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WEF/U.S. EPA Biosolids Fact Sheet Project

Biosolids: A Short Explanation and Discussion

The WEF/EPA Biosolids Fact Sheet series addresses concerns and controversies surrounding several biosolids land application sites. In each case, a treated and tested wastewater residual called biosolids was applied to agricultural or damaged land to promote plant growth and condition the soil. Biosolids is a relatively new term for a specific product of wastewater treatment that may be used as a beneficialamendment to soil and meets all regulations for such use. Solids removal and management are essential to clean discharge from municipal wastewater treatment plants.

What are Biosolids?

Biosolids are a subset of what is commonly known as sewage sludge. Today the term *wastewater solids* describes the solid material produced at several stages of wastewater treatment before federal and state regulations governing beneficial recycling are met. *Solids* should be used together with the treatment process which generates such material, for example, *primary solids* is the wastewater solids collected from primary treatment. When primary solids are tested, treated, and processed, the material may meet the standards of biosolids. *Biosolids* is a more precise term properly used only to describe that portion of the wastewater solids stream which meets federaland state regulations for beneficial use by land application or other methods. The narrow definition of the word allows biosolids generators and appliers to speak concisely with their colleagues and the general public when discussing wastewater residuals.

The word *biosolids* originated from within the wastewater treatment industry, many members of which sought to give a name to the clean, agriculturally viable product generated by modem wastewater treatment. Advances in technology and regulation led wastewater treatment plants to create a product so significantly improved over traditional wastewater solids that a term for the new material was deemed appropriate. The Water Environment Federation solicited suggestions for such a word after several water quality professionals publicly requested a new word for the agriculturally viable portion of sewage sludge.

Biosolids, a twist on the use of *bio* logical processing of wastewater solids, was one of 300 responses to WEF's call for suggestions. Dr. Bruce Logan of the University of Arizona created the word. WEF's Executive Committee formally recognized the term in 1991. The U.S. Environmental Protection Agency (U.S. EPA) began using the word soon thereafter, and "biosolids" is used by most federal and many state agencies today. A new word was coined for the same reason the word is used today: to describe the primarily organic byproduct of wastewater treatment which can be beneficially recycled.

How Are Biosolids Produced?

Solids from primary and secondary wastewater treatment are the main constituents of most biosolids materials. U.S. EPA defines biosolids as solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works. The residue processed to become biosolids can include scum or solids removed in primary, secondary, or tertiary (advanced) wastewater treatment processes. Materials collected at treatment plants but not included in biosolids production include grit, screenings, and ash generated by incineration.

Biosolids generally is understood to be a semi-liquid material containing at least 10 percent suspended solids. The material may be heat dried to close to loo-percent solid content. The chemical composition of biosolids may vary considerably between sewage treatment plants and within a single treatment plant at separate points of residual collection. Municipal biosolids commonly contain an inorganic mineral fraction and an organic fraction. Water usually is as much as 90 percent of the total weight of biosolids. The solids removed from these processes, once treated to conform with federal and state standards, are biosolids.

Virtually all the constituents of finished, processed biosolids are contained in the sewage which flows to municipal wastewater treatment plants. Municipal sewer-system users include households, commercial businesses, and some industrial sites. Most material washed down sewers travels to a wastewater treatment plant. After screens and filters remove larger items and grit from the sewage, the remaining solids - many of which are visible only through a microscope - are separated from the stream by a series of mechanical and biological processes.

In order to produce a clean effluent that may be discharged to natural bodies of water, wastewater treatment managers employ a panoply of processes to remove contaminants and pollutants. Most treatment plants use three or four distinct stages of treatment. *Preliminary* wastewater treatment extract coarse solids and sand-like solids by screening and grit removal. Left in the sewage inflow, these materials interfere with equipment and treatment processes. The coarse solids and grit are not incorporated in biosolids. *Primary* wastewater treatment usually involves gravity sedimentation of screened, degritted wastewater to remove settled solids. Half the solids suspended in wastewater generally are removed by primary treatment. Primary treatment reduces concentrations of nutrients, pathogens, trace elements, and organic compounds in the wastewater stream. The residue from primary treatment of wastewater is a concentrated suspension of particles in water called ‘primary sludge.’ Primary sludge may be further processed and treated to become biosolids.

Secondary municipal wastewater treatment almost always is accomplished through a biological treatment process to remove biodegradable organic material. Secondary treatment processes add microorganisms which consume organic material to the primary sludge. Some organics are oxidized by the microorganisms to produce carbon dioxide and other end products. The remainder of the organics provide energy and matter necessary to support the microorganism community. Once fed, the microorganisms biologically thicken and settle to the bottom of processing tanks. The enlarged microorganisms are separated in sedimentation tanks as a concentrated suspension called secondary sludge, biological sludge, waste activated sludge, or trickling filter humus.

