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REPORT ON BIOSOLIDS CHARACTERISTICS FOR

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REPORT ON BIOSOLIDS CHARACTERISTICS

BY

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INTRODUCTION

The Metropolitan Water Reclamation District of Greater Chicago (District) generates about 180,000 dry tons of biosolids annually through the operation of seven water reclamation plants (WRPs). Final biosolids products are generated at four of the District's WRPs: Calumet, John E. Egan (Egan), Hanover Park, and Stickney. The biosolids are produced through two main biosolids processing trains (BPTs), the high solids biosolids processing train (HSBPT) and low solids biosolids processing train (LSBPT).

In the HSBPT, anaerobically digested sludge is centrifuged to a solids content of 20 – 30 percent. At this stage, it satisfies the Class B pathogen criteria of the United States Environmental Protection Agency's (USEPA) Part 503 regulations for the land application of biosolids. The centrifuge cake biosolids are either land applied directly (Calumet, Egan, and Stickney WRPs) or are further processed by lagoon-aging followed by air-drying to approximately 65 percent solids at the Calumet and Stickney Solids Management Areas (SMAs).

In the LSBPT, the anaerobically-digested sludge is gravity thickened by lagoon-aging and then air-dried. The air-dried biosolids from both processing trains satisfy the Part 503 Class A pathogen criteria, the Part 503 vector attraction reduction requirements, and have a soil-like appearance and properties that allow them to be used as a soil conditioner.

Most of the District's biosolids are managed by land application through the following programs under permits issued by the Illinois Environmental Protection Agency (IEPA):

- Fischer Farm Land Application - The anaerobically digested liquid Class B biosolids from the Hanover Park WRP are applied to the Fischer Farm fields located on the plant grounds.
- Farmland Application - Class B centrifuge cake biosolids from the Calumet, Stickney, and Egan WRPs are used to fertilize farmland in Cook and other nearby counties.
- Controlled Solids Distribution - Aged, air-dried Class A biosolids from the Stickney and Calumet WRPs are used in the Chicago Metropolitan area as a soil substitute or amendment for the construction of recreational fields, golf courses, etc., and in landscaping. The biosolids are also used as a fertilizer topdress for turfgrasses in these areas.
- Landfill Final and Daily Covers - Biosolids from the Stickney and Calumet WRPs are also used for landfill final and daily covers.

The District generates data on the characteristics of its biosolids through routine monitoring and reporting requirements of regulatory agencies and operating permits. Data on biosolids properties are also generated through scientific research or other studies that are designed specifically for evaluating biosolids characteristics not measured in the routine monitoring programs.

The purpose of this report is to provide information on the chemical characteristics of the District's biosolids to biosolids users.

BIOSOLIDS CHEMICAL CHARACTERISTICS

Biosolids Nutrients and Trace Metal Chemistry

The District conducts analysis of its biosolids as required by the USEPA's Part 503 biosolids land application regulations and by permits issued by the IEPA. The data reported here also include several parameters that are not required for Part 503 or IEPA monitoring compliance. Such datasets are primarily used to provide information to biosolids users, and for estimating agronomic and metal loading rates for the Class B biosolids farmland application program.

Class B Centrifuge Cake Fertilizer Products. A summary of the nutrient and trace metal data for centrifuge cake biosolids generated at the Calumet, Egan, and Stickney WRPs in 2008 is presented in Tables 1, 2, and 3, respectively. These biosolids are used as fertilizer on farmland in Cook and other neighboring counties. They are Class B with respect to the Part 503 pathogen standards and can meet the vector attraction reduction requirements through incorporation into soil. These biosolids have higher nitrogen (N) content than Class A biosolids and are not as extensively stabilized. For this reason, they are primarily used as an agricultural fertilizer, and application rates are typically computed to supply crop N requirements. Using data from Tables 1 through 3, the plant-available nitrogen (PAN) content of these biosolids is computed based on total Kjeldahl N (TKN) and ammonia N (NH_3-N) according to the IEPA Part 391 rule, as follows:

$$\text{PAN (lb N/ton)} = (f \times NH_3\text{-N} + 0.2 \times \text{Organic N}) \times 0.002 \quad [1]$$

where Organic N = (TKN – NH_3-N)

$$\text{Biosolids rate (ton/ac)} = \text{crop N req. (1b/ac)} \times 1/\text{PAN (1b/ton)} \quad [2]$$

The factor of 0.2 represents the fraction of organic N that is available during the first year following application. The factor *f* represents the fraction of NH_3-N that is plant available. The availability of NH_3-N from biosolids is dependent on soil texture and the method of application and is estimated as follows:

- 100 percent – subsurface injection of liquid biosolids in non-sandy soils
- 80 percent – surface application followed by incorporation through disc or chisel plow
- 50 percent – surface or subsurface injection in sandy soils
- 25 percent – surface application without incorporation in heavy clay soil

TABLE 1: CHEMICAL COMPOSITION OF CENTRIFUGE CAKE BIOSOLIDS GENERATED AT THE CALUMET WATER RECLAMATION PLANT IN 2008 AND APPLICABLE PART 503 EQ LIMITS

Constituent	Unit	Mean	Minimum	Maximum	503 Limit[1]
pH		7.8	7.1	8.3	
Total Solids	%	18.7	7.8	40.8	
Total Volatile Solids	"	41.2	15.9	49.6	
TKN	mg/kg	37,044	10,016	69,555	
NH_3-N	"	7,394	684	14,126	
NO_2+NO_3-N	"	296	24	5,484	
Total P	"	22,713	8,497	44,259	
Volatile Acids	"	336	135	571	
Ag	"	13	2	20	
Al	"	17,429	11,969	29,536	
As	"	10	<8.6	11	41
Ba	"	459	258	552	
Be	"	<0.1	<0.1	<0.1	
Ca	"	49,594	43,493	56,431	
Cd	"	4	3	7	39
Co	"	8	7	12	
Cr	"	96	74	141	NL
Cu	"	404	164	494	1,500
Fe	"	28,134	25,074	34,814	
Hg	"	1.1	0.43	2.2	17
K	"	4,620	2,895	10,212	
Mg	"	17,531	13,441	25,131	
Mn	"	960	588	1,109	NL
Mo	"	16	9	19	75
Na	"	1,336	300	2,209	
Ni	"	40	35	45	420
Pb	"	113	80	162	300
Sb	"	3	<1.4	5	
Se	"	<11	<11	<11	100
Tl	"	<2.3	<2.3	<2.3	
V	"	36	26	57	
Zn	"	1,040	516	1,232	2,800

[1]USEPA Part 503 exceptional quality limit.

