

Protecting Our Water Environment



Metropolitan Water Reclamation District of Greater Chicago

***RESEARCH AND DEVELOPMENT
DEPARTMENT***

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BIOSOLIDS CHEMICAL CHARACTERISTICS

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BIOSOLIDS CHEMICAL CHARACTERISTICS

By

Pauline Lindo
Soil Scientist I

Albert E. Cox
Soil Scientist III (Acting)

Thomas C. Granato
Soil Scientist IV (Acting)

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DISCLAIMER

Mention of propriety equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

INTRODUCTION

The Metropolitan Water Reclamation District of Greater Chicago (District) generates about 190,000 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, Hanover Park, and Stickney. The biosolids are produced through two main sludge processing trains (SPTs), the high solids sludge processing train (HSSPT) and low solids sludge processing train (LSSPT). In the HSSPT, anaerobically digested sludge is centrifuged to 20 - 30 percent solids content. At this stage, it meets 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 (Calumet and Stickney WRPs). In the LSSPT, the anaerobically-digested sludge is gravity thickened by lagoon-aging and then air-dried. The air-dried biosolids from both processing trains meet 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 located on the plant grounds.

- Farmland Application - Class B centrifuge cake biosolids from the Calumet, Stickney, and John E. 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, landscaping, golf courses etc.
- 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 some parameters that are not required for Part 503 or IEPA monitoring compliance. These data 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.

A summary of the nutrient and trace metal data for centrifuge cake biosolids generated at the Calumet, John E. Egan, and Stickney WRPs in 2003 are presented in Tables 1, 2, and 3, respectively. These biosolids are used to fertilize crops. They are Class B with respect to the Part 503 pathogen standards and can meet the vector attraction reduction requirements through incorporation into soil.

Data for the Class A lagoon-aged, air-dried biosolids from the Calumet and Stickney WRPs are presented in Tables 4 and 5, respectively. The John E. Egan WRP does not produce lagoon-aged, air-dried biosolids. All lagoon-aged, air-dried District biosolids that are land applied as a soil conditioner or topsoil substitute meet the Part 503 Exceptional Quality (EQ) criteria. The most distinct chemical differences between the centrifuge cake and the air-dried biosolids are the lower concentrations of volatile solids, total Kjeldhal nitrogen (TKN), and ammonia-nitrogen (NH₃-N) in the air-dried biosolids. These lower concentrations are mainly due to the loss of volatile solids and NH₃-N by volatilization during the lagoon-

aging and air-drying processes.

Biosolids Toxicity Characteristic Leaching Procedure (TCLP) Analyses

The TCLP analyses of biosolids are required to meet the requirements of the USEPA's Part 261 rule where biosolids are used as landfill daily cover. The suite of analyses needed to meet those requirements includes total-extractable as well as TCLP-extractable concentrations. The TCLP data generated for lagoon-aged, air-dried biosolids from the Calumet and Stickney WRPs, and for centrifuge cake biosolids from the John E. Egan WRP are presented in Tables 6, 7, and 8, 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. All District biosolids passed the TCLP test and are thereby classified by the USEPA and IEPA as non-hazardous and are suitable for use as daily landfill cover.

Tiered Approach to Corrective Action Objectives (TACO)

The 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. The 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 devel-

TABLE 1. CHEMICAL COMPOSITION OF CENTRIFUGE CAKE BIOSOLIDS
COLLECTED FROM THE CALUMET WRP IN 2003 AND APPLICABLE
PART 503 EQ LIMITS

Parameter	Units	Mean	Min.	Max.	503 Limit
pH		8.1	7.7	8.5	
Total Solids	%	26.4	18.8	33.7	
Total Volatile Solids	%	51.7	39.3	66.3	
Volatile Acids	mg/dry kg	558	96	1,570	
Total Kjeldahl-N	"	43,767	28,372	77,673	
NH ₃ -N	"	4,805	2,581	8,435	
Total P	"	23,465	16,833	36,339	
Ag	"	14	9	19	
Al	"	14,411	9,496	20,261	
As	"	7	3	10	41
Ba	"	465	326	600	
Be	"	<0.06	<0.06	<0.06	
Ca	"	43,232	25,956	55,457	
Cd	"	4	3	6	39
Cr	"	107	57	134	
Cu	"	400	249	478	1,500
Fe	"	28,909	14,157	39,496	
Hg	"	0.63	0.26	1.6	17
K	"	3,071	1,584	5,362	
Mg	"	13,802	6,995	20,803	
Mn	"	721	493	1,271	
Mo	"	17	9	21	75
Na	"	1,086	668	3,572	
Ni	"	37	23	48	420
Pb	"	123	58	161	300
Sb	"	3	1	4	
Se	"	6	2	9	100
Tl	"	<6	<6	<6	
Zn	"	1,057	544	1,220	2,800

TABLE 2. CHEMICAL COMPOSITION OF CENTRIFUGE CAKE BIOSOLIDS COLLECTED FROM THE JOHN E. EGAN WRP IN 2003 AND APPLICABLE PART 503 EQ LIMITS

Parameter	Units	Mean	Min.	Max.	503 Limit
pH		8.4	7.8	8.7	
Total Solids	%	24.8	21.8	29.9	
Total Volatile Solids	%	65.3	59.9	76.3	
Volatile Acids	mg/dry kg	ND ¹	ND	ND	
Total Kjeldahl-N	"	52,223	32,905	126,562	
NH ₃ -N	"	5,857	3,964	17,202	
Total P	"	24,211	12,685	60,440	
Ag	"	ND	ND	ND	
Al	"	9,572	7,705	10,968	
As	"	0.7	<1.0	4.1	41
Ba	"	ND	ND	ND	
Be	"	ND	ND	ND	
Ca	"	34,103	29,877	37,985	
Cd	"	5	4	7	39
Cr	"	139	102	192	
Cu	"	816	727	896	1,500
Fe	"	ND	ND	ND	
Hg	"	0.80	0.37	1.3	17
K	"	2,046	1,542	2,538	
Mg	"	7,006	5,021	9,037	
Mn	"	606	442	805	
Mo	"	24	19	30	75
Na	"	1,122	692	2,928	
Ni	"	61	49	84	420
Pb	"	59	49	70	300
Sb	"	ND	ND	ND	
Se	"	<1	<1	3	100
Tl	"	ND	ND	ND	
Zn	"	941	834	1,042	2,800

¹ ND=No data.