Tertiary or *advanced* treatment is used at wastewater treatment plants which must produce extremely high-quality effluent. For instance, a treatment plant discharging final effluent directly to a drinking water source may use advanced treatment. The matter collected through tertiary treatment often consists of chemicals added to clean the effluent and reclaimed before effluent discharge, andgenerally is not incorporated into biosolids.

After collection through basic wastewater treatment, primary and secondary solids comprise the majority of material used for biosolids production at municipal plants. Yet, plant operators use a wide variety of treatment processes before wastewater residuals are ready for recycling and other uses. Modem treatment technology allows plant operators to control the solids content, constituents, and other traits of biosolids.

A main concern of biosolids generators is water content of the final product. Primary and secondary solids generally contain no more than 3 percent solids, which make storage, transport, and reuse of the materials logistically complicated and financially prohibitive. Processes to remove water from solids, therefore, are common in biosolids production. The simplest water removal method is called *gravity thickening,* which is concentration by simple sedimentation. Allowing time for solids to settle in tanks can increase total weight by 5 percent or 6 percent. Thickening also can include processes which make solids float, gravity drainage belts, perforated rotating drums, and centrifuges. Nothing is added to biosolids in gravity thickening processes.

Dewatering is another standard method of water removal in biosolids production. Simple dewatering involves application of wastewater solids to sand drying beds or lagoons, where gravity, drainage, and evaporation remove moisture. More often, dewatering involves mechanical equipment such as filter presses, belt filter presses, vacuum filters, and centrifuges. Mechanically dewatered solids typically contain between 20 percent and 45 percent solids. Finally, dryingprocesses can remove even larger volumes of water from biosolids. Thermal drying with direct or indirect dryers can remove virtually all water from biosolids and can stabilize biosolids toregulatory standards.

The processing stage at which ‘wastewater solids’ ordinarily become ‘biosolids’ is *stabilization,* which hastens biodegradation of organic compounds and makes biosolids acceptable for agricultural use. As mentioned above, some thermal drying processes also stabilize biosolids. *Biological stabilization* reduces the organic content of solids through controlled biodegradation or decomposition. Most commonly, wastewater solids are sent to anaerobic digesters in whichbacteria consume organics. Aerobic digesters use air to achieve the same ends. Cornposting also is a method of biological stabilization. *Chemical stabilization* does not reduce the quantity of biodegradable organic matter in solids, but creates process conditions that inhibit microorganismsin order to slow the degradation of organic materials and reduce odors. The most common chemical stabilization procedure is b elevate the pH level of solids using lime or other akaline material.

Table 1. Trace Elements in Biosolids Over Time all measurements mg/kg

	Mean	***Values***
	1977	1988
Zinc	2,790	1,202
Copper	1,210	741
Manganese	380	---
Cadmium	110	7
Arsenic	43	.009
Chromium	2,620	119
Lead	1,360	134
Mercury	733	5
Nickel	320	43
Barium	77	---

1977 figures by Sommers. Mean values for 250 samples from 150 treatment plants.
1988 figures by U.S. EPA. Mean values for United States based on sampling from 208 treatment plants.
Source: Linden, 1995.

Why Should I Care About Biosolids?

Wastewater treatment and management of wastewater residuals should concern all municipal sewer users, agricultural interests, and environmentalists. More than $2 billion is spent annuallytreating and managing approximately 5.3 million dry metric tons of biosolids from publicly owned wastewater treatment plants in the United States. Land application of biosolids, often to food crops, has gamed popularity and widespread approval from the scientific and environmentalcommunities and has increased.

National biosolids generation rates are estimated to reach 47 dry pounds per American yearly. In 1972, 20 percent of all U.S. biosolids was land applied, while 40 percent went to landfills. In 1989, about 33 percent of total biosolids was land applied and 34 percent was landfilled. By 1995,36 percent of all yearly biosolids was land applied and 38 percent was landfilled. The remainder of the material was incinerated or surface disposed. These figures are in line with biosolids management methods in Europe. Disposing of biosolids by shipment to landfills is considered a beneficial use only when such disposal includes methane gas recovery for fuel. Methane operations are relatively rare, however, which establishes land application for soil conditioning and fertilizer as the primary beneficial use of biosolids.