TABLE 2: CHEMICAL COMPOSITION OF CENTRIFUGE CAKE BIOSOLIDS GENERATED AT THE JOHN E. EGAN WATER RECLAMATION PLANT IN 2008 AND APPLICABLE PART 503 EQ LIMITS

Constituent	Unit	Mean	Minimum	Maximum	503 Limit[1]
pH		8.0	7.7	8.6	
Total Solids	%	25.2	22.6	29.3	
Total Volatile Solids	%	61.3	53.6	68.6	
Total Kjeldahl-N	mg/kg	30,357	10,113	50,200	
NH_3-N	"	5,566	2,083	16,593	
NO_2+NO_3-N	"	19	6	101	
Total P	"	17,287	3,483	31,062	
Volatile Acids	"	3,622	1,341	8,896	
Ag	"	14	11	22	
Al	"	7,921	6,452	9,954	
As	"	<1	<1	3	41
B	"	<0.007	<0.007	<0.007	
Ba	"	397	360	429	
Be	"	<0.05	<0.05	<0.05	
Ca	"	32,392	30,036	36,316	
Cd	"	3	2	4	39
Co	"	0.5	<0.05	1.0	
Cr	"	146	128	160	NL
Cu	"	654	514	744	1,500
Fe	"	70,698	45,538	86,987	
Hg	"	1.0	0.61	1.3	17
K	"	2,136	1,597	2,862	
Mg	"	7,629	5,222	10,095	
Mn	"	555	444	978	NL
Mo	"	14	11	19	75
Na	"	1,113	374	1,478	
Ni	"	62	47	75	420
Pb	"	41	35	46	300
Sb	"	7	5	10	
Se	"	<0.8	<0.8	1.8	100
Tl	"	<7	<7	<7	
V	"	27	26	27	
Zn	"	814	694	976	2,800

[1]USEPA Part 503 exceptional quality limit.

TABLE 3: CHEMICAL COMPOSITION OF CENTRIFUGE CAKE BIOSOLIDS GENERATED AT THE STICKNEY WATER RECLAMATION PLANT IN 2008 AND APPLICABLE PART 503 EQ LIMITS

Constituent	Unit	Mean	Minimum	Maximum	503 Limit[1]
pH		7.8	7.6	8.2	
Total Solids	%	24.8	20.5	32.0	
Total Volatile Solids	%	47.2	37.2	60.3	
Total Kjeldahl-N	mg/kg	40,426	23,579	56,248	
NH_3-N	"	8,932	3,245	13,653	
NO_2+NO_3-N	"	113	16	243	
Total P	"	20,227	10,450	31,149	
Volatile Acids	"	2,212	680	7,322	
Ag	"	9	7	19	
Al	"	18,774	7,794	25,785	
As	"	5	<5	5	41
B	"	15	<3	38	
Ba	"	307	277	438	
Ca	"	37,757	32,295	41,604	
Cd	"	3	<0.4	5	39
Co	"	6	<6	8	
Cr	"	152	125	185	NL
Cu	"	390	329	585	1,500
Fe	"	19,365	14,836	67,343	
Hg	"	0.90	0.41	1.3	17
K	"	3,051	1,668	5,809	
Mg	"	16,769	6,651	20,216	
Mn	"	569	486	651	NL
Mo	"	14	10	18	75
Na	"	1,545	848	2,432	
Ni	"	41	33	69	420
Pb	"	127	46	163	300
Se	"	6	<4	17	100
V	"	24	17	35	
Zn	"	840	747	986	2,800

[1]USEPA Part 503 exceptional quality limit.

The total P content of biosolids is relatively high, but only a small fraction is readily plant available. Land application of biosolids based on N content usually results in excessive application of P, which can contaminate surface waters through runoff. Land application rates based on P content are being adopted in several U.S. states to reduce P runoff. The IEPA Part 391 rule recommends that after five years of biosolids application, soil test P shall be monitored and biosolids application terminated if this value exceeds 400 lb/ac in sandy soils and 800 lb/ac in non-sandy soils.

Class A Soil Amendment Products. Data for Class A lagoon-aged, air-dried biosolids from the Calumet and Stickney WRPs are presented in Tables 4 and 5, respectively.

The Egan WRP does not produce lagoon-aged, air-dried biosolids. All lagoon-aged, air-dried District biosolids that are land applied meet the Part 503 Exceptional Quality (EQ) criteria. These biosolids comply with the Class A pathogen and vector attraction reduction standards, and the concentrations of trace metals are much lower than the Part 503 EQ limits.

The air-dried biosolids are distinctly different from centrifuge cake in that they contain lower concentrations of volatile solids, TKN, and NH_3-N. These lower concentrations are mainly due to the loss of volatile solids and NH_3-N by volatilization during the lagoon-aging and air-drying processes. This renders the biosolids a less odorous product, which can be used at higher than fertilizer rates.