TABLE 3. CHEMICAL COMPOSITION OF CENTRIFUGE CAKE BIOSOLIDS
COLLECTED FROM THE STICKNEY WRP IN 2003 AND APPLICABLE
PART 503 EQ LIMITS

Parameter	Unit	Mean	Min.	Max.	503 Limit
pH		7.6	6.9	8.2	
Total Solids	%	24.2	16.2	31.8	
Total Volatile Solids	%	52.0	40.3	69.5	
Volatile Acids	mg/dry kg	558	276	1,099	
Total Kjeldhal-N	"	49,966	31,081	83,186	
NH ₃ -N	"	7,331	2,555	17,441	
Total P	"	20,915	13,745	28,901	
Ag	"	ND ¹	ND	ND	
Al	"	17,633	8,759	24,750	
As	"	8	<1	12	41
Ba	"	ND	ND	ND	
Be	"	ND	ND	ND	
Ca	"	35,264	23,450	55,089	
Cd	"	4	2	5	39
Cr	"	272	134	422	
Cu	"	405	274	768	1,500
Fe	"	16,464	10,200	36,564	
Hg	"	0.72	0.26	1.5	17
K	"	2,829	1,405	4,233	
Mg	"	15,075	5,468	24,363	
Mn	"	477	272	737	
Mo	"	17	12	25	75
Na	"	1,153	475	2,122	
Ni	"	58	38	75	420
Pb	"	137	52	224	300
Sb	"	ND	ND	ND	
Se	"	2	<1	6	100
Tl	"	ND	ND	ND	
Zn	"	806	580	1,196	2,800

¹ ND=No data.

TABLE 4. CHEMICAL COMPOSITION OF LAGOON-AGED, AIR-DRIED BIOSOLIDS COLLECTED FROM THE CALUMET WRP IN 2003 AND APPLICABLE PART 503 EQ LIMITS

Parameter	Units	Mean	Min.	Max.	503 Limit
pH		6.7	6.0	7.8	
Total Solids	%	67.3	60.9	79.1	
Total Volatile Solids	"	41.7	28.6	47.1	
Volatile Acids	mg/dry kg	263	113	597	
Total Kjeldahl-N	"	22,859	13,440	33,045	
NH ₃ -N	"	2,535	31	7,565	
NO ₂ +NO ₃ -N	"	679	12	1,922	
Total P	"	22,826	13,159	32,058	
Al	"	19,205	10,637	26,289	
As	"	10	8	13	41
Ca	"	48,291	38,561	57,175	
Cd	"	8	6	13	39
Cr	"	224	94	372	
Cu	"	441	304	538	1,500
Fe	"	24,547	17,095	33,041	
Hg	"	0.86	0.31	1.2	17
K	"	3,670	1,948	4,901	
Mg	"	17,989	14,944	21,779	
Mn	"	632	544	744	
Mo	"	19	12	24	75
Na	"	1,238	548	1,664	
Ni	"	50	34	89	420
Pb	"	173	140	227	300
Se	"	10	3	20	100
Zn	"	1,399	1,009	1,874	2,800

TABLE 5. CHEMICAL COMPOSITION OF LAGOON-AGED, AIR-DRIED BIOSOLIDS COLLECTED FROM THE STICKNEY WRP IN 2003 AND APPLICABLE PART 503 EQ LIMITS

Parameter	Unit	Mean	Minimum	Maximum	503 Limit
pH		6.8	5.7	7.9	
Total Solids	%	69.8	55.1	90.3	
Total Volatile Solids	%	38.1	14.1	47.1	
Volatile Acids	mg/dry kg	119	64	224	
Total Kjeldhal-N	"	20,330	7,209	60,633	
NH ₃ -N	"	4,144	247	12,344	
NO ₃ +NO ₂ -N	"	544	16	2,812	
Total P	"	16,069	2,182	25,962	
Al	"	22,263	12,556	36,267	
As	"	7	0.5	15	41
Ca	"	44,214	36,097	55,670	
Cd	"	8	3	34	39.0
Cr	"	362	199	542	1,500
Cu	"	455	146	624	
Fe	"	20,396	16,470	26,100	
Hg	"	1.1	0.23	2.7	17
K	"	4,007	1,554	6,575	
Mg	"	20,005	317	26,414	
Mn	"	601	317	853	
Mo	"	18	5	28	75
Na	"	1,149	308	2,825	
Ni	"	63	43	89	420
Pb	"	176	126	266	300
Se	"	1	<1	5	100
Zn	"	1,065	569	1,505	2,800

TABLE 6. TCLP ANALYSIS¹ OF A COMPOSITE SAMPLE OF LAGOON-AGED, AIR-DRIED BIOSOLIDS COLLECTED FROM THE CALUMET WRP ON APRIL 14, 2003 AND THE APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Concentration	Regulatory Limit
Flash Point, Open Cup	>180°F	<140°F
Paint Filter Test	NFL ²	NL ³
pH, 10 Percent Solution	6.80	2.1-12.4
Total Solids	84.0%	NL
Ash, Percent of Total Solids	61.0%	NL
	Total Concentration (mg/dry kg)	
Extractable Halogens	<50.0	NL
Phenols	6.80	NL
Cyanide – Reactive	<1.30	NL
Sulfide – Reactive	<19.0	NL
Total PCB	1.62	NL
<u>Inorganics</u>		
Ag	25.0	NL
As	11.0	NL
Ba	480	NL
Cd	4.00	NL
Cr	83.0	NL
Hg	1.30	NL
Pb	140	NL
Se	14.0	NL
	TCLP ⁴ Extract Concentration (mg/L)	
<u>Inorganics</u>		
Ag	<0.020	5.0
As	<0.050	5.0
Ba	2.50	100.0
Cd	<0.010	1.0
Cr	<0.010	5.0
Hg	<0.0002	0.2

