
loop
Turn your dirt around
2021
Loop Quality
Data Summary

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1.0 Introduction

Biosolids are the nutrient-rich organic products of the wastewater treatment process. Biosolids contain water, organic matter, sand, nutrients, microorganisms, trace metals, and trace organic compounds. Because of their moisture content, carbon-rich characteristics, essential nutrients for plants, and very low levels of pollutants, biosolids are an effective, high quality, and sustainable fertilizer replacement and soil amendment for forest trees and agricultural crops, and an ingredient in compost for landscaping.

The King County Wastewater Treatment Division began conducting research and recycling biosolids through land application in 1973. The program has grown to beneficially recycle 100% of the over 120,000 wet tons (or approximately 30,000 dry tons) produced annually in agriculture, forestry, soil reclamation, and/or compost.

King County's biosolids are called Loop®, a name and brand created in 2011, to reflect the nature of biosolids and the benefits of returning carbon and nutrients to the land.

Loop is certified as Class B biosolids. Biosolids are classified as Class A or Class B based on the level of pathogen reduction. Class A biosolids are treated to eliminate pathogens and can be used in landscaping and home gardens. Class B biosolids are treated to significantly reduce, but not eliminate, pathogens. Therefore, use of Class B biosolids requires application site permits which include public access and crop harvest restrictions to allow for die-off of pathogens to non-detectable levels after application. These regulatory requirements make the use of Class A and Class B biosolids equally safe.

To ensure the safety and efficacy of Loop, we routinely monitor its physical, chemical, and microbial characteristics. This monitoring is performed monthly in order to characterize the biosolids, evaluate changes over time, and provide data to determine appropriate application rates for Loop biosolids.

Summary data for all parameters is included in the appendix of this report and raw data is available on request from King County. All data included in tables have been rounded in accordance with the accuracy of the specific analytical procedure. Unless otherwise noted, all concentrations are reported on a dry weight basis. Concentrations of metals, nutrients, and organic compounds are reported in terms of parts per million (mg/kg) dry. Microbiological data are reported in terms of organisms per gram or organisms per 4 grams on a dry weight basis.

This report summarizes the 2021 monitoring of Loop biosolids from West Point Treatment Plant, South Treatment Plant, and Brightwater Treatment Plant. Both state and federal regulations (WAC 173-308 and 40 CFR Part 503) apply to biosolids. Loop meets the most stringent quality standards for metals, as well as the anaerobic digestion process requirements for Class B pathogen reduction and vector attraction reduction.

Regular quality testing not only fulfills our regulatory requirements, but also ensures that we are providing a safe and effective product to our partners and customers.

2.0 Metals

Every month, the King County Environmental Lab analyzes Loop samples from all three plants for the presence and concentrations of 18 metals. Eight of these metals are regulated under state and federal biosolids rules: arsenic, cadmium, copper, lead, mercury, nickel, selenium and zinc. Molybdenum is also regulated, but only has a ceiling limit for land application rather than a cumulative loading rate. We began collecting metals data as soon as we began biosolids production (since 1981 at West Point, 1988 at South Plant, and 2012 at Brightwater).

Throughout 2021 the concentrations of the eight regulated metals in Loop biosolids fell well below the most stringent state and federal regulatory levels (Figure 1). Since 1990, there has been a statistically significant decrease in all regulated metals. All treatment plant levels of molybdenum were significantly below the 75 mg/kg ceiling limit in 2021 (6.8 mg/kg at Brightwater, 7.4 mg/kg at South Plant, and 11.1 mg/kg at West Point).

The overall reduction in concentration of many metals in Loop over time is attributed to King County's source control efforts, as well as the ongoing pollution control programs implemented by the Cities of Renton and Seattle and the removal of lead from gasoline and leaded solder from plumbing.

