LAND APPLICATION OF ANAEROBICALLY DIGESTED BIOSOLIDS IN USEPA REGION 8

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ABSTRACT

Most municipal wastewater in USEPA Region 8 (covering the states of CO, MT, ND, SD, UT, and WY) flows through facilities where the sludge is treated using anaerobic digestion in order to meet pathogen reduction and vector attractiveness requirements. Tracking the application of anaerobically digested biosolids is an important step in determining the fate of carbon, nutrients, and potential contaminants from this widely used biosolids treatment process. The biosolids application rate to agricultural crops in Region 8 averages from 0.8 to 2.9 tons acre^{-1} depending on which state the application is performed. The low application rate is most likely related to dryland agriculture dominating the EPA region. This paper describes trends in biosolids application of anaerobically digested sewage sludge including location and crops grown in EPA Region 8.

INTRODUCTION

Biosolids is a term developed to designate sewage sludge from a municipal wastewater treatment plant that has been treated to meet certain regulatory requirements for beneficial use including land application to agricultural land (NRC 2002) Biosolids are a nutrient-rich material regularly produced by municipalities throughout the United States and elsewhere. This nutrient-rich material has been used as a fertilizer in the United States for many decades. It has been projected that in the United States 7,180,000 dry tons was produced and 41% was land applied to agricultural lands in 2004 (NEBRA 2007) to an estimated 588,760 acres (at 5 dry tons per acre). In the reporting year 2005, in USEPA Region 8 alone, 216,520 tons were produced and 70 percent was land applied to approximately 80,899 acres with anaerobically digested biosolids accounting for 43,171 acres.

EPA is divided into 10 regions covering various state groupings. Region 8 includes Colorado, Utah, Wyoming, Montana, North Dakota and South Dakota.

Biosolids have been land applied to agricultural lands in the USA for more than 75 years with the benefits reported by DeTurk and Harper in the 1930s (DeTurk 1935, Harper 1931). The nutritive value has been long known, studied and utilized. In Colorado biosolids have been land applied and studied for several decades (e.g. McBride et al 1990, Barbarick and Ippolito 2000).

The examination of regional and local trends in biosolids land application is important for many reasons. Chief among these reasons is to examine, on a large scale, the scope of land application to agricultural lands. In addition to this large-scale context, the local, smaller-scale context of land application is also important. Since biosolids are typically produced in the greatest quantities near urban centers, it is plausible that these biosolids are applied most heavily in areas where transport is most economically feasible from treatment plants in urban areas.

Determination of the fate and transport of various constituents of biosolids is another important reason to track application trends.

Within the local context, the fate of carbon (C), nutrients, and potentially known and emerging contaminants associated with biosolids is of particular interest. In recent years, the management of soil C has garnered considerable attention as a method of atmospheric C sequestration. Increased soil C has many other benefits as well, and management changes such as no-till farming are touted by many authors as methods for increasing soil C (e.g., see Lal et al. 2004, and Lal 2004). Janzen (2006) noted the apparent "dilemma" of sequestering organic matter when the very act of adding C stimulates microbial activity to degrade it, but asserted that increasing soil C inputs is a "win-win" proposition. Janzen suggests that some of the applied C will be used, but some of it will be sequestered. However, Schlesinger (2000) argues that manure application does not result in net C sequestration. A similar conclusion could be reached for biosolids application (Parat et al 2007). In any case, the fate of C in land-applied biosolids and manures will undoubtedly face increasing scrutiny in the coming years. Tracking biosolids application is an important step in studying C fluxes, sinks, and trends on a local and regional level.

In addition to C, the fate and transport of nutrients and potential contaminants in biosolids is important for the protection of water quality and animal and human health. Nutrients from biosolids or manure application could conceivably cause non-point source pollution of surface waters (Carpenter et al. 1998), though regulations are intended to reduce the risks of water pollution from biosolids application by preventing their over-application. Nonetheless, the concentrated production of large amounts of biosolids in urban areas calls attention to the importance of tracing these nutrients and tracking trends through treatment and land application, as the information would be useful when conducting water quality risk assessments.