TABLE 6 (Continued). TCLP ANALYSIS¹ OF A COMPOSITE SAMPLE OF LAGOON-AGED, AIR-DRIED BIOSOLIDS COLLECTED FROM THE CALUMET WRP ON APRIL 14, 2003 AND THE APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Concentration	Regulatory Limit
	TCLP ⁴ Extract Concentration (mg/L)	
Pb	<0.050	5.0
Se	<0.100	1.0
<u>Organo-chlorine Pesticides</u>		
Chlordane	<0.010	0.03
Endrin	<0.002	0.02
Heptachlor	<0.001	0.008
Heptachlor Epoxide	<0.001	0.008
Lindane	<0.001	0.4
Methoxychlor	<0.010	10.0
Toxaphene	<0.060	0.5
<u>Chlorinated Herbicides</u>		
2,4-D	<0.010	10.0
2,4,5-TP	<0.010	400.0
<u>Volatile Organic Compounds</u>		
Benzene	<0.100	0.5
Carbon Tetrachloride	<0.100	0.5
Chlorobenzene	<0.100	100.0
Chloroform	<0.100	6.0
Methyl ethyl ketone	<1.000	200.0
Tetrachloroethylene	<0.100	0.5
Trichloroethylene	<0.100	0.5
Vinyl Chloride	<0.100	0.2
1,4-Dichlorobenzene	<0.100	7.5
1,2-Dichloroethane	<0.100	0.5
1,1-Dichloroethylene	<0.100	0.7

TABLE 6 (Continued). TCLP ANALYSIS¹ OF A COMPOSITE SAMPLE OF LAGOON-AGED, AIR-DRIED BIOSOLIDS COLLECTED FROM THE CALUMET WRP ON APRIL 14, 2003 AND THE APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Concentration	Regulatory Limit
	TCLP ⁴ Extract Concentration (mg/L)	
<u>Semi-Volatile Organic Compounds</u>		
o-Cresol	<0.050	200
m,p-Cresols	140	200
Hexachlorobenzene	<0.050	0.13
Hexachloro-1,3-butadiene	<0.050	0.13
Hexachloroethane	<0.050	3.0
Nitrobenzene	<0.050	2.0
Pentachlorophenol	<0.250	100.0
Pyridine	<0.400	5.0
2,4-Dinitrotoluene	<0.050	0.13
2,4,5-Trichlorophenol	<0.050	400.0
2,4,6-Trichlorophenol	<0.050	2.0

¹All analyses were performed using EPA Method SW-846 and Standard Methods for the Examination of Water and Wastewater.

²NFL – No Free Liquid.

³NL=No limit.

⁴Toxicity Characteristic Leaching Procedure (TCLP).

TABLE 7. TCLP ANALYSIS¹ OF AIR-DRIED CENTRIFUGE
CAKE BIOSOLIDS COLLECTED FROM THE JOHN E. EGAN WRP ON
FEBRUARY 11, 2003 AND THE APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Concentration	Regulatory Limit
Flash Point, Open Cup	>180°F	<140°F
Paint Filter Test	NFL ²	
pH, 10 Percent Solution	8.55	2.1-12.4
Total Solids	11.0%	NL
Ash, Percent of Total Solids		NL
	Total Concentration (mg/dry kg)	
Extractable Halogens	<180	NL
Phenols	59.0	NL
Cyanide - Reactive	<4.50	NL
Sulfide - Reactive	<68.0	NL
Total PCB	<0.077	NL
<u>Inorganics</u>		
Ag	50.0	NL
As	2.80	NL
Ba	440	NL
Cd	<4.50	NL
Cr	130	NL
Hg	2.00	NL
Pb	33.0	NL
Se	5.90	NL
	TCLP ³ Extract Concentration (mg/L)	
<u>Inorganics</u>		
Ag	<0.020	5.0
As	<0.050	5.0
Ba	2.40	100.0
Cd	<0.010	1.0
Cr	<0.010	5.0
Hg	<0.010	0.2
Pb	<0.050	5.0
Se	<0.100	1.0

TABLE 7 (Continued). TCLP ANALYSIS¹ OF AIR-DRIED CENTRIFUGE
 CAKE BIOSOLIDS COLLECTED FROM THE JOHN E. EGAN WRP ON
 FEBRUARY 11, 2003 AND THE APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Concentration	Regulatory Limit
	TCLP ³ Extract Concentration (mg/L)	
<u>Organo-chlorine Pesticides</u>		
Chlordane	<0.010	0.03
Endrin	<0.002	0.02
Heptachlor	<0.001	0.008
Heptachlor Epoxide	<0.001	0.008
Lindane	<0.001	0.4
Methoxychlor	<0.010	10.0
Toxaphene	<0.060	0.5
<u>Chlorinated Herbicides</u>		
2,4-D	<0.010	10.0
2,4,5-TP	<0.010	400.0
<u>Volatile Organic Compounds</u>		
Benzene	<0.100	0.5
Carbon Tetrachloride	<0.100	0.5
Chlorobenzene	<0.100	100.0
Chloroform	<0.100	6.0
Methyl ethyl ketone	<1.000	200.0
Tetrachloroethylene	<0.100	0.5
Trichloroethylene	<0.100	0.5
Vinyl Chloride	<0.100	0.2
1,4-Dichlorobenzene	<0.100	7.5
1,2-Dichloroethane	<0.100	0.5
1,1-Dichloroethylene	<0.100	0.7
<u>Semi-Volatile Organic Compounds</u>		
o-Cresol	<0.050	200
m,p-Cresols	<0.050	200
Hexachlorobenzene	<0.050	0.13

TABLE 7 (Continued). TCLP ANALYSIS¹ OF AIR-DRIED CENTRIFUGE
CAKE BIOSOLIDS COLLECTED FROM THE JOHN E. EGAN WRP ON
FEBRUARY 11, 2003 AND THE APPLICABLE PART 261 REGULATORY LIMIT

Parameter	Concentration	Regulatory Limit
	TCLP ³ Extract Concentration (mg/L)	
Hexachloro-1,3-butadiene	<0.050	0.13
Hexachloroethane	<0.050	3.0
Nitrobenzene	<0.050	2.0
Pentachlorophenol	<0.250	100.0
Pyridine	<0.400	5.0
2,4-Dinitrotoluene	<0.050	0.13
2,4,5-Trichlorophenol	<0.050	400.0
2,4,6-Trichlorophenol	<0.050	2.0

¹ All analyses were performed using EPA Method SW-846 and Standard Methods for the Examination of Water and Wastewater.