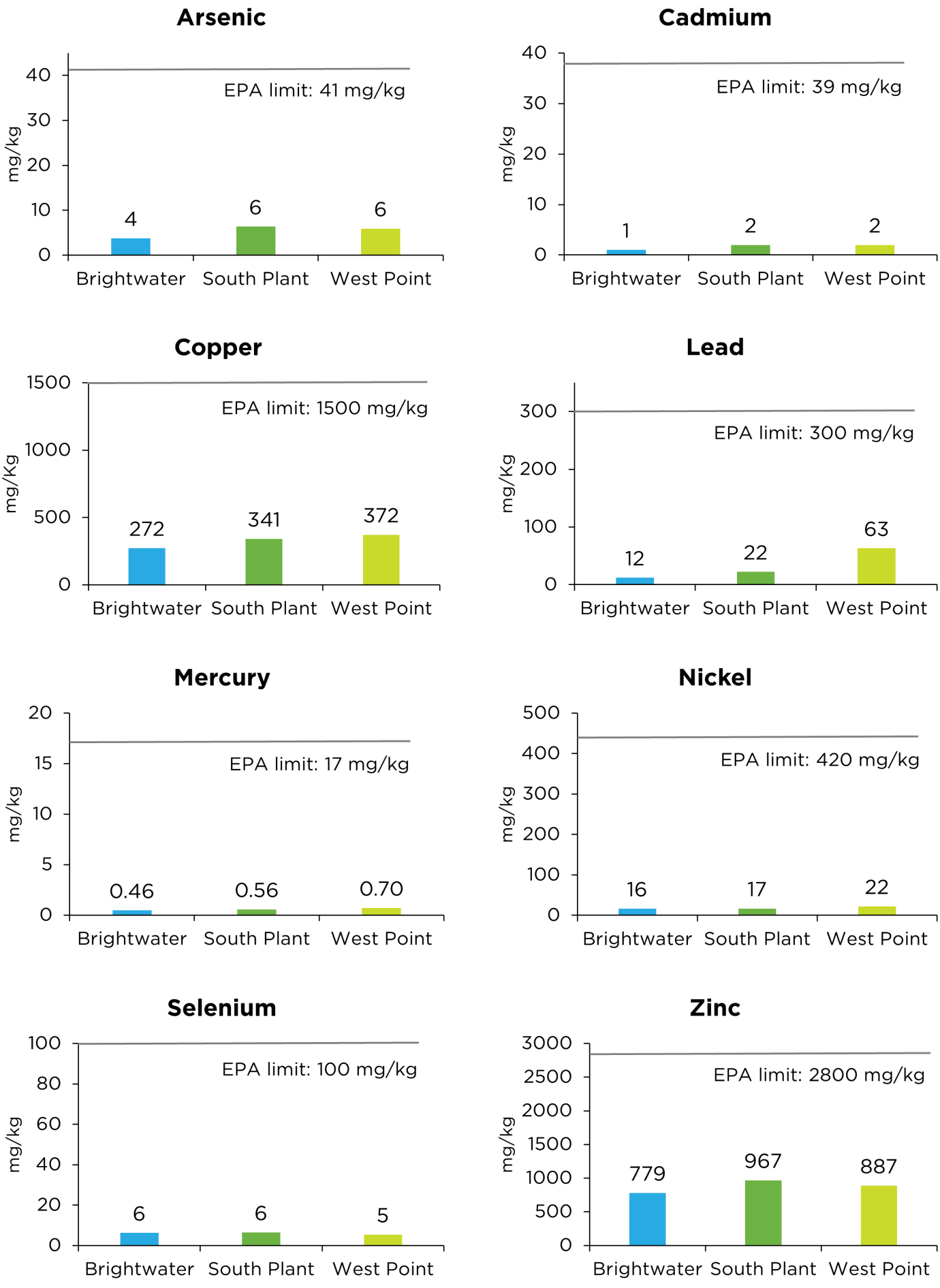


Figure 1. Average metal concentrations in 2021, compared to EPA safety limits.

3.0 Conventional Constituents

3.1 Nutrients

In order to calculate application rates and the value of Loop as a fertilizer replacement, we test for total nitrogen, phosphorus, sulfate, and potassium on a monthly basis. Nitrogen is limiting factor on which we base all application rates. 2021 levels of nitrogen, phosphorus, sulfate, and potassium are comparable to previous years (Figure 2).

