially toxic elements in plants and their transfer to human food chain (Abstract)." *Journal Environmental Science and Health* 34 (1999) 681-708.

39. McBride, *op. cit.,* Growing.

40. Gattie, *op. cit.*

41. Paul S. Mead et al. "Food-Related Illness and Death in the United States." Emerging Infectious Diseases. Centers for Disease Control and Prevention. Aug. 26, 2008 <http://www.cdc.gov/ncidod/eid/Vol5no5/mead.htm>.

42. Suzanne R. Jenkins, Carl W. Armstrong and Michele M. Monti. *Health Effects of Biosolids Applied to Land: Available Scientific Evidence.* Virginia Department of Health Nov. 2007, p. 12. Jun. 30, 2008 < http://www.deq.virginia.gov/info/biosolidspanelcorrespondence.html>. *See also* Duwiontet, *op.cit.,* pp. 857-858. Gattie, *op.cit.,* p.130. Gerba, *op.cit.* 44-47.

43. Harrison, *op.cit.,* p. 485.

44. A. O. Summers. "Genetic linkage and horizontal gene transfer, the roots of the antibiotic multi-resistance problem (Abstract)." *Animal Biotechnology* 17 (2006) 125-35. *See also* Amy R. Sapkota, Lance B. Price, Ellen K. Silbergeld and Kellogg J. Schwab. "Arsenic Resistance in Campylobacter spp. Isolated from Retail Poultry Products." *Applied Environmental Microbiology* 72 (2006) 3069-3071. T J. F. Timoney et al. "Heavy-Metal and Antibiotic Resistance in the Bacterial Flora of Sediments of New York Bight (Abstract)". *Applied and Environmental Microbiology* 36 (1978) 465-472

45. Dumonet, *op. cit.,* p. 853.

46. Agency for Toxic Substances and Disease Registry. Agency for Toxic Substances and Disease Registry ToxFAQs. Arsenic Aug. 2007. Jun. 15, 2008 <http://www.atsdr.cdc.gov/toxfaq.html>.

47. Agency for Toxic Substances and Disease Registry. Agency for Toxic Substances and Disease Registry ToxFAQs. Cadmium Jun. 1999. Jun. 15, 2008 <http://www.atsdr.cdc.gov/toxfaq.html>.

48. Agency for Toxic Substances and Disease Registry. Agency for Toxic Substances and Disease Registry ToxFAQs. Lead Aug. 2007. Jun. 15, 2008 <http://www.atsdr.cdc.gov/toxfaq.html>.

49. Agency for Toxic Substances and Disease Registry. Agency for Toxic Substances and Disease Registry ToxFAQs. Mercury Apr. 1999. Jun. 15, 2008 <http://www.atsdr.cdc.gov/toxfaq.html>.

50. ToxFAQs, Arsenic, *op. cit.*

51. Jennifer C. Davey et al. "Arsenic as an Endocrine Disruptor: Arsenic Disrupts Retinoic Acid Receptor-and Thyroid Hormone Receptor-Mediated Gene Regulation and Thyroid Hormone-Medicated Amphibian Tail Metamorphosis." *Environmental Health Perspectives* 116 (2008) 165-172. *See also* R.C. Kaltreider, A. M. Davis, J. P. Lariviere and J. W. Hamilton. "Arsenic alters the function of the glucocorticoid receptor as a transcription factor." *Environmental Health Perspectives* 109 (2001) 245-51.

52. ToxFAQs, Cadmium, *op. cit.*

53. Bruce P. Lanphear et al. "Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis." *Environmental Health Perspectives* 113 (2005) 894-899. *See also* Todd A. Jusko et al. "Blood Lead Concentrations <10μg/dL and Child Intelligence at 6 Years of Age." *Environmental Health Perspectives* 116 (2008) 243-248.

54. European Food Safety Authority (EFSA). "Opinion of the Scientific Panel on contaminants in the food chain [CONTAM] related to mercury and methylmer-cury in food." *The EFSA Journal 34* (2004) 1-14. Sep. 2, 2008 <http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178620763245.htm>.

55. R. Iranpour et. al. "Regulations for Biosolids Land Application in U.S. and European Union." *Journal of Residuals Science & Technology* 1(2004) 209-222.

56. Andrew C. Chang et al. Developing Human Health-related Chemical Guidelines for Reclaimed Waster and Sewage Sludge Applications in Agriculture. World Health Organization European Environmental Bureau, p. 13 Sep. 30, 2001(revised May 17, 2002) Dec. 18, 2006. http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index. html>. *See also* S. Rhind, *op. cit.,* Endocrine.

57. Environmental Protection Agency. "A Plain English Guide to the EPA 503 Part Biosolids Rule." http://www.epa.gov/owm/mtb/biosolids/503pe/index.htm

58. McBride, *op. cit.,* Growing, p. 2274.

59. National Research Council of the National Academies. Biosolids Applied to Land-Advancing Standards and Practices. Washington DC: The National Academies Press, 2002, pp. 208-209, 217. *See also* Jenkins, *op. cit.* p. 12.

60. Lanphear, *op. cit.*

61. NEBRA, *op. cit.,* p. 14.

62. National Research Council, *op. cit.,* p.13-14.

63. de las Heras, *op. cit.,* p. 446.

64. Gattie, *op. cit.,* p. 127.

65. National Research Council, *op. cit.* pp. 13-14, 257-262

66. Jenkins, *op. cit.* p. 15. *See also* Gattie, *op. cit.,* p. 127.

67. Gattie, *op. cit.*

68. Dumontet, *op. cit.,* p. 857. *See also* Jenkins, *op. cit.,* p. 16.

69. National Research Council, *op. cit.,* pp. 11-12.

70. "The State of Biosolids in America." *BioCycle* Dec. 2000, 50.

71. NEBRA, *op. cit.,* pp. 23-25, Appendix B.

72. *Ibid*. B-3.

This guide was written by Marie Kulick,
Senior Associate, Institute for Agriculture and Trade Policy.