² NFL¹ – No Free Liquid

³ Toxicity Characteristic Leaching Procedure (TCLP).

TABLE 8. TCLP ANALYSIS¹ OF AIR-DRIED CENTRIFUGE
CAKE BIOSOLIDS COLLECTED FROM THE STICKNEY WRP ON
OCTOBER 4, 2004 AND THE APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Concentration	Regulatory Limit
Flash Point, Open Cup	>180°F	<140°F
Paint Filter Test	NFL ²	
pH, 10 Percent Solution	6.94	2.1-12.4
Total Solids	69.0%	NL
Ash, Percent of Total Solids	68.0%	NL
Total Concentration (mg/dry kg)		
Extractable Halogens	<60.0	NL
Phenols	0.81	NL
Cyanide – Reactive	<1.50	NL
Sulfide - Reactive	120	NL
Total PCB		NL
<u>Inorganics</u>		
Ag	28.0	NL
As	14.0	NL
Ba	360	NL
Cd	3.30	NL
Cr	240	NL
Hg	0.92	NL
Pb	160	NL
Se	4.2	NL
TCLP ³ Extract Concentration (mg/L)		
<u>Inorganics</u>		
Ag	<0.020	5.0
As	<0.050	5.0
Ba	<0.210	100.0
Cd	<0.010	1.0
Cr	<0.010	5.0
Hg	<0.0002	0.2
Pb	<0.050	5.0
Se	<0.100	1.0

TABLE 8 (Continued). TCLP ANALYSIS¹ OF AIR-DRIED CENTRIFUGE
CAKE BIOSOLIDS COLLECTED FROM THE STICKNEY WRP ON
OCTOBER 4, 2004 AND THE APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Concentration	Regulatory Limit
	TCLP ³ Extract Concentration (mg/L)	
<u>Organo-chlorine Pesticides</u>		
Chlordane	<0.025	0.03
Endrin	<0.005	0.02
Heptachlor	<0.0025	0.008
Heptachlor Epoxide	<0.0025	0.008
Lindane	<0.0025	0.4
Methoxychlor	<0.025	10.0
Toxaphene	<0.150	0.5
<u>Chlorinated Herbicides</u>		
2,4-D	<0.100	10.0
2,4,5-TP	<0.100	400.0
<u>Volatile Organic Compounds</u>		
Benzene	<0.100	0.5
Carbon Tetrachloride	<0.100	0.5
Chlorobenzene	<0.100	100.0
Chloroform	<0.100	6.0
Methyl ethyl ketone	<1.000	200.0
Tetrachloroethylene	<0.100	0.5
Trichloroethylene	<0.100	0.5
Vinyl Chloride	<0.100	0.2
1,4-Dichlorobenzene	<0.100	7.5
1,2-Dichloroethane	<0.100	0.5
1,1-Dichloroethylene	<0.100	0.7
<u>Semi-Volatile Organic Compounds</u>		
o-Cresol	<0.050	200
m,p-Cresols	<0.050	200
Hexachlorobenzene	<0.050	0.13

TABLE 8 (Continued). TCLP ANALYSIS¹ OF AIR-DRIED CENTRIFUGE
 CAKE BIOSOLIDS COLLECTED FROM THE STICKNEY WRP ON
 OCTOBER 4, 2004 AND THE APPLICABLE PART 261 REGULATORY LIMITS

Parameter	Concentration	Regulatory Limit
	TCLP ³ Extract Concentration (mg/L)	
Hexachloro-1,3-butadiene		
Hexachloroethane	<0.050	0.13
Nitrobenzene	<0.050	3.0
Pentachlorophenol	<0.250	2.0
Pyridine	<0.400	100.0
2,4-Dinitrotoluene	<0.050	5.0
2,4,5-Trichlorophenol	<0.050	0.13
2,4,6-Trichlorophenol	<0.050	400.0
		2.0

¹ All analyses were performed using EPA, Method SW-846 and Standard Methods.

² NFL-No Free Liquid.

³ Toxicity Characteristic Leaching procedure (TCLP).

oped 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 risk level of 10^{-6} with many worst-case assumptions built into the risk pathways, the default for Tier I residential property are extremely conservative.

The objectives of the TACO program are not directly applicable to biosolids. However, in 2000, the District conducted an evaluation of its biosolids to consider instances in which the TACO standards may be applicable to biosolids use in the remediation of brownfields. The TACO analyses for four biosolids samples and the corresponding TACO Tier 1 Residential objectives are presented in Tables 9 and 10. Total extract concentrations (Table 9) are used to evaluate the objectives for the soil exposure and dust inhalation routes for organic compounds and inorganic parameters and the groundwater route for organic compounds. The TCLP extract concentrations (Table 10) are used to evaluate the groundwater route for inorganic parameters. The data indicate that biosolids are very clean and meet nearly all of the Tier I residential objectives.

The data for the four biosolids samples show that most of the organic compounds are undetectable and that the concentrations of most of the detectable compounds are lower than the TACO Tier 1 residential limits.

The concentrations of most of the inorganic parameters are also much lower than the TACO standards.

Topsoil Properties of Biosolids

Some of the lagoon-aged, air-dried biosolids from the Stickney and Calumet WRPs are used as topsoil substitutes or amendments. Information in this section may be helpful in planning the use of biosolids as a topsoil or soil conditioner. The District has conducted studies of biosolids physical properties. The results of these studies are available in Research and Development Department reports (Nos. 03-8 and 03-10).