This product is best utilized as a fertilizer for top-dressing or preparing seedbeds for turf establishment on golf courses. It may also be used for the construction of athletic fields, for the establishment of prairie grasses and ornamental plants along highways, and in the establishment and rejuvenation of parks and gardens. As a nutrient source for turf, biosolids are typically applied as a ¼-inch layer (approximately 20 dry tons/ac) on the established turf. This application rate typically supplies approximately 200 lbs PAN/ac, 400 lbs/ac P_2O_5, (only about 50 percent of this total P_2O_5 is plant available), and 60 lbs/ac K_2O. All air-dried biosolids utilized as soil amendment or fertilizer are analyzed immediately before distribution for parameters listed in Tables 4 and 5, and the analytical data can be used to estimate PAN content according to the following equation:

$$\text{PAN (lb N/ton)} = (0.25 \times NH_3\text{-N} + NO_3\text{-N} + 0.1 \times \text{Organic N}) \times 0.002 \quad [3]$$

where Organic N = (TKN – NH_3-N).

The factor 0.25 represents the fraction of NH_3-N that is plant available from surface-applied biosolids, and 0.1 represents the approximate fraction of organic N that is available during the first year following application.

As a soil conditioner, the biosolids are typically blended with bulk soil or in-place soil by volume at a rate of 1 part biosolids to 3 parts soil. However, this rate may be adjusted depending on specific project needs.

TABLE 4: CHEMICAL COMPOSITION OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE CALUMET WATER RECLAMATION PLANT IN 2008 AND APPLICABLE PART 503 EQ LIMITS

Constituent	Unit	Mean	Minimum	Maximum	503 Limit[1]
pH		6.9	6.2	7.9	
Total Solids	%	70.6	47.3	86.4	
Total Volatile Solids	%	32.2	10.4	55.3	
Total Kjeldahl-N	mg/kg	17,808	7,576	28,608	
NH_3-N	"	858	19	4,153	
NO_2+NO_3-N	"	496	19	1,588	
Total P	"	19,903	4,596	29,724	
Volatile Acids	"	165	28.8	1,370	
Ag	"	12	2	17	
Al	"	19,287	4,962	26,138	
As	"	10	<8.6	11	41
Ba	"	435	188	555	
Be	"	<0.1	<0.1	0.13	
Ca	"	53,771	38,381	58,349	
Cd	"	5	<0.2	11	39
Co	"	9	2	11	
Cr	"	102	19	143	NL
Cu	"	366	167	494	1,500
Fe	"	29,782	7,212	42,234	
Hg	"	1.1	0.50	2.8	17
K	"	5,373	3,244	7,969	
Mg	"	20,184	10,718	25,531	
Mn	"	934	540	1,474	NL
Mo	"	13	4	19	75
Na	"	657	122	1,924	
Ni	"	39	12	43	420
Pb	"	109	15	135	300
Sb	"	2	<1.4	4	
Se	"	<11	<11	<11	100
Tl	"	<2.3	<2.3	<2.3	
V	"	49	6	83	
Zn	"	895	404	1,224	2,800

[1]USEPA Part 503 exceptional quality limit.

TABLE 5: CHEMICAL COMPOSITION OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY WATER RECLAMATION PLANT IN 2008 AND APPLICABLE PART 503 EQ LIMITS

Constituent	Unit	Mean	Minimum	Maximum	503 Limit[1]
pH		6.5	6.0	7.2	
Total Solids	%	71.7	56.2	90.4	
Total Volatile Solids	%	37.7	32.3	41.8	
Total Kjeldahl-N	mg/kg	21,624	10,027	28,971	
NH_3-N	"	2,318	333	4,088	
NO_2+NO_3-N	"	295	12	1,227	
Total P	"	19,047	7,476	27,134	
Volatile Acids	"	326	130	634	
Ag	"	14	12	16	
Al	"	19,577	16,532	22,278	
As	"	<5	<5	<5	41
B	"	29	10	41	
Ba	"	311	267	377	
Ca	"	40,665	38,210	50,247	
Cd	"	4	3	4	39
Co	"	7.5	6	10	
Cr	"	177	152	223	NL
Cu	"	425	369	459	1,500
Fe	"	17,914	15,514	19,623	
Hg	"	1.1	0.86	1.5	17
K	"	2,734	1,856	3,412	
Mg	"	18,169	16,793	25,544	
Mn	"	548	477	592	NL
Mo	"	15	14	18	75
Na	"	695	265	1,263	
Ni	"	49	40	53	420
Pb	"	140	120	168	300
Se	"	14	11	16	100
V	"	25	22	28	
Zn	"	907	797	1,007	2,800

[1]USEPA Part 503 exceptional quality limit.

Biosolids Toxicity Characteristic Leaching Procedure Analysis

The Toxicity Characteristic Leaching Procedure (TCLP) analysis of biosolids is required to satisfy the requirements of the USEPA's Part 261 regulations where biosolids are used as landfill daily cover. The analysis includes total and TCLP-extractable concentrations of biosolids constituents. The most recent TCLP data for lagoon-aged, air-dried biosolids generated at the Calumet WRP (2007) and the Stickney WRP (2005) are presented in Tables 6 and 7, respectively. The data show that, in the TCLP extracts, most of the organic compounds are undetectable and the concentrations of the metals are much lower than the Part 261 regulatory limits. The District biosolids have always fulfilled the requirements of the TCLP test and are thereby classified by the USEPA and IEPA as non-hazardous and suitable for use as daily landfill cover.