Table 2. Biosolids Management Methods in European Nations and in the United States

		Management method (percentage of total)			
	Total/ 1,000 dtpy	*Agriculture*	*Landfilling*	*Incineration*	*Other*
Austria	320	13	56	31	0
Belgium	75	31	56	9	4
Denmark	130	37	33	28	2
France	700	50	50	0	0
Germany	2500	25	63	12	0
Greece	15	3	97	0	0
Ireland	24	28	18	0	54
Italy	800	34	55	11	0
Luxemb.	15	81	18	0	1
Holland	282	44	53	3	0
Portugal	200	80	13	0	7
Spain	280	10	50	10	30
Switzer.	215	50	30	20	0
UK	1075	51	16	5	28
US	5357	36	38	16	10
Total/Avg.	11988	38	43	10	9

Source: Chang, Page, and Asano, 1996.

The public should be knowledgeable about the beneficial use of biosolids. In many cases, opposition to land application sites has centered on regional issues, such as the shipment of city biosolids to rural locations. Aside from regionalism, the most pervasive public concerns about biosolids land application appear to involve the release of trace elements to soil and groundwater, and human pathogens released to sewers by households and other sources. The WEF/U.S. EPA Biosolids Fact Sheets attempt to address some public complaints about biosolids which havegained wide regional or national attention. Federal and state regulations based on sound science are the public's prime safeguard against potentially negative effects of biosolids reuse. The federal rules are contained in Title 40 of the Code of Federal Regulations, Part 503. Concise explanations of the rules can be found in U.S. EPA's *Plain English Guide to the EPA Part 503 Biosolids Rule.*

Biosolids generally contain concentrations of trace elements greater than the concentrations in typical soil. Therefore, biosolids applications usually increase the concentrations of trace elements in soils. Most trace elements are immobile, however, and tend to concentrate in the soil only as deep as biosolids are incorporated into the soil. The National Research Council found that where biosolids have been added to soil according to existing guidelines and regulations, consumers have reported no phytotoxicity or accumulation of trace elements in plants attributable to biosolids. If the agricultural uses of biosolids follow state and federal regulations, including pH standards, noadverse effects should be expected or observed.

The second main concern about biosolids is the transmission of pathogens contained in wastewater to human beings near biosolids land application sites. Biosolids contain the same pathogenic organisms found in the domestic waste of the population and in foodrelated industries. The pathogens found in raw sewage have included bacteria such as *Salmonella,* viruses such as Hepatitis A, and parasites such as tapeworms. Pathogen populations are significantly reducedthrough wastewater treatment and biosolids production, as well as by compliance with federal and state standards for pathogenic concentrations in reused material. Except for the use of raw sewage or primary effluent on sewage farms in the late 19th century, there have been no documented cases of infectious disease resulting from reclaimed water or biosolids use in the United States. No adverse effects have been reported resulting from ingestion of food plants grown in biosolids-amended soils. The National Research Council's review of the Part 503 rules took issuewith only one aspect of the regulations pertaining to the survival of tapeworms in Class Bbiosolids applied to cattle grazing areas. The council concluded that U.S. EPA's Part 503 rule "appears to be ... adequate for the protection of the public from the transmission of waste associatedpathogens."

What are the Benefits of Biosolids?

Biosolids applications to agricultural land provide an excellent and profitable alternative to disposal by utilizing the recyclable components of wastewater in the production of crops. Biosolids recycling and reuse not only save local and state governmentssignificant amounts of money through lower disposal costs and sales of biosolids-derived products, but add nutrients and positive soil characteristics to agricultural land. Biosolids land application is a beneficial recycling process with economic and environmental benefits for many Americans.

Biosolids can provide essential plant nutrients, water, and organic matter which can improve the physical condition of soil and render it a more favorable environment to manage nutrients and water. Biosolids contain all the elements essential for the growth of higher plants. Because nitrogen and phosphorus are the most abundant major plant nutrients in biosolids, the material's agriculturaluse is almost exclusively as a supplemental source of nitrogen and phosphorus fertilizer.

Biosolids also contains all essential plant nutrients, with the possible exception of potassium, to satisfy most crop requirements. As with the addition to soils of other organic materials, such as hay and animal manures, the addition of organic matter accompanying successive biosolids additionsimproves the physical properties of soils. This, in turn, exerts a positive influence on waterpenetration, porosity, bulk density, strength, and aggregate stability.

Farmers earn productivity from their crops by using biosolids. Taxpayers save money when their local jurisdictions land apply biosolids instead of paying ever-increasing landfill fees. The benefits of biosolids recycling, combined with several rounds of research by federal agencies and independent laboratories, provide a safe and economical recycling practice.

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