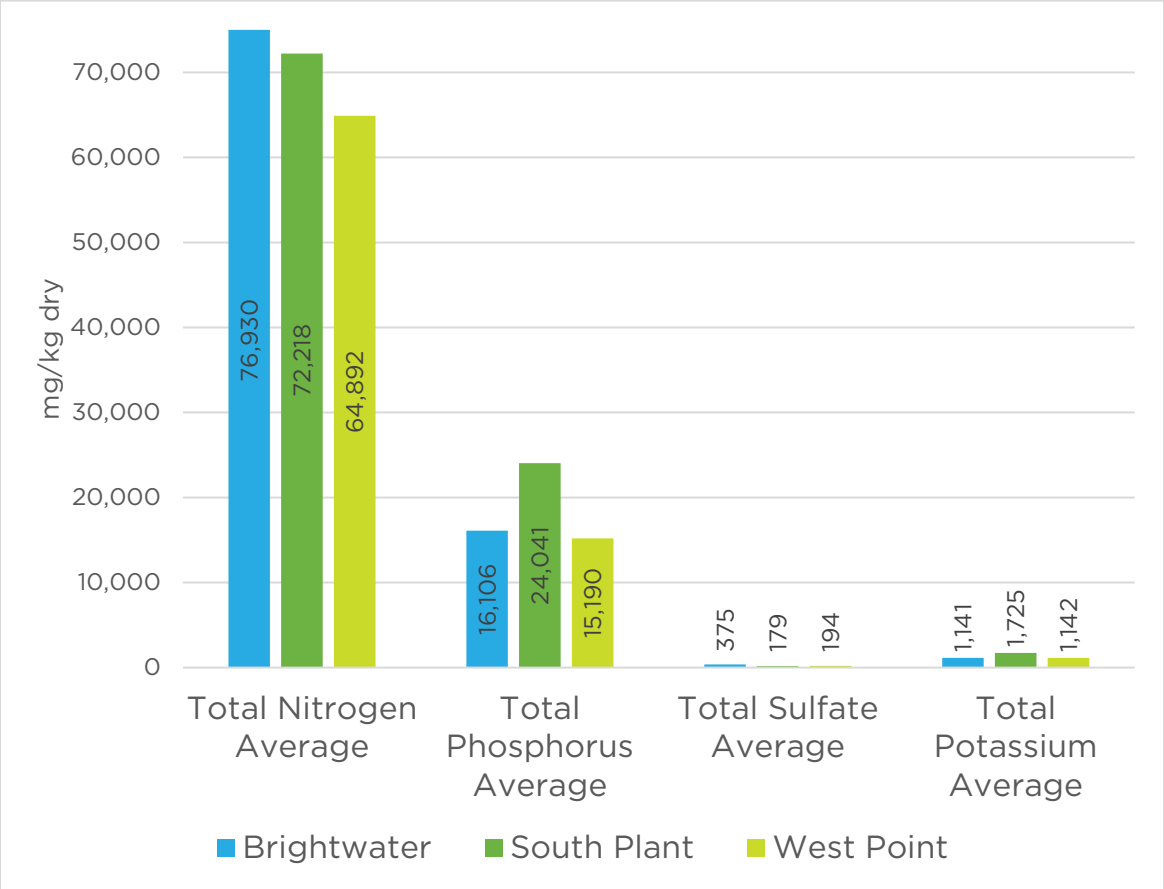


Figure 2. Average 2021 nitrogen, phosphorus, sulfate, and potassium levels of Loop.

3.2 pH

Average pH values of biosolids in 2021 at Brightwater, South Plant, and West Point were 9.1, 8.9, and 8.9 respectively. The pH of biosolids at all the treatment plants has changed little over time.