Tiered Approach to Corrective Action Objectives

The Tiered Approach to Corrective Action Objectives (TACO) Standards were promulgated in 1997 as a voluntary program under Title 35, Illinois Administrative Code Part 742 to establish standards for the cleanup of contaminated sites in Illinois. This program was designed primarily to address the "how clean is clean" problem experienced in the implementation of other brownfield cleanup programs, such as the Site Remediation Program and the Leaking Underground Storage Tanks Program. For brownfields that meet the TACO cleanup objectives in the respective programs, the state issues a "No Further Remediation" letter. Objectives were developed for intended future land uses, specifically residential or commercial/industrial. The most stringent objectives were developed for sites anticipated for residential redevelopment. The default objectives are risk-based and include the following human exposure routes: soil ingestion, dust inhalation, and leachability to potable groundwater. Because the TACO standards are based on a cancer risk level of one in one million with many worst-case assumptions built into the risk pathways, the default for Tier I residential property is extremely conservative.

The objectives of the TACO program are not directly applicable to land application of biosolids. However, in 2000, the District began to evaluate its biosolids by considering instances in which the TACO standards may be applicable to biosolids use in the remediation of brownfields. The TACO analysis for two biosolids samples from the Calumet and Stickney WRPs, and the corresponding TACO Tier 1 residential objectives are presented in Table 8. Extract concentrations (Table 8) are used to evaluate the objectives for soil exposure through ingestion and dust inhalation for organic compounds and inorganic parameters, and the groundwater route for organic compounds. The data indicate that biosolids fulfill the requirements of most Tier 1 residential objectives.

The data presented for biosolids samples from the Calumet and Stickney WRPs (Table 8) depict all concentrations of organic and inorganic compounds measured by the TACO analysis. Most of the organic compounds are undetectable, and the concentrations of most of the detectable compounds are lower than the TACO Tier 1 residential limits. The concentrations of all inorganic parameters are also much lower than the TACO limits.

TABLE 6: TOXICITY CHARACTERISTIC LEACHING PROCEDURE ANALYSIS[1] OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE CALUMET WATER RECLAMATION PLANT IN 2007 AND APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Value	Part 261 Limit
Flash Point, Open Cup	>205º F	<140ºF
Paint Filter Test	NFL	
pH, 10 Percent Solution	6.4	2.1-12.4
Total Solids	71%	NL
	---------- Total Concentration (mg/dry kg) ----------	
Inorganics		
Extractable Organic Halogens	31.2	NL
Cyanide - Reactive	<10	NL
Sulfide - Reactive	<10	NL
Ag	2.1	NL
As	<5.0	NL
Ba	236	NL
Cd	6.1	NL
Cr	100	NL
Hg	0.56	NL
Pb	80.4	NL
Se	<5.0	NL
	---------- TCLP[2] Extract (mg/L) ----------	
Ag	<0.20	5
As	<0.50	5
Ba	<1.00	100
Cd	<0.10	1
Cr	<0.25	5
Hg	<0.002	0.2
Pb	<0.20	5
Se	<0.50	1

TABLE 6 (Continued): TOXICITY CHARACTERISTIC LEACHING PROCEDURE ANALYSIS OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE CALUMET WATER RECLAMATION PLANT IN 2007 AND APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Value	Part 261 Limit
	---------- TCLP Extract (mg/L) ----------	
Organics		
Phenols	0.51	NL
Total PCB	<1.0	NL
Chlordane	<0.02	0.03
Endrin	<0.01	0.02
Heptachlor	<0.004	0.008
Heptachlor Epoxide	<0.004	0.008
Lindane	<0.01	0.4
Methoxychlor	<1.0	10
Toxaphene	<0.01	0.5
2,4-D	<10.0	10
2,4,5-TP	<1.0	1
Benzene	<0.10	0.5
Carbon Tetrachloride	<0.10	0.5
Chlorobenzene	<0.10	100
Chloroform	<0.10	6
2-Butanone (methyl ethyl ketone)	<2.00	200
Tetrachloroethylene	<0.10	0.7
Trichloroethylene	<0.10	0.5
Vinyl Chloride	<0.10	0.2
1,4-Dichlorobenzene	<0.10	7.5
1,2-Dichloroethane	<0.10	0.5
1,1-Dichloroethylene	<0.10	0.7
o-Cresol	<1.0	200
m,p-Cresols	<1.0	200
Hexachlorobenzene	<0.10	0.13
Hexachlorobutadiene	<0.10	0.5
Hexachloroethane	<0.10	3

TABLE 6 (Continued): TOXICITY CHARACTERISTIC LEACHING PROCEDURE ANALYSIS OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE CALUMET WATER RECLAMATION PLANT IN 2007 AND APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Value	Part 261 Limit
	---------- TCLP Extract (mg/L) ----------	
Organics (Continued)		
Nitrobenzene	<0.1000	2
Pentachlorophenol	<5.0	100
Pyridine	<0.10	5
2,4-Dinitrotoluene	<0.10	0.13
2,4,5-Trichlorophenol	<1.0	400
2,4,6-Trichlorophenol	<1.0	2

[1]All analyses were performed using EPA Method SW-846 and Standard Methods (most recent data available).
[2]Toxicity Characteristic Leaching Procedure.
NFL = No free liquid.
NL = No limit.

TABLE 7: TOXICITY CHARACTERISTIC LEACHING PROCEDURE ANALYSIS[1] OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY WATER RECLAMATION PLANT IN 2005 AND APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Value	Regulatory Limit
Flash Point, Open Cup	>200ºF	<140ºF
Paint Filter Test	NFL	
pH, 10 Percent Solution	6.6	2.1-12.4
Total Solids	53%	NL
	---------- Total Concentration (mg/dry kg) ----------	
Inorganics		
Extractable Organic Halogens	<33.0 mg/kg	NL
Cyanide - Reactive	3.6 mg/kg	NL
Sulfide - Reactive	<8.1 mg/kg	NL
Ag	18	NL
As	6.4	NL
Ba	210	NL
Cd	4.9	NL
Cr	190	NL
Hg	0.63	NL
Pb	100	NL
Se	2.7	NL
	---------- TCLP[2] Extract (mg/L) ----------	
Ag	<0.005	5
As	<0.100	5
Ba	<1.000	100
Cd	<0.050	1
Cr	<0.010	5
Hg	<0.002	0.2
Pb	<0.005	5
Se	<0.100	1