The same is true for so-called "emerging contaminants" such as steroid hormones, pharmaceuticals, and personal care products. A review by Xia et al. (2005) noted that hydrophobic pharmaceuticals, personal care products, and other chemicals do show a tendency to sorbed to biosolids, and land application of biosolids could indeed be a source for these substances in the environment. However, the same investigators pointed out that analytical limitations make the study of these compounds in the environment challenging. Lorenzen et al. (2004) found estrogenic and androgenic hormone activity to be detectable in anaerobically treated biosolids, and generally undetectable in those treated aerobically. This potential for increased hormone risk from anaerobically digested biosolids highlights the need to distinguish between treatment methods in the tracking of biosolids land application. It needs to be noted that clearly our ability to detect these emerging contaminates far exceeds our ability to understand risks and effect of the substances.

Tracking the application of anaerobically digested biosolids is an important step in determining the fate of carbon, nutrients, and potential contaminants from this widely used biosolids treatment process. Region 8 has utilized Biosolids Data Management System (BDMS) as a method of tracking biosolids production and use/disposal, including in recent years land application sites. This paper describes trends in biosolids application of anaerobically digested sewage sludge, including location and crops grown, in EPA Region 8.

MATERIALS AND METHODS

Summarized biosolids data was obtained from individual facility annual reports, which are entered into Region 8's Biosolids Data Management System originally developed by the corresponding author in the early 1990s to summarize the data. BDMS utilizes data that are provided by wastewater treatment plants that produce biosolids. The annual reports provide both quantity and quality data for entry into BDMS.

Basic agricultural data was derived from data that were summarized from the 2002 Agricultural Census and NASS updates. Data were analyzed using a spreadsheet program. Data was mapped in ArcGIS (ESRI, Redlands CA)

Typically the regulated metals in biosolids are often referred to as being high or in excess. However, it can be seen that the concentrations are well below the risk derived regulatory limits. It is important to note that several of the regulated parameters are also referred to as micronutrients.

Table 1 Comparison of Mean Biosolids Quality, Typical Soil Quality and Regulatory Limits

40CFR503 Regulated Parameter	Regional 2005 mg/Kg[1]	National (TNSSS)2006 mg/Kg[2]	Typical Soil Concentration mg/Kg[3,4]	40CFR503 Table 3 Limit mg/Kg[5]
As	4	7	5.5	41
Cd	2.5	3	0.271	39
Cu	550	569	16.3	1500
Pb	34	80	11.8	300
Hg	0.8	1.3	0.05	17
Mo	11	17		N.R.(75)
Ni	18	53	15	420
Se	8	7	0.29	100
Zn	599	1029	54.3	2800

Notes: [1]2005 Annual Reports summarized in US EPA Region 8 BDMS,[2] US EPA 2007, [3] As, Hg, Se are median values from Shacklette and Boerngen 1984; [4] Cd, Pb, Zn, Cu and Ni are background Great Plains means from Holmgren et al 1993; [5] US EPA 1993

Calculating the application rate for biosolids requires information on the crop grown, soil status, biosolids information and a basic knowledge of the principles of biosolids application. It is not the intent of this paper to go into details of calculating the agronomic rate for biosolids application. There are many references that provide detailed information on application of biosolids in the Great Plains such as; Barbarick and Ippolito 2000 and CDPHE 2005.

We have provided some basic quality information in table 2 so the reader is able to place the application rate discussed in the upcoming text in context with other fertilizers.

RESULTS AND DISCUSSION

Biosolids in Region 8 are produced by using chiefly four treatment types to assure the pathogen and vector attractiveness quality requirements are met. Each of those treatment systems produce biosolids with different fertility characteristics. Three are aerobic processes: composting, aerobic digestion and air drying; and the other is anaerobic digestion. This paper will review those biosolids that are produced utilizing anaerobic digestion that are land applied to crop lands.