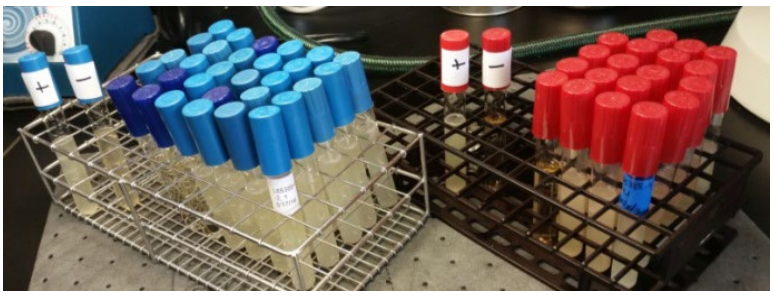
3.3 Volatile Solids Reduction

Volatile solids represent the organic matter fraction of the biosolids that can be degraded by microorganisms over time. Volatile solids reduction ensures that vectors, such as insects and rodents, are not attracted to the biosolids, thereby reducing the spread of pathogens and diseases. Brightwater, South Plant, and West Point reduced their volatile solids by 59%, 62%, and 69% respectively, well above the 38% required by the EPA.

4.0 Microbial Constituents

Loop biosolids are digested for the required time and at specific temperatures to meet the Class B regulatory requirement to significantly reduce pathogens. Since the anaerobic digestion used at our treatment plants is known to be effective, we are not required to test for microbial properties of Loop. However, we monitor pathogens regardless of regulatory requirements.

Fecal coliform and Salmonella are analyzed on a monthly basis. The levels of fecal coliform at Brightwater, South Plant, and West Point fell well below the acceptable two million most probable number (MPN)/gram for Class B biosolids.



Blue tubes show the two tests for fecal coliform. Positive results are indicated by turbidity (cloudiness) and small gas bubbles.

Loop is tested quarterly for the presence of viruses and several parasites with public health significance. These parasites include *Ascaris species, Giardia lamblia*, hookworm, *Hymenolepis species, Taenia species, Trichuris trichiura* and *Toxocara species*. It is important to note that the tests can only determine if parts of these parasites are present, not the viability of the parasites. Of these, hookworm was detected at all three plants in all quarterly samples, *Ascaris species* was detected in four samples from Brightwater, one sample from South Plant, and three samples from West Point, and *Hymenolepis species* was found in one sample from Brightwater. It is not uncommon in Class B biosolids (and regular soil) to have some parasites present. In 2021, we found no detectable viruses.

5.0 Trace Organic Constituents

Loop was analyzed for 141 trace organic compounds, many of which are identified by EPA as priority pollutants. Seventeen of these 141 organic compounds were detected at very small concentrations in Loop. This degree of testing for trace organics, though not required by federal or state regulations for biosolids use, provides additional information and assurance as to the high quality of the Loop product.

The following types of organic compounds were detected in very low concentrations during 2021:

- Phthalates, which are plasticizers used in many products (including food wrap, cosmetics, and PVC), are prevalent in the environment. Phthalates do not persist in soils and are rapidly removed by volatilization and microbial decomposition.

- Solvents, such as phenol, acetone, toluene, and carbon disulfide are widely used in both residences and industry, and are commonly found in high concentrations in commercial products such as paint and resins. Concentrations in biosolids are very low. Solvents degrade or volatilize rapidly in soil, and land application of biosolids is not considered a significant pathway of human exposure.

- Polycyclic Aromatic Hydrocarbons (PAHs) are a product of incomplete combustion and are ubiquitous environmental pollutants due to their transport in the atmosphere. Natural sources include forest fires and volcanic eruptions, while anthropogenic sources include creosote, asphalt, and burning of fossil fuels and biomass, including residential wood burning and automobiles. Transfer of PAHs from soil has been shown to be minimal for root crops, and essentially zero for above-ground crops. Total PAH concentrations in Loop are small and similar to urban soil background concentrations.

- Although EPA banned manufacture and commercial use of polychlorinated biphenyls, also called PCBs or aroclors, in 1979, these compounds are persistent in the environment. PCBs enter wastewater from atmospheric deposition and stormwater runoff and may be found in very low concentrations in biosolids. In 2021, the total aroclors detected in Loop at all three treatment plants had concentrations ranging from 0.04 to 0.18 mg/kg dry.