TABLE 7 (Continued): TOXICITY CHARACTERISTIC LEACHING PROCEDURE ANALYSIS OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY WATER RECLAMATION PLANT IN 2005 AND APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Value	Regulatory Limit
	---------- TCLP Extract (mg/L) ----------	
Organics		
Phenols	1.30	NL
Total PCB	<0.567	NL
Chlordane	<0.0010	0.03
Endrin	<0.0005	0.02
Heptachlor	<0.0005	0.008
Heptachlor Epoxide	<0.0005	0.008
Lindane	<0.0005	0.4
Methoxychlor	<0.0025	10
Toxaphene	<0.0050	0.5
2,4-D	<0.1000	10
2,4,5-TP	<0.0100	1
Benzene	<0.0250	0.5
Carbon Tetrachloride	<0.0250	0.5
Chlorobenzene	<0.0250	100
Chloroform	<0.1000	6
2-Butanone (methyl ethyl ketone)	<0.0250	200
Tetrachloroethylene	<0.0250	0.7
Trichloroethylene	<0.0250	0.5
Vinyl Chloride	<0.0250	0.2
1,4-Dichlorobenzene	<0.1000	7.5
1,2-Dichloroethane	<0.0250	0.5
1,1-Dichloroethylene	<0.0250	0.7
o-Cresol	<0.1000	200
m,p-Cresols	<0.1000	200
Hexachlorobenzene	<0.1000	0.13

TABLE 7 (Continued): TOXICITY CHARACTERISTIC LEACHING PROCEDURE ANALYSIS OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY WATER RECLAMATION PLANT IN 2005 AND APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Value	Regulatory Limit
	---------- TCLP Extract (mg/L) ----------	
Organics (Continued)		
Hexachlorobutadiene	<0.1000	0.5
Hexachloroethane	<0.1000	3
Nitrobenzene	<0.1000	2
Pentachlorophenol	<0.5000	100
Pyridine	<0.2000	5
2,4-Dinitrotoluene	<0.1000	0.13
2,4,5-Trichlorophenol	<0.5000	400
2,4,6-Trichlorophenol	<0.1000	2

[1]All analyses were performed using EPA Method SW-846 and Standard Methods.
[2]TCLP = Toxicity Characteristic Leaching Procedure.
NFL = No free liquid.
NL = No limit specified.

TABLE 8: CONCENTRATIONS OF ORGANIC COMPOUNDS AND INORGANIC SPECIES IN TWO SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY AND CALUMET WATER RECLAMATION PLANTS IN 2008, AND THEIR CORRESPONDING TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES, TIER I RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Compound/Element	Stickney WRP Sample	Calumet WRP Sample	TACO Tier I Residential Objectives			
			Soil Exposure Route		Groundwater Exposure Route	
			Inhalation	Ingestion	Class I	Class II
	---------- Total Concentration (mg/kg) ----------					
Herbicides						
2,4-D	<0.74	<0.71	780	NA	1.5	7.7
2,4,5-TP (Silvex)	<0.074	<0.072	630	NA	11	55
Alachlor	<0.95	<0.018	8.0	NA	0.04	0.20
Atrazine	<9.4	<0.18	2,700	NA	0.066	0.33
Dalapon	<0.74	<0.71	2,300	NA	0.85	8.5
Dinoseb	<0.074	<0.072	78	NA	0.34	3.4
Picloram	<0.074	<0.072	5,500	NA	2.0	20
Simazine	<3.8	<0.072	390	NA	0.04	0.37
Pesticides						
4,4'-DDD	<0.94	<0.018	3.0	NA	16	80
4,4'-DDE	<0.095	0.014	2.0	NA	54	270
4,4'-DDT	<0.074	<0.072	2.0	NA	32	160
alpha-BHC	<0.095	<0.0018	0.10	0.80	0.0005	0.003
gamma-BHC (Lindane)	<0.095	<0.0018	0.50	NA	0.009	0.047
Aldicarb	<0.095	<0.0018	78	NA	0.013	0.07
Aldrin	<0.095	<0.0018	0.04	3.0	0.50	2.5
Carbofuran	<17	<18	390	NA	0.22	1.1

TABLE 8 (Continued): CONCENTRATIONS OF ORGANIC COMPOUNDS AND INORGANIC SPECIES IN TWO SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY AND CALUMET WATER RECLAMATION PLANTS IN 2008, AND THEIR CORRESPONDING TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES, TIER I RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Compound/Element	Stickney WRP Sample	Calumet WRP Sample	TACO Tier I Residential Objectives			
			Soil Exposure Route		Groundwater Exposure Route	
			Inhalation	Ingestion	Class I	Class II
	---------- Total Concentration (mg/kg) ----------					
alpha-Chlordane	<0.095	<0.0018	0.50	20	10	48
gamma-Chlordane	<0.095	0.0033	0.50	20	10	48
Dieldrin	<0.095	<0.0018	0.04	1.0	0.004	0.02
Endosulfan I	<0.095	<0.0018	470	NA	18	90
Endosulfan II	<0.095	<0.0018	470	NA	18	90
Endrin	<0.095	0.0044	23	NA	1.0	5.0
Heptachlor	<0.095	<0.0018	0.10	0.10	23	110
Heptachlor epoxide	0.53	<0.009	0.07	5.0	0.70	3.3
Methoxychlor	<0.095	<0.0018	390	NA	160	780
Pentachlorophenol	<35	<37	3.0	NA	0.03	0.14
Toxaphene	<0.095	0.0058	0.60	89	31	150
Volatile Organics						
1,1,1,2-Tetrachloroethane	<0.0056	<0.0055	NA	NA	NA	NA
1,1,1-Trichloroethane	<0.0056	<0.0055	NA	1,200	2.0	9.6
1,1,2-Trichloroethane	<0.0056	<0.0055	310	1,800	0.02	0.30
1,1-Dichloroethane	<0.0056	<0.0055	7,800	1,300	23	110
1,1-Dichloroethene	<0.0056	<0.0055	700	1,500	0.06	0.30
1,1-Dichloropropene	<0.0056	<0.0055	NA	NA	NA	NA