Biosolids used as a soil conditioner or soil substitute 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 chemical characteristics of its lagoon-aged, air-dried biosolids that are important in assessing the suitability of topsoil for establishing vegetation. The results from this study are presented in Table 11. The data show that biosolids are a good source of macro- and micro-nutrients. The electrical conductivity (a measure of soluble salt content) tends to be higher than the suitability range for some 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 or topsoil substitute. These inquiries may be initiated by contacting Dr. Thomas Granato at 708-588-4116 or Dr. Albert Cox at 708-588-4054.

TABLE 9. TOTAL CONCENTRATIONS OF TACO TARGET ORGANIC COMPOUNDS AND INORGANIC PARAMETERS IN FOUR AIR-DRIED BIOSOLIDS SAMPLES COLLECTED IN 2000 AND THEIR CORRESPONDING TACO TIER 1 RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Parameter	Biosolids Source				TACO Tier 1 Residential Objectives			
	Stickney WRP		Calumet WRP		Soil Exposure Route		Groundwater Exposure Route	
	Sample 1	Sample 2	Sample 1	Sample 2	Ingestion	Inhalation	Class I	Class II
	----- Total Concentration (mg/kg) -----							
<u>Organics</u>								
DDD	<0.00079	<0.00079	<0.00079	<0.00077	3	NL ¹	16	80
DDE	0.07	0.036	0.036	<0.00019	2	NL	54	270
DDT	<0.00079	<0.00079	<0.00079	<0.00077	2	NL	32	160
Alachlor	<0.0098	<0.0099	<0.0099	<0.0096	8	NL	0.04	0.2
Aldrin	<0.00059	<0.00059	<0.0006	<0.00058	0.04	3	0.5	2.5
alpha-HCH (alpha-BHC)	<0.00039	<0.00039	<0.0004	<0.00039	0.1	0.8	0.0005	0.003
Atrazine	<0.0098	<0.0099	<0.0099	<0.0096	2,700	NL	0.066	0.33
Chlordane	<0.0024	<0.0024	<0.0024	<0.0023	0.5	20	10	48
Dieldrin	<0.00039	<0.00039	<0.0004	<0.00039	0.04	1	0.004	0.02
Endosulfan	--	--	--	--	470	NL	18	90
Endosulfan I	<0.00059	<0.00059	<0.0006	<0.00058	--	--	--	--
Endosulfan II	<0.0022	<0.0022	<0.0022	<0.0021	--	--	--	--
Endrin	<0.00098	<0.00099	<0.00099	<0.00096	23	NL	1	5
Gamma-HCH (Lindane)	<0.00059	<0.00059	<0.0006	<0.00058	0.5	NL	0.009	0.047
Heptachlor	<0.0012	<0.0012	<0.0012	<0.0012	0.1	0.1	23	110
Heptachlorepoxyde	<0.00039	<0.00039	<0.0004	<0.00039	0.07	5	0.7	3.3
Methoxychlor	<0.0055	<0.0055	<0.0056	<0.0054	390	NL	160	780
Simazine	<0.0098	<0.0099	<0.0099	<0.0096	390	NL	0.04	0.37
Toxaphene	<0.042	<0.042	<0.042	<0.041	0.6	89	31	150
Polychlorinated biphenyls (PCBs)	--	--	--	--	1	NL	NL	NL
Aroclor 1016	<0.0581	<0.0582	<0.0586	<0.0569	--	--	--	--

TABLE 9 (Continued). TOTAL CONCENTRATIONS OF TACO TARGET ORGANIC COMPOUNDS AND INORGANIC PARAMETERS IN FOUR AIR-DRIED BIOSOLIDS SAMPLES COLLECTED IN 2000 AND THEIR CORRESPONDING TACO TIER 1 RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Parameter	Biosolids Source				TACO Tier 1 Residential Objectives			
	Stickney WRP		Calumet WRP		Soil Exposure Route		Groundwater Exposure Route	
	Sample 1	Sample 2	Sample 1	Sample 2	Ingestion	Inhalation	Class I	Class II
	----- Total Concentration (mg/kg) -----							
Aroclor 1221	<0.0492	<0.0494	<0.0497	<0.0482	--	--	--	--
Aroclor 1232	<0.0585	<0.0586	<0.059	<0.0573	--	--	--	--
Aroclor 1242	<0.0581	<0.0582	<0.0586	<0.0569	--	--	--	--
Aroclor 1248	0.458	0.488	0.512	1.06	--	--	--	--
Aroclor 1254	<0.0492	<0.0494	<0.0497	<0.0482	--	--	--	--
Aroclor 1260	0.212	0.295	0.671	0.439	--	--	--	--
1,1,1-Trichloroethane	<0.0011	<0.0011	<0.0011	<0.0011	NL	1,200	2	9.6
1,1,2-Trichloroethane	<0.0009	<0.0009	<0.0009	<0.0009	310	1,800	0.02	0.3
1,1-Dichloroethane	<0.0008	<0.0008	<0.0008	<0.0008	7,800	1,300	23	110
1,1-Dichloroethene	<0.0011	<0.0011	<0.0011	<0.0011	700	1,500	0.06	0.3
1,2-Dibromo-3-chloropropane	<0.005	<0.005	<0.005	<0.005	0.46	11	0.002	0.002
1,2-Dibromoethane	<0.0007	<0.0007	<0.0007	<0.0007	0.0075	0.17	0.0004	0.004
1,2-Dichlorobenzene	<0.0016	<0.0016	<0.0016	<0.0016	7,000	560	17	43
1,2-Dichloroethane	<0.0012	<0.0012	<0.0012	<0.0012	7	0.4	0.02	0.1
1,2-Dichloropropane	<0.0008	<0.0008	<0.0008	<0.0008	9	15	0.03	0.15
1,4-Dichlorobenzene	<0.001	<0.001	<0.001	<0.001	NL	NL	2	11
1-Butanol	<0.05	<0.05	<0.05	<0.05	7,800	10,000	17	17
Acetone	<0.03	<0.03	<0.03	<0.03	7,800	100,000	16	16
Benzene	0.0016	<0.0007	<0.0007	<0.0007	22	0.8	0.03	0.17
Bromodichloromethane	<0.0007	<0.0007	<0.0007	<0.0007	10	3,000	0.6	0.6
Bromoform	<0.005	<0.005	<0.005	<0.005	81	53	0.8	0.8