After extensive review of biosolids data, EPA chose not to establish criteria or monitoring requirements for organic compounds due to the low concentrations found in biosolids and the minimal risk to public health and the environment. Research on the bioavailability of trace organic compounds to plants indicates that the risk to humans consuming food crops grown on soils amended with biosolids is negligible.

6.0 Conclusions

Loop continues to be an excellent product, with respect to all relevant criteria. Concentrations of regulated metals were consistently well below the most stringent state and federal standards for land application of biosolids. Loop from all three treatment plants may be used to effectively improve soils, sequester carbon, provide nutrients for agricultural crops and forest plantations, and make high-quality compost.

7.0 Appendix

Table 1: 2021 Summary of Metals, Conventional, Microbial, and Organics Data for Brightwater Loop

Table 2: 2021 Summary of Metals, Conventional, Microbial, and Organics Data for South Plant Loop

Table 3: 2021 Summary of Metals, Conventional, Microbial, and Organics Data for West Point Loop

Table 4: List of Organic Compounds Analyzed in Loop

Table 1. 2021 Summary of Metals, Conventional, Microbial, and Organics Data for Brightwater Loop

Metals	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean	Regulatory Limits
Arsenic (mg/kg)	12	3	4	4	0.35	4	41
Barium (mg/kg)	12	128	156	179	14	155	
Beryllium (mg/kg)	12	0.16	0.19	0.21	0.02	0.19	
Boron (mg/kg)	12	46	60	78	9	60	
Cadmium (mg/kg)	12	1	1	1	0.07	1	39
Calcium (mg/kg)	12	18,756	22,108	24,155	1,615	22,080	
Chromium (mg/kg)	12	14	17	20	1.64	17	
Copper (mg/kg)	12	243	273	304	24	272	1,500
Iron (mg/kg)	12	8,408	9,458	10,842	744.35	9,440	
Lead (mg/kg)	12	10	12	15	1.33	12	300
Magnesium (mg/kg)	12	4,647	5,508	15,157	3,035	6,952	
Manganese (mg/kg)	12	726	871	1,074	99	887	
Mercury (mg/kg)	12	0.21	0.43	0.81	0.16	0.46	17
Molybdenum (mg/kg)	12	6	7	8	0.59	7	
Nickel (mg/kg)	12	14	16	19	1.38	16	420
Selenium (mg/kg)	12	5	6	7	0.74	6	100
Silver (mg/kg)	12	2	3	3	0.35	3	
Zinc (mg/kg)	12	689	742	962	90	779	2,800

Conventional	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Total Solids (%)	12	19.97%	20.62%	21.80%	0.01	20.62%
Total Volatile Solids Reduction (%)	12	53.90%	59.70%	62.30%	2.92	58.93%
pH	12	8.8	9.0	9.9	0.32	9.1
Total Kjeldahl Nitrogen (mg/kg)	12	69,058	75,950	87,000	4,788	76,930
Ammonia Nitrogen (mg/kg)	12	8,073	9,401	11,408	1,033	9,727
Organic Nitrogen (mg/kg)	12	58,296	66,996	77,778	4,986	67,191
Total Phosphorus (mg/kg)	12	11,960	15,094	25,291	3,518	16,106
Total Potassium (mg/kg)	12	876	1,146	1,342	131	1,141
Total Sulfate (mg/kg)	12	120	293	814	237	375

Microbiological	Number of Detections	Minimum	Median	Maximum	Geometric Mean
Fecal Coliform (org/g dry)	12	7,054	42,793	1,292,135	43,714
Salmonella (org/4g dry)	12	0.4	12.3	89.3	12.1
Total Viruses (PFU/4g dry)	ND				
Parasites (no units)	4				