TABLE 8 (Continued): CONCENTRATIONS OF ORGANIC COMPOUNDS AND INORGANIC SPECIES IN TWO SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY AND CALUMET WATER RECLAMATION PLANTS IN 2008, AND THEIR CORRESPONDING TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES, TIER I RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Compound/Element	Stickney WRP Sample	Calumet WRP Sample	TACO Tier I Residential Objectives			
			Soil Exposure Route		Groundwater Exposure Route	
			Inhalation	Ingestion	Class I	Class II
	Total Concentration (mg/kg)					
1,2-Dibromo-3-Chloropropane	<0.0056	<0.0055	0.46	11	0.002	0.002
1,2-Dibromoethane (EDB)	<0.0056	<0.0055	0.0075	0.17	0.0004	0.004
1,2-Dichloroethane	<0.0056	<0.0055	7.0	0.40	0.02	0.10
1,2-Dichloropropane	<0.0056	<0.0055	9.0	15	0.03	0.15
Acetone	<0.0056	0.0150	7,800	100,000	16	16
Benzene	<0.0056	<0.0055	22	0.80	0.03	0.17
Bromodichloromethane	<0.0056	<0.0055	10	3,000	0.60	0.60
Bromoform	<0.0056	<0.0055	81	53	0.80	0.80
Bromomethane	<0.0056	<0.0055	110	10	0.20	1.2
Carbon disulfide	<0.0056	<0.0055	7,800	720	32	160
Carbon tetrachloride	<0.0056	<0.0055	5.0	0.30	0.07	0.33
Chlorobenzene	<0.0056	<0.0055	1,600	130	1.0	6.5
Chloroform	<0.0056	<0.0055	100	0.30	0.60	2.9
cis-1,2-Dichloroethene	<0.0056	<0.0055	780	1,200	0.40	1.1
cis-1,3-Dichloropropene	<0.0056	<0.0055	4.0	0.10	0.004	0.02
Dibromochloromethane	<0.0056	<0.0055	1,600	1,300	0.40	0.40
Ethylbenzene	<0.0056	<0.0055	7,800	400	13	19
m,p-Xylenes	<0.0110	<0.0110	160,000	440	205	205
Methylene Chloride	<0.0056	<0.0055	85	13	0.02	0.20

TABLE 8 (Continued): CONCENTRATIONS OF ORGANIC COMPOUNDS AND INORGANIC SPECIES IN TWO SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY AND CALUMET WATER RECLAMATION PLANTS IN 2008, AND THEIR CORRESPONDING TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES, TIER I RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Compound/Element	Stickney WRP Sample	Calumet WRP Sample	TACO Tier I Residential Objectives			
			Soil Exposure Route		Groundwater Exposure Route	
			Inhalation	Ingestion	Class I	Class II
	---------- Total Concentration (mg/kg) ----------					
n-Butyl alcohol	<0.4500	<0.4400	7,800	10,000	17	17
o-Xylene	<0.0056	<0.0055	160,000	410	190	190
Phenol	<8.8	<9.2	47,000	NA	100	100
Styrene	<0.0056	<0.0055	16,000	1,500	4.0	18
Tetrachloroethene	<0.0056	<0.0055	12	11	0.06	0.30
Toluene	<0.0056	<0.0055	16,000	650	12	29
trans-1,2-Dichloroethene	<0.0056	<0.0055	1,600	3,100	0.70	3.4
trans-1,3-Dichloropropene	<0.0056	<0.0055	4.0	0.10	0.004	0.02
Trichloroethene	<0.0056	<0.0055	58	5.0	0.06	0.30
Vinyl acetate	<0.0056	<0.0055	78,000	1,000	170	170
Vinyl chloride	<0.0056	<0.0055	0.30	0.03	0.01	0.07
Xylenes, total	<0.0094	ND	160,000	410	150	150
Semi-Volatile Organics						
1,2,4-Trichlorobenzene	<8.8	<9.2	780	3,200	5.0	53
1,2-Dichlorobenzene	<8.8	<9.2	7,000	560	17	43
1,4-Dichlorobenzene	<8.8	<9.2	NA	NA	2.0	11
2,4,5-Trichlorophenol	<17	<18	7,800	NA	270	1,400
2,4,6-Trichlorophenol	<17	<18	58	200	0.20	0.77