TABLE 9 (Continued). TOTAL CONCENTRATIONS OF TACO TARGET ORGANIC COMPOUNDS AND INORGANIC PARAMETERS IN FOUR AIR-DRIED BIOSOLIDS SAMPLES COLLECTED IN 2000 AND THEIR CORRESPONDING TACO TIER 1 RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Parameter	Biosolids Source				TACO Tier 1 Residential Objectives			
	Stickney WRP		Calumet WRP		Soil Exposure Route		Groundwater Exposure Route	
	Sample 1	Sample 2	Sample 1	Sample 2	Ingestion	Inhalation	Class I	Class II
	----- Total Concentration (mg/kg) -----							
Bromomethane	<0.0014	<0.0014	<0.0014	<0.0014	110	10	0.2	1.2
Carbon disulfide	<0.0012	<0.0012	<0.0012	<0.0012	7,800	720	32	160
Carbon tetrachloride	<0.0017	<0.0017	<0.0017	<0.0017	5	0.3	0.07	0.33
Chlorobenzene	<0.0012	<0.0012	<0.0012	<0.0012	1,600	130	1	6.5
Chloroform	<0.0013	<0.0013	<0.0013	0.0074	100	0.3	0.6	2.9
cis-1,2-Dichloroethene	<0.0011	<0.0011	<0.0011	<0.0011	780	1,200	0.4	1.1
1,3-dichloropropene	--	--	--	--	4	0.1	0.004	0.02
cis-	<0.0007	<0.0007	<0.0007	<0.0007	--	--	--	--
trans-	<0.0006	<0.0006	<0.0006	<0.0006	--	--	--	--
Dibromochloromethane	<0.0012	<0.0012	<0.0012	<0.0012	1,600	1,300	0.4	0.4
Ethylbenzene	<0.0014	<0.0014	<0.0014	<0.0014	7,800	400	13	19
m-Xylene	<0.0024	<0.0024	<0.0024	<0.0024	160,000	420	210	210
p-Xylene	<0.0024	<0.0024	<0.0024	<0.0024	160,000	460	200	200
Methylene chloride	<0.0027	<0.0027	<0.0027	0.0179	85	13	0.02	0.2
o-Xylene	<0.005	<0.005	<0.005	<0.005	160,000	410	190	190
Styrene	0.0011	<0.0011	<0.0011	<0.0011	16,000	1,500	4	18
Tetrachloroethene	<0.0016	<0.0016	<0.0016	<0.0016	12	11	0.06	0.3
Toluene	0.0062	0.0183	0.0055	<0.0016	16,000	650	12	29
trans-1,2-Dichloroethene	<0.0011	<0.0011	<0.0011	<0.0011	1,600	3,100	0.7	3.4
Trichloroethene	<0.001	<0.001	<0.001	<0.001	58	5	0.06	0.3
Vinyl acetate	<0.01	<0.01	<0.01	<0.01	78,000	1,000	170	170
Vinyl chloride	<0.0013	<0.0013	<0.0013	<0.0013	0.3	0.03	0.01	0.07

TABLE 9 (Continued). TOTAL CONCENTRATIONS OF TACO TARGET ORGANIC COMPOUNDS AND INORGANIC PARAMETERS IN FOUR AIR-DRIED BIOSOLIDS SAMPLES COLLECTED IN 2000 AND THEIR CORRESPONDING TACO TIER 1 RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Parameter	Biosolids Source				TACO Tier 1 Residential Objectives			
	Stickney WRP		Calumet WRP		Soil Exposure Route		Groundwater Exposure Route	
	Sample 1	Sample 2	Sample 1	Sample 2	Ingestion	Inhalation	Class I	Class II
	----- Total Concentration (mg/kg) -----							
Xylenes, Total	<0.005	<0.005	<0.005	<0.005	160,000	410	150	150
1,2,4-Trichlorobenzene	<0.74	<0.67	<0.84	<0.45	780	3,200	5	53
2,4,5-Trichlorophenol	<0.62	<0.55	<0.69	<0.37	7,800	NL	270	1,400
2,4,6-Trichlorophenol	<0.44	<0.39	<0.49	<0.27	58	200	0.2	0.77
2,4-Dichlorophenol	<0.67	<0.6	<0.76	<0.41	230	NL	1	1
2,4-Dimethylphenol	<0.33	<0.3	<0.37	<0.2	1,600	NL	9	9
2,4-Dinitrophenol	<1.1	<0.97	<1.2	<0.65	160	NL	0.2	0.2
2,4-Dinitrotoluene	<0.38	<0.34	<0.42	<0.23	0.9	NL	0.0008	0.0008
2,6-Dinitrotoluene	<0.3	<0.26	<0.33	<0.18	0.9	NL	0.0007	0.0007
2-Chlorophenol	<0.55	<0.49	<0.62	<0.33	390	53,000	4	4
3,3'-Dichlorobenzidine	<1.6	<1.4	<1.8	<0.97	1	NL	0.007	0.033
4-Chloroaniline	<0.33	<0.29	1.3	1.2	310	NL	0.7	0.7
Acenaphthene	<0.56	0.66	<0.63	<0.34	4,700	NL	570	2,900
Anthracene	1.2	1.4	1.2	0.9	23,000	NL	12,000	59,000
Benz(a)anthracene	1.7	1.4	2.7	2.4	0.9	NL	2	8
Benzo(a)pyrene	1.5	1.6	4	3.6	0.09	NL	8	82
Benzo(b)fluoranthene	<0.78	<0.7	<0.87	<0.47	0.9	NL	5	25
Benzo(k)fluoranthene	<0.78	<0.7	<0.87	<0.47	9	NL	49	250
Benzoic acid	<6.8	<6.1	<7.7	<4.1	310,000	NL	400	400
Bis(2-chloroethyl)ether	<0.71	<0.64	<0.8	<0.43	0.6	0.2	0.0004	0.0004
Bis(2-ethylhexyl)phthalate	54	58	55	29	46	31,000	3,600	31,000