Organics	Compound Name	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Volatiles (mg/kg)	2-Butanone (MEK)	2	0.20	0.83	1.46	0.89	0.83
	Acetone	2	0.62	4.59	8.55	5.61	4.59
	Carbon Disulfide	1	0.07				
	n-Octadecane	2	19.60	19.85	20.10	0.35	19.85
	n-Decane	1	2.46				
	Toluene	2	0.03	0.03	0.03	0.00	0.03
Semivolatiles (mg/kg)	Benzoic Acid	2	10.65	11.59	12.54	1.33	11.59
	Bis(2-Ethylhexyl) Phthalate	2	11.90	11.95	11.99	0.06	11.95
	Diethyl Phthalate	1	0.83				
	Phenol	1	10.00				
PCBs (mg/kg)	Total Aroclors	2	0.04	0.04	0.05	0.00	0.04

Table 2. 2021 Summary of Metals, Conventional, Microbial, and Organics Data for South Plant Loop

Metals	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean	Regulatory limits
Arsenic (mg/kg)	12	5	6	7	0.56	6	41
Barium (mg/kg)	12	146	171	192	12	170	
Beryllium (mg/kg)	3	0.10	0.10	0.12	0.01	0.11	
Boron (mg/kg)	12	10	18	23	4	17	
Cadmium (mg/kg)	12	1	1	2	0.20	2	39
Calcium (mg/kg)	12	18,926	26,053	29,234	2,447	25,855	
Chromium (mg/kg)	12	18	23	26	2	23	
Copper (mg/kg)	12	283	344	374	27	341	1,500
Iron (mg/kg)	12	12,934	18,489	24,008	3,861	18,702	
Lead (mg/kg)	12	16	21	31	4	22	300
Magnesium (mg/kg)	12	5,121	7,265	11,091	1,901	7,850	
Manganese (mg/kg)	12	298	409	509	73	408	
Mercury (mg/kg)	12	0.34	0.52	1.24	0.26	0.56	17
Molybdenum (mg/kg)	12	6	7	9	1.02	7	
Nickel (mg/kg)	12	12	17	19	2	17	420
Selenium (mg/kg)	12	5	6	7	0.62	6	100
Silver (mg/kg)	12	2	3	9	2	4	
Zinc (mg/kg)	12	789	964	1,144	112	967	2,800

Conventional	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Total Solids (%)	12	21.42%	23.47%	24.53%	0.01	23.34%
Total Volatile Solids Reduction (%)	12	58.90%	62.30%	65.60%	1.93	62.48%
pH	12	8.8	9.0	9.3	0.15	9.0
Total Kjeldahl Nitrogen (mg/kg)	12	64,516	70,350	84,700	5,966	72,218
Ammonia Nitrogen (mg/kg)	12	9,746	10,672	13,301	1,240	11,189
Organic Nitrogen (mg/kg)	12	54,032	59,797	74,043	5,977	61,125
Total Phosphorus (mg/kg)	12	19,395	23,236	30,165	3,869	24,041
Total Potassium (mg/kg)	12	1,273	1,729	2,087	249	1,725
Total Sulfate (mg/kg)	12	80	140	389	99	179

Microbiological	Number of Detections	Minimum	Median	Maximum	Geometric mean
Fecal Coliform (org/g dry)	12	34,826	89,385	300,429	90,368
Salmonella (org/4g dry)	12	1	15.4	487	21.1
Total Viruses (PFU/4g dry)	ND				
Parasites (no units)	4				

Organics	Compound Name	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Volatiles (mg/kg)	2-Butanone (MEK)	4	1.27	3.21	4.94	1.55	3.16
	2-Hexanone	3	0.18	0.19	0.20	0.01	0.19
	Acetone	4	1.50	2.42	4.81	1.42	2.79
	Carbon Disulfide	4	0.04	0.06	0.08	0.02	0.06
	n-Decane	4	3.58	4.46	5.02	0.60	4.38
	n-Octadecane	4	14.22	26.95	30.83	7.26	24.74
	Toluene	3	0.02	0.03	0.03	0.00	0.03
	Total Xylenes	3	0.04	0.05	0.05	0.00	0.04
Semivolatiles (mg/kg)	Benzoic Acid	2	9.96	12.81	15.65	4.03	12.81
	Bis(2-Ethylhexyl) Phthalate	4	28.35	37.26	44.35	6.55	36.81
	Diethyl Phthalate	1	1.16				
	Phenol	4	12.87	15.12	19.18	2.75	15.57
PCBs (mg/kg)	Total Aroclors	4	0.05	0.10	0.11	0.03	0.09