TABLE 8 (Continued): CONCENTRATIONS OF ORGANIC COMPOUNDS AND INORGANIC SPECIES IN TWO SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY AND CALUMET WATER RECLAMATION PLANTS IN 2008, AND THEIR CORRESPONDING TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES, TIER I RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Compound/Element	Stickney WRP Sample	Calumet WRP Sample	TACO Tier I Residential Objectives			
			Soil Exposure Route		Groundwater Exposure Route	
			Inhalation	Ingestion	Class I	Class II
	Total Concentration (mg/kg)					
2,4-Dichlorophenol	<17	<18	230	NA	1.0	1
2,4-Dimethylphenol	<17	<18	1,600	NA	9.0	9
2,4-Dinitrophenol	<35	<37	160	NA	0.20	0.2
2,4-Dinitrotoluene	<8.8	<9.2	0.90	NA	0.0008	0.0008
2,6-Dinitrotoluene	<8.8	<9.2	0.90	NA	0.0007	0.0007
2-Chlorophenol	<8.8	<9.2	390	53,000	4.0	4
2-Methylphenol (o-cresol)	<8.8	<9.2	3,900	NA	15	15
3,3-Dichlorobenzidine	<8.8	<9.2	1.0	NA	0.007	0.033
3,4- Methylphenol (m/p-cresol)	<8.8	<9.2	3,900	NA	15	15
4-Chloroaniline	<35	<37	310	NA	0.70	0.7
4-Chlorophenyl phenyl ether	<8.8	<9.2	NA	NA	NA	NA
Acenaphthene	<1.7	<1.8	4,700	NA	570	2,900
Anthracene	<1.7	1.9	23,000	NA	12,000	59,000
Benzo[a]anthracene	2.6	5.5	0.90	NA	2.0	8.0
Benzo[a]pyrene	3.0	6.1	0.09	NA	8.0	82
Benzo[b]fluoranthene	4.8	11	0.90	NA	5.0	25
Benzo[k]fluoranthene	2.9	4.0	9.0	NA	49	250
Benzoic acid	<88	<92	310,000	NA	400	400
bis(2-chloroethyl)ether	<8.8	<9.2	0.60	0.20	0.0004	0.0004

TABLE 8 (Continued): CONCENTRATIONS OF ORGANIC COMPOUNDS AND INORGANIC SPECIES IN TWO SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY AND CALUMET WATER RECLAMATION PLANTS IN 2008, AND THEIR CORRESPONDING TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES, TIER I RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Compound/Element	Stickney WRP Sample	Calumet WRP Sample	TACO Tier I Residential Objectives			
			Soil Exposure Route		Groundwater Exposure Route	
			Inhalation	Ingestion	Class I	Class II
	Total Concentration (mg/kg)					
bis(2-ethylhexyl) phthalate	37	73	46	31,000	3,600	31,000
Butyl benzyl phthalate	<8.8	<9.2	16,000	930	930	930
Carbazole	<8.8	<9.2	32	NA	0.60	2.8
Chrysene	3.7	8.4	88	NA	160	800
Dibenz(a,h)anthracene	<1.7	<1.8	0.09	NA	2.0	7.6
Diethyl phthalate	<8.8	<9.2	63,000	2,000	470	470
Di-n-butylphthalate	<8.8	<9.2	7,800	2,300	2,300	2,300
Di-n-octyl phthalate	<8.8	<9.2	1,600	10,000	10,000	10,000
Fluoranthene	4.4	15	3,100	NA	4,300	21,000
Fluorene	<1.7	<1.8	3,100	NA	560	2,800
Hexachlorobenzene	<3.5	<3.7	0.40	1.0	2.0	11
Hexachlorocyclopentadiene	<35	<37	550	10	400	2,200
Hexachloroethane	<8.8	<9.2	78	NA	0.50	2.6
Indeno[1,2,3-cd]pyrene	2.5	4.5	0.90	NA	14	69
Isophorone	<8.8	<9.2	15,600	4,600	8	8
Naphthalene	<1.7	<1.8	3,100	NA	84	420
Nitrobenzene	<1.7	<1.8	39	92	0.1	0.1
n-Nitrosodi-n-propylamine	<8.8	<9.2	0.09	NA	0.00005	0.00005
n-Nitrosodiphenylamine	<8.8	<9.2	130	NA	1.0	5.6

TABLE 8 (Continued): CONCENTRATIONS OF ORGANIC COMPOUNDS AND INORGANIC SPECIES IN TWO SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY AND CALUMET WATER RECLAMATION PLANTS IN 2008, AND THEIR CORRESPONDING TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES, TIER I RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Compound/Element	Stickney WRP Sample	Calumet WRP Sample	TACO Tier I Residential Objectives			
			Soil Exposure Route		Groundwater Exposure Route	
			Inhalation	Ingestion	Class I	Class II
	---------- Total Concentration (mg/kg) ----------					
Pyrene	3.7	13	2,300	NA	4,200	21,000
PCBs						
PCB -1016	<1.900	<0.0180	NA	NA	NA	NA
PBC-1221	<1.900	<0.0180	NA	NA	NA	NA
PCB-1232	<1.900	<0.0180	NA	NA	NA	NA
PCB-1242	<1.900	<0.0180	NA	NA	NA	NA
PCB-1248	<1.900	<0.0180	NA	NA	NA	NA
PCB-1254	<1.900	<0.0180	NA	NA	NA	NA
PCB-1260	<1.900	0.1400	1.0	1.0	1.0	1.0
PCBs, Total	<1.900	0.1400	1.0	1.0	1.0	1.0
Inorganics						
Cyanide, Total	4.2	4.0	1,600	NA	0.20	0.60
Ag	14	12	390	NA	0.05	NA
Al	19,577	19,287	NA	NA	NA	NA
As	<5	10	0.40	750	0.05	0.20

TABLE 8 (Continued): CONCENTRATIONS OF ORGANIC COMPOUNDS AND INORGANIC SPECIES IN TWO SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY AND CALUMET WATER RECLAMATION PLANTS IN 2008, AND THEIR CORRESPONDING TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES, TIER I RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Compound/Element	Stickney WRP Sample	Calumet WRP Sample	TACO Tier I Residential Objectives			
			Soil Exposure Route		Groundwater Exposure Route	
			Inhalation	Ingestion	Class I	Class II
	SPLP-extract concentration (mg/L)					
B	29	ND	7,000	NA	2.0	2.0
Ba	311	435	5,500	690,000	2.0	2.0
Be	ND	<0.1	0.10	1,300	0.00	0.50
Ca	40,665	53,771	NA	NA	NA	NA
Cd	4	5	78	1,800	0.005	0.05
Co	7.5	9	4,700	NA	1.0	1.0
Cr	177	102	390	270	0.10	1.0
Cu	425	366	2,900	NA	0.65	0.65
Fe	17,914	29,782	NA	NA	5.0	5.0
Hg	1.1	1.1	23	10	0.002	0.01
K	2,734	5,373	NA	NA	NA	NA
Mg	18,169	20,184	NA	NA	NA	NA
Mn	548	934	3,700	69,000	0.15	10
Mo	15	13	NA	NA	NA	NA
Na	695	657	NA	NA	NA	NA
Ni	49	39	1,600	13,000	0.10	2.0
Pb	140	109	400	NA	0.0075	0.10
Sb	ND	2	31	NA	0.006	0.024
Se	14	<11	390	NA	0.05	0.05