TABLE 9 (Continued). TOTAL CONCENTRATIONS OF TACO TARGET ORGANIC COMPOUNDS AND INORGANIC PARAMETERS IN FOUR AIR-DRIED BIOSOLIDS SAMPLES COLLECTED IN 2000 AND THEIR CORRESPONDING TACO TIER 1 RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Parameter	Biosolids Source				TACO Tier 1 Residential Objectives			
	Stickney WRP		Calumet WRP		Soil Exposure Route		Groundwater Exposure Route	
	Sample 1	Sample 2	Sample 1	Sample 2	Ingestion	Inhalation	Class I	Class II
	----- Total Concentration (mg/kg) -----							
Butyl benzyl phthalate	<0.45	<0.4	<0.51	<0.27	16,000	930	930	930
Carbazole	<0.53	<0.47	<0.59	<0.32	32	NL	0.6	2.8
Chrysene	1.9	2.1	3.4	3	88	NL	160	800
Di-n-butyl phthalate	<0.61	<0.55	<0.69	<0.37	7,800	2,300	2,300	2,300
Di-n-octyl phthalate	4	<0.31	<0.39	<0.21	1,600	10,000	10,000	10,000
Dibenzo(a,h)anthracene	<0.47	<0.42	<0.53	<0.29	0.09	NL	2.0	7.6
Diethyl phthalate	<0.42	<0.38	<0.47	<0.25	63,000	2,000	470	470
Fluoranthene	3.8	4	3.5	2.8	3,100	NL	4,300	21,000
Fluorene	0.55	0.79	<0.45	<0.24	3,100	NL	560	2,800
Hexachlorobenzene	<0.32	<0.29	<0.36	<0.19	0.4	1	2.0	11
Hexachlorocyclopentadiene	<0.86	<0.77	<0.96	<0.52	550	10	400	2,200
Hexachloroethane	<0.75	<0.67	<0.84	<0.45	78	NL	0.5	2.6
Indeno(1,2,3-cd)pyrene	<0.44	0.48	1	0.76	0.9	NL	14	69
Isophorone	<0.57	<0.52	<0.65	<0.35	15,600	4,600	8	8
N-Nitrosodi-n-propylamine	<0.92	<0.83	<1	<0.56	0.09	NL		0.00005
N-Nitrosodiphenylamine	<1.1	<1	<1.3	<0.67	130	NL	1	5.6
Naphthalene	<0.6	1.4	<0.67	0.46	3,100	NL	84	420
Nitrobenzene	<0.58	<0.52	<0.65	<0.35	39	92	0.1	0.1
o-Cresol	<0.87	<0.78	<0.98	<0.53	3,900	NL	15	15
Pentachlorophenol	<0.9	<0.8	<1	<0.54	3	NL	0.03	0.14

TABLE 9 (Continued). TOTAL CONCENTRATIONS OF TACO TARGET ORGANIC COMPOUNDS AND INORGANIC PARAMETERS IN FOUR AIR-DRIED BIOSOLIDS SAMPLES COLLECTED IN 2000 AND THEIR CORRESPONDING TACO TIER 1 RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Parameter	Biosolids Source				TACO Tier 1 Residential Objectives			
	Stickney WRP		Calumet WRP		Soil Exposure Route		Groundwater Exposure Route	
	Sample 1	Sample 2	Sample 1	Sample 2	Ingestion	Inhalation	Class I	Class II
	----- Total Concentration (mg/kg) -----							
Phenol	15	2.4	<0.62	<0.33	47,000	NL	100	100
Pyrene	4.2	4.8	4.2	3.9	2,300	NL	4,200	21,000
Aldicarb	<0.025	<0.025	<0.025	<0.025	78	NL	0.013	0.07
Carbofuran	<0.035	<0.035	<0.035	<0.035	390	NL	0.22	1.1
2,4,5-TP (Silvex)	<1.3	<1.5	<1.5	<1.3	630	NL	11	55
2,4-D	<1.3	<1.5	<1.5	<1.6	780	NL	1.5	7.7
Dalapon	<90	<100	<100	<90	2,300	NL	0.85	8.5
Picloram	<0.8	<0.9	<0.9	<0.8	5,500	NL	2	20
Endothal	280	<5	<3.1	<5	1,600	NL	0.4	0.4
Dinoseb	<1	<0.5	<1	<1	78	NL	0.34	3.4
<u>Inorganics²</u>								
Antimony	125	94.4	185	132	31	NL		
Arsenic	6.72	7.1	8.1	6.8	13	750		
Barium	225	215	334	192	5,500	690,000		
Beryllium	0.301	0.248	0.338	0.305	0.1	1,300		
Boron	<36.3	<36.3	<36.6	<35.9	7,000	NL		
Cadmium	4.47	4.56	8.00	9.66	78	1,800		
Chloride	188	195	196	74	NL	NL		
Chromium	206	198	105	94.8	390	270		
Chromium ion, trivalent	204	197	104	93.8	78,000	NL		

TABLE 9 (Continued). TOTAL CONCENTRATIONS OF TACO TARGET ORGANIC COMPOUNDS AND INORGANIC PARAMETERS IN FOUR AIR-DRIED BIOSOLIDS SAMPLES COLLECTED IN 2000 AND THEIR CORRESPONDING TACO TIER 1 RESIDENTIAL OBJECTIVES FOR THE SOIL AND GROUNDWATER EXPOSURE ROUTES