Table 3. 2021 Summary of Metals, Conventional, Microbial, and Organics Data for West Point Loop

Metals	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean	Regulatory Limits
Arsenic (mg/kg)	12	4	6	7	1.13	6	**41**
Barium (mg/kg)	12	107	183	294	56	187	
Beryllium (mg/kg)	10	0.11	0.13	0.19	0.03	0.14	
Boron (mg/kg)	12	8	11	13	1.38	11	
Cadmium (mg/kg)	12	1	2	2	0.22	2	**39**
Calcium (mg/kg)	12	11977	18140	20171	2470	17577	
Chromium (mg/kg)	12	14	29	38	7	28	
Copper (mg/kg)	12	299	373	434	43	372	**1,500**
Iron (mg/kg)	12	8555	15703	21860	3909	15698	
Lead (mg/kg)	12	36	64	83	14	63	**300**
Magnesium (mg/kg)	12	3698	5195	7888	1097	5186	
Manganese (mg/kg)	12	213	785	1393	377	741	
Mercury (mg/kg)	12	0.37	0.58	1.38	0.33	0.70	**17**
Molybdenum (mg/kg)	12	9	11	16	2	11.1	
Nickel (mg/kg)	12	11	22	29	5	22	**420**
Selenium (mg/kg)	12	4	5	6	0.84	5	**100**
Silver (mg/kg)	12	2	3	4	0.61	3	
Zinc (mg/kg)	12	692	883	1055	111	887	**2,800**

Conventional	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Total Solids (%)	12	25.68%	27.45%	29.75%	0.01	27.39%
Total Volatile Solids Reduction (%)	12	62.40%	68.65%	75.40%	4	68.84%
pH	12	8.4	8.8	10.0	0.42	8.9
Total Kjeldahl Nitrogen (mg/kg)	12	54,500	65,750	73,400	6302	64,892
Ammonia Nitrogen (mg/kg)	12	7,865	8,189	10,464	725	8,476
Organic Nitrogen (mg/kg)	12	46,575	54,547	64,639	6085	56,009
Total Phosphorus (mg/kg)	12	13,554	14,670	21,315	2129	15,190
Total Potassium (mg/kg)	12	681	1,157	1,442	202	1,142
Total Sulfate (mg/kg)	12	62	177	418	102	194

Microbiological	Number of Detections	Minimum	Median	Maximum	Geometric Mean
Fecal Coliform (org/g dry)	12	25,455	170,477	1,842,105	205,737
Salmonella (org/4g dry)	12	3.9	49.5	771	54.1
Total Viruses (PFU/4g dry)	ND				
Parasites (no units)	4				

Organics	Compound Name	Number of Detections	Minimum	Median	Maximum	Standard Deviation	Mean
Volatiles (mg/kg)	2-Butanone (MEK)	2	0.59	1.47	2.35	1.24	1.47
	Acetone	2	1.36	1.41	1.46	0.07	1.41
	Carbon Disulfide	2	0.02	0.03	0.04	0.01	0.03
	n-Octadecane	2	20.63	22.55	24.46	2.71	22.55
	n-Decane	2	2.55	3.31	4.07	1.08	3.31
	Toluene	2	0.04	0.06	0.08	0.03	0.06
Semivolatiles (mg/kg)	Benzoic Acid	2	8.26	9.41	10.56	1.63	9.41
	Bis(2-Ethylhexyl) Phthalate	2	32.67	34.53	36.39	2.64	34.53
	Fluoranthene	1	0.53				
	Phenanthrene	2	0.66	0.80	0.93	0.19	0.80
	Phenol	2	3.64	7.43	11.23	5.37	7.43
PCBs (mg/kg)	Total Aroclors	2	0.15	0.16	0.18	0.02	0.16