TABLE 8 (Continued): CONCENTRATIONS OF ORGANIC COMPOUNDS AND INORGANIC SPECIES IN TWO SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE STICKNEY AND CALUMET WATER RECLAMATION PLANTS IN 2008, AND THEIR CORRESPONDING TIERED APPROACH TO CORRECTIVE ACTION OBJECTIVES, TIER I RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Compound/Element	Stickney WRP Sample	Calumet WRP Sample	TACO Tier I Residential Objectives			
			Soil Exposure Route		Groundwater Exposure Route	
			Inhalation	Ingestion	Class I	Class II
	---------- SPLP-extract concentration (mg/L) ----------					
Tl	ND	<2.3	6.3	NA	0.002	0.02
V	25	49	550	NA	0.049	NA
Zn	907	895	23,000	NA	5.0	10

NA = Not available.

ND = Not determined.

Values preceded by "<" are method detection limits and are dependent on sample solids content.

Topsoil Properties of Biosolids

A portion of the lagoon-aged, air-dried biosolids from the Stickney and Calumet WRPs is used as a soil amendment or conditioner to improve the topsoil characteristics of poor-quality or degraded soils. Information in this section may be helpful in planning the use of biosolids as a soil conditioner. The District has conducted studies of biosolids physical properties. Included in these studies were particle size analysis, particle density, bulk density, porosity, moisture/suction relationship, water repellency (hydrophobicity), and saturated hydraulic conductivity (permeability). The results of these studies show that biosolids have physical properties similar to silt loam soils. Results are available in Monitoring and Research Department reports (Nos. 03-8 and 03-10).

Biosolids used as a soil conditioner or amendment also have a significant inherent fertilizer value, which can be determined from the information presented in this section. In 2000, the District conducted a study to determine the chemical characteristics of its lagoon-aged, air-dried biosolids that are important in assessing their suitability as topsoil for establishing vegetation. The results from this study (Table 9) show that biosolids contain organic carbon and are a good source of macro- and micro-nutrients. Additional N is released by organic matter degradation over time. As a soil conditioner, the high organic matter content of biosolids improves soil physical properties, such as moisture retention in sandy soils and permeability in heavy clays.

The electrical conductivity (a measure of soluble salt content) tends to be higher than the suitability range for several sensitive plant species. Biosolids users should be aware of this and should consult with soil science professionals in the Biosolids Utilization and Soil Science Section when planning the use of biosolids as a soil conditioner. These inquiries may be initiated by contacting the head of the Biosolids Utilization and Soil Science Section at 708-588-4063.

TABLE 9: TOPSOIL CHEMICAL PROPERTIES OF SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE CALUMET AND STICKNEY WATER RECLAMATION PLANTS IN 2000

Analysis	Unit	Minimum	Maximum	Mean
Cation Exchange Capacity	cmol/kg	56.1	84.4	73.4
EC[1]	dS/m	2.31	8.29	4.54
pH[1]		5.94	7.18	6.58
Organic Carbon	%	8.4	14.6	11.9
Bray P1 Extractable P[2]	mg/kg	252	523	407
Total Kjeldahl-N	mg/kg	13,655	28,228	20,554
1 M KCl-Extractable				
NH_3-N	mg/kg	28	3,547	1,776
NO_3-N	"	134	458	144
1 M NH_4OAc Exchangeable Bases				
Ca	mg/kg	3,691	8,417	5,649
K	"	366	980	787
Mg	"	862	1,969	1,528
Na	"	81	573	320
DTPA-Extractable				
Cd	mg/kg	3.2	8.6	4.8
Cr	"	0.0	0.6	0.1
Cu	"	6.7	126	50.5
Fe	"	4.9	275	114
Mn	"	27	131	65
Ni	"	5.1	23.0	14.0
Pb	"	11	36	17
Zn	"	150	1,049	485
Hot Water Extractable B	mg/kg	4.56	7.14	5.83
0.1 M HCl-Extractable				
Cd	mg/kg	0.08	0.41	0.24
Cr	"	0.27	1.73	0.80
Cu	"	1.3	5.1	2.4
Fe	"	35.6	120	67.5
Mn	"	8.4	13.9	11.0
Ni	"	0.40	1.08	0.66
Pb	"	0.06	0.84	0.32
Zn	"	20	42	31

TABLE 9 (Continued): TOPSOIL CHEMICAL PROPERTIES OF SAMPLES OF LAGOON-AGED, AIR-DRIED BIOSOLIDS GENERATED AT THE CALUMET AND STICKNEY WATER RECLAMATION PLANTS IN 2000

Analysis	Unit	Minimum	Maximum	Mean
Saturation Paste Extractable				
Saturation moisture	%	118	217	159
Alkalinity (as $CaCO_3$)	mg/L	300	2,745	1,527
B	"	0.31	0.51	0.38
Cl	"	15	2,865	895
PO_4-P	"	1.6	6.3	3.7

[1] Electrical conductivity (EC) and pH in 1:2 ratio of air-dried biosolids:water.
[2] Standard soil test method used in Illinois to determine plant-available P content of soils.