Parameter	Biosolids Source				TACO Tier 1 Residential Objectives			
	Stickney WRP		Calumet WRP		Soil Exposure Route		Groundwater Exposure Route	
	Sample 1	Sample 2	Sample 1	Sample 2	Ingestion	Inhalation	Class I	Class II
	----- Total Concentration (mg/kg) -----							
Chromium ion, hexavalent	<2.5	<1	<1	<1	390	270		
Cobalt	6.18	4.85	6.41	4.85	4,700	NL		
Copper	289	292	251	144	2,900	NL		
Cyanide	11	4	4	5	1,600	NL		
Fluoride	<5	<5	<5	<5	4,700	NL		
Iron	13,500	12,700	32,500	17,300	NL	NL		
Lead	125	109	122	97.2	400	NL		
Manganese	422	355	570	261	3,700	69,000		
Mercury	1.42	1.72	1.11	0.882	23	10		
Nickel	33.1	34.8	26.7	21.6	1,600	13,000		
Nitrate-N	82	<20	255	263	130,000	NL		
Selenium	<33.5	10.6	20	13.9	390	NL		
Silver	23	25.9	19.2	9.7	390	NL		
Sulfate	6,160	6,630	4,850	3,800	NL	NL		
Thallium	0.284	0.26	0.41	0.375	6.3	NL		
Vanadium	11.5	10.1	19.2	21.6	550	NL		
Zinc	784	622	1,020	697	23,000	NL		

¹ NL=No limit.

² Objectives for groundwater exposure route for inorganics are based on TCLP concentrations.

TABLE 10. TCLP¹-EXTRACT CONCENTRATIONS OF TACO TARGET INORGANIC PARAMETERS IN FOUR AIR-DRIED BIOSOLIDS SAMPLES COLLECTED IN 2000 AND THEIR CORRESPONDING TACO TIER 1 RESIDENTIAL OBJECTIVES FOR THE GROUNDWATER EXPOSURE ROUTE

Parameter	Biosolids Source				TACO Tier 1 Residential Objectives	
	Stickney WRP		Calumet WRP		Groundwater Exposure Route	
	Sample 1	Sample 2	Sample 1	Sample 2	Class I	Class II
	----- TCLP-extract Concentration (mg/L) -----					
Antimony	0.025	0.024	<0.009	<0.009	0.006	0.024
Arsenic	0.09	0.098	0.065	<0.05	0.05	0.2
Barium	0.103	0.085	0.032	0.022	2.0	2.0
Beryllium	<0.007	<0.007	<0.007	<0.007	0.004	0.5
Boron	<2	<2	<2	<2	2.0	2.0
Cadmium	0.007	0.007	0.009	0.016	0.005	0.05
Chloride	15.6	15.4	15.6	8.2	200	200
Chromium	<0.042	<0.042	<0.042	<0.042	0.1	1.0
Chromium ion, trivalent	<0.04	<0.04	<0.04	<0.04	NL ²	NL
Chromium ion, hexavalent	<0.5	<0.25	<0.1	<0.1	NL	NL
Cobalt	<0.136	<0.136	<0.136	<0.136	1.0	1.0
Copper	0.503	0.157	<0.087	<0.087	0.65	0.65
Cyanide	<0.05	<0.05	<0.05	<0.05	0.2	0.6
Fluoride	<0.5	<0.5	<0.5	<0.5	4.0	4.0
Iron	1.23	0.316	0.394	0.334	5.0	5.0
Lead	0.025	<0.002	0.006	<0.004	0.0075	0.1
Manganese	1.69	1.69	2.87	1.59	0.15	10.0
Mercury	<0.015	<0.015	<0.015	<0.015	0.002	0.01
Nickel	<0.153	<0.153	<0.153	<0.153	0.1	2.0
Nitrate-N	6.39	3.6	13	12.6	10.0	100

TABLE 10 (Continued). TCLP¹-EXTRACT CONCENTRATIONS OF TACO TARGET INORGANIC PARAMETERS IN FOUR AIR-DRIED BIOSOLIDS SAMPLES COLLECTED IN 2000 AND THEIR CORRESPONDING TACO TIER 1 RESIDENTIAL OBJECTIVES FOR THE GROUNDWATER EXPOSURE ROUTE

Parameter	Biosolids Source				TACO Tier 1 Residential Objectives	
	Stickney WRP		Calumet WRP		Groundwater Exposure Route	
	Sample 1	Sample 2	Sample 1	Sample 2	Class I	Class II
	----- TCLP-extract Concentration (mg/L) -----					
Selenium	0.009	<0.008	0.015	0.008	0.05	0.05
Silver	<0.062	<0.062	<0.062	<0.062	0.05	NL
Sulfate	322	361	257	188	400	400
Thallium	<0.005	<0.005	<0.005	<0.005	0.002	0.02
Vanadium	<0.165	<0.165	<0.165	<0.165	0.049	NL
Zinc	0.82	0.581	1.37	1.39	5.0	10

¹ TCLP = Toxicity characteristic leaching procedure.

² NL=No Limit.

TABLE 11. TOPSOIL CHEMICAL PROPERTIES OF FIVE BIOSOLIDS
 SAMPLES FROM CALUMET WRP AND FOUR SAMPLES FROM STICKNEY WRP
 COLLECTED IN 2000

Analysis	Units	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	mg/kg	252	523	407
Total Kjeldahl-N	mg/kg	13,655	28,228	20,554
<u>1 M KCl-Extractable</u>				
NH ₃ -N	mg/kg	28	3,547	1,776
NO ₃ -N	"	134	458	144
<u>1 M NH₄OAc Exchangeable Bases</u>				
Ca	mg/kg	3,691	8,417	5,649
K	"	366	980	787
Mg	"	862	1,969	1,528
Na	"	81	573	320
<u>DTPA-Extractable</u>				
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
<u>0.1 M HCl-Extractable</u>				
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

TABLE 11 (Continued). TOPSOIL CHEMICAL PROPERTIES OF FIVE BIOSOLIDS SAMPLES FROM CALUMET WRP AND FOUR SAMPLES FROM STICKNEY WRP COLLECTED IN 2000

Analysis	Units	Minimum	Maximum	Mean
Pb	"	0.06	0.84	0.32
Zn	"	20	42	31
<u>Saturation Paste Extractable</u>				
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 air-dried biosolids:water ratio.

² Standard soil test method used in Illinois to determine plant available P content of soils.