Table 4. List of Organic Compounds Analyzed in King County Biosolids

Pesticides and PCBS	Volatiles	Semivolatiles	
4,4-DDE	1,1-Dichloroethane	1,2-Dichlorobenzene	Bis(2-chloroethoxy) methane
4,4-DDD	1,1-Dichloroethylene	1,2-Diphenylhydrazine	Bis(2-chloroethyl)ether
4,4-DDT	1,2-Dichloroethane	1,3-Dichlorobenzene	Bis(2-chloroisopropyl)-ether
Aldrin	1,2-Dichloropropane	1,4-Dichlorobenzene	Bis(2-ethylhexyl)phthalate
Alpha-BHC	1,2-Trans-Dichloroethylene 1,1,1-	1,2,4-Trichlorobenzene	Benzyl Butyl Phthalate
Alpha Chlordane	Trichloroethane	2-Chloronaphthalene	Carbazole
Total Aroclors**	1,1,2-Trichloroethane	2-Chlorophenol	Chrysene*
Beta-BHC	1,1,2-Trichloroethylene	2-Methylnaphthalene	Di-n-Butyl Phthalate
Delta-BHC	1,1,2,2-Tetrachloroethane	2-Methylphenol	Di-n-Octyl Phthalate
Dieldrin	1,3-Trans-Dichloropropene	2-Nitroaniline	Dibenzo(a,h)anthracene*
Endosulfan 1	2-Butanone (MEK)	2-Nitrophenol	Dibenzofuran
Endosulfan Sulfate	2-Chloroethylvinyl Ether	2,4-Dichlorophenol	Diethyl Phthalate
Endosulfan11	2-Hexanone	2,4-Dimethylphenol	Dimethyl Phthalate
Endrin	4-Methyl-2-Pentanone (MIBK)	2,4-Dinitrophenol	Fluoranthene*
Endrin Aldehyde	Acetate	2,4-Dinitrotoluene	Fluorene*
Gamma-BHC	Acetone	2,6-Dinitrotoluene	Hexachlorobenzene
Heptachlor	Acrolein	2,4,5-Trichlorophenol	Hexachlorobutadiene
Heptachlor Epoxide	Acrylonitrile	2,4,6-Trichlorophenol	Hexachlorocyclopentadiene
Methoxychlor	Benzene	3-Nitroaniline	Hexachloroethane
Toxaphene	Bromodichloromethane	3-,4-Methylphenol	Indeno(1,2,3-c,d)pyrene*
Trans Chlordane	Bromoform	4-Bromophenyl Phenyl Ether	Isophorone
	Bromomethane	4-chloro-3-methylphenol	N-Nitroso-di-n-propylamine
	Carbon Disulfide	4-Chloroaniline	N-Nitrosodimethylamine
	Carbon Tetrachloride	4-Chlorophenyl Phenyl Ester	N-Nitrosodiphenylamine
	Chlorobenzene	4-Nitroaniline	Naphthalene*
	Chlorodibromoethane	4-Nitrophenol	Nitrobenzene
	Chloroethane	4,6-Dinitro-O-Cresol	Pentachlorophenol
	Chloroform	Acenaphthene*	Phenanthrene*
	Chloromethane	Acenaphthylene*	Phenol
	Cis-1,3-Dichloropropane	Aniline	Pyrene*
	Ethylbenzene	Anthracene*	
	Methylene Chloride	Benzoic Acid	
	N-decane	Benzo(a)anthracene*	
	N-Octadecane	Benzo(a)pyrene*	
	Styrene	Benzo(b,j,k)fluoranthene*	
	Tetrachloroethylene	Benzo(g,h,i)perylene*	
	Toluene	Benzyl Alcohol	
	Total Xylenes		
	Trichlorofluoromethane		
	Vinyl Chloride		

* Polynuclear Aromatic Hydrocarbons (PAHs)

** Polychlorinated Biphenyls (PCBs)