Table 2: Typical Nutrient Components and Concentrations of Anaerobically Digested Biosolids

NH4/3	TKN	Org- N	NO3	P	K
2-4%	3-8%	4-8%	0.01-0.2%	1-4%	0.5-1.5%
40-80#/t	60-160#/t	80-160#/t	2-4#/t	20-80#/t	10-30#/t

Table 3 shows that the tendency of 34% of the larger facilities (greater wastewater flow) is to utilize anaerobic digestion and 66% of the smaller facilities (lesser wastewater flow) tend to utilize the simpler aerobic processes for treatment of solids. Overall 74% of the wastewater treated in Region 8 passes through wastewater treatment plants that utilize anaerobic digestion for treatment of biosolids.

Table 3: Land Application of Biosolids by Treatment Type

Treatment Type	% Facilities	% Biosolids
Anaerobic Digestion	34%	74%
Aerobic Processes	66%	26%

Typical biosolids application rates in Region 8 tend to be less that 2 tons/acre as shown in Table 4. These application rates are indicative of the nitrogen needs of the crops. Application rates for altered environments (e.g. irrigation) or regions of more moisture and different crops require additional N, therefore higher application rates. This is the reason South Dakota has a mean application rate of almost 3 tons/acre. The facilities in South Dakota that produce and land apply anaerobic biosolids are located in the wetter eastern portion of the state.

Table 4: 2005 Biosolids production and application by USEPA Region 8 state.

State	Total Biosolids Produced (tons)	Anaerobic Biosolids Produced Land Applied (tons)	Anaerobic Biosolids Land Applied to Crop Land(tons)	Anaerobic biosolids applied to Crop Land(acres)	Average Application rates (tons/acre)
CO	123,414	79,029	69,711	37,671	1.8
MT	10,486	2,535	959	994	1.0
ND	8,671	642	643	478	1.3
SD	9,936	4,534	4,534	1,574	2.9
UT	50,183	16,614	1,554	1,954	0.8
WY	13,830	1,530	606	500	1.2

We are assessing application of biosolids to crop land, but other land application projects occur such as reclamation (e.g. mineland, landfills), and construction (e.g. golf courses). This may explain the difference between column 3 and column 4 in table 4.

Anaerobically digested biosolids in the Great Plains are applied to many types of crops. Table 5 only looks at the top four. Wheat clearly is the favored crop for application. This is most likely explained by the dryland management practice of wheat-fallow allowing a much longer timeframe for application of the biosolids as well as larger contiguous fields (i.e. less setups).

Table 5: 2005 Crop and Acres Land Applied with Anaerobic Biosolids

Crop	Biosolids Land Applied Acres by crop	Acres of Crop Grown in Region	% Acres w biosolids
Wheat	28,676	20,159,000	0.14
Hay/Alfalfa	5,988	20,530,000	--
Corn	3,908	6,178,000	0.01
Sunflower	1,152	1,840,000	0.01
Misc.	3,447	--	--

EPA Region 8 is a small rural region that has limited urban population and therefore limited biosolids available for recycling to the land. If you look at the percent of acres applied with biosolids by crop you see that there is a decimal fraction on a region-wide basis. When the data are reviewed at a county level rather than a state level the picture can be quite different. For example 80% of the biosolids applied in Colorado is applied in 5 counties (USEPA 2002). The application of biosolids tends to concentrate near urban area or areas with adequate transportation infrastructure. Prowers County, Colorado, is the county where New York City sends via rail a large portion of its anaerobically digested biosolids. When reviewing that data, only 2.5% of the acres were planted with wheat and 7% of the private pasture lands were fertilized with biosolids.

CONCLUSIONS

Tracking the application of anaerobically digested biosolids is an important step in determining the fate of carbon, nutrients, and potential contaminants from this widely used biosolids treatment process. Biosolids application rate to agricultural crops in Region 8 averages from 0.8 to 2.9 tons acre^{-1} depending on the state. The low application rate is most likely related to dryland agriculture dominating the EPA region. When considering effects of biosolids applications one must consider local as well as region effects. Since biosolids are typically produced in the greatest quantities near urban centers, it is plausible that these biosolids are applied most heavily in areas where transport is most economically feasible from treatment plants in urban areas. Determination of the fate and transport of various constituents of biosolids is an important reason to track application trends. For these reasons USEPA Region 8 will continue to track land application site information.

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