Deliverable 4.1 = Microbiology and chemistry of effluent from clean water conditioning

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As previously reported in Deliverable 3.2, three eight-inch diameter surrogate columns were constructed with the same soil materials and following the same installation and conditioning protocol used during the installation of the field bioretention columns (Figure 1). This was done so that the columns could be destructively sampled to determine if stratification of the soil constituents had occurred (reported in Deliverable 3.2). Each of the three small soil columns received 18.1 ± 0.004 dry kg of BSM compacted to a depth of 40.9 ± 1.2 cm resulting in a soil bulk density of 1.36 ± 0.04 g/cm^3. Columns were conditioned with dechlorinated municipal water during hydraulic conductivity testing; in total, each column received 0.14 ± 0.021 m^3 (17.5 ± 2.7 soil pore volume equivalents).

Figure 1: Surrogate columns for destructive soil layer sampling.

After the hydraulic conductivity testing/conditioning process, we simulated a "time 0" event as a baseline assessment for water chemistry and microbiology sampling. For this simulated event, all hydraulic loading was consistent with loading rates of the field mesocosms.

These baseline effluent water quality data essentially represent the leachate from the BSM because the influent water for this test was dechlorinated municipal water with copper and zinc levels typical of plumbing infrastructure.

Water quality of conditioned bioretention effluent

Similar to clean water tests of new BSM observed in other studies, fresh 60:40 BSM exported suspended sediment (TSS), organic matter (BOD, TOC, DOC), and phosphorus (ortho-P and TP), and increased the alkalinity of effluent water (Table 1). Some metals were detectable in the influent municipal water, and these concentrations increased in effluent for As, Cr, Cu, and Ni. In contrast, concentrations of metals in effluent were reduced from influent for dissolved Cd, Pb, and Zn. It is important to note that the influent municipal water was elevated in dissolved Zn (>200 g/L). This was an artefact of legacy plumbing to the fish lab building on the WSU campus as has been documented in other studies using this water source. A reverse osmosis (RO) system was recently installed in this building but was unfortunately not yet available at the time the column conditioning was conducted. The BSM effluent concentrations of PAHs and bacteria remained near or below detection limits.

Table 1. Average microbiology, conventional, nutrient, and metal concentrations in influent and effluent waters following BSM conditioning with clean water.

Type		Units	D.L.[a]	Influent (SD)[b]	Effluent (SD)
Microbiology	Fecal Coliform	MPN/100 mL	2	<[c]	<
	E. coli	CFU/100 mL	2	1 (0)	5 (0)
Conventional	pH	n.a.	0.1	6.9 (<0.1)	7.4 (0.1)
	TSS	mg/L	1	1 (0)	10 (5)
	BOD	mg/L	2	<	6 (<2)
	COD	mg/L	10	<	50 (34)
	TOC	mg/L	0.5	1.1 (0)	34.7 (13.3)
	DOC	mg/L	0.5	1.0 (0.1)	28.3 (6.7)
	Alkalinity	mg/L as $CaCO_3$	1	97 (4)	243 (12)
Nutrients	TAN	mg/L	0.005	0.054 (0.068)	0.059 (0.020)
	TKN	mg/L	0.1	<	1.9 (1.6)
	Nitrate + Nitrite	mg/L	0.01	2.55 (0.21)	2.30 (0.53)
	ortho-P	mg/L	0.005	0.037 (0)	0.447 (0.129)
	TP	mg/L	0.005	0.044 (0.006)	0.539 (0.108)
Total Metal	Arsenic	ug/L	0.5	1.2 (0.2)	2.6 (0.4)
	Cadmium	ug/L	0.5	<	<
	Chromium	ug/L	0.5	<	<
	Copper	ug/L	1	23 (30)	17 (4)
	Lead	ug/L	0.5	1.8 (0.2)	1.8 (1.0)
	Nickel	ug/L	0.5	23.6 (33.1)	6.6 (1.8)
	Zinc	ug/L	5	282 (55)	60 (16)
Dissolved Metal	Arsenic	ug/L	0.05	1.01 (0.02)	2.30 (0.26)
	Cadmium	ug/L	0.05	0.14 (0)	0.07 (0.01)
	Chromium	ug/L	0.1	0.4 (<0.1)	1.0 (0.2)
	Copper	ug/L	0.1	1.4 (0.2)	13.6 (3.3)
	Lead	ug/L	0.1	0.3 (<0.1)	0.1 (<0.1)
	Nickel	ug/L	0.05	0.67 (0.04)	5.32 (0.94)
	Zinc	ug/L	0.5	221.5 (0.7)	30.3 (11.6)

[a] Detection Limit

[b] Standard deviation

[c] '<' indicates all values were below the detection limit

Table 2. Average polycyclic aromatic hydrocarbon (PAH) concentrations in influent and effluent waters following conditioning of BSM with clean water.

PAH	Unit	D.L.[a]	Influent (SD[b])	Effluent (SD)
Naphthalene	ug/L	0.011	<[c]	<
1-Methylnaphthalene	ug/L	0.011	<	<
2-Methylnaphthalene	ug/L	0.011	<	<
Acenaphthylene	ug/L	0.011	<	<
Acenaphthene	ug/L	0.011	<	<
Dibenzofuran	ug/L	0.011	<	<
Fluorene	ug/L	0.011	<	<
Phenanthrene	ug/L	0.011	<	<
Anthracene	ug/L	0.011	<	<
Fluoranthene	ug/L	0.011	<	<
Pyrene	ug/L	0.011	<	0.017 (<0.011)
Benzo(a)anthracene	ug/L	0.011	<	<
Chrysene	ug/L	0.011	<	<
Benzo(a)pyrene	ug/L	0.011	<	<
Indeno(1,2,3-cd)pyrene	ug/L	0.011	<	<
Dibenzo(a,h)anthracene	ug/L	0.011	<	<
Benzo(g,h,i)perylene	ug/L	0.011	<	<
Perylene	ug/L	0.011	<	<

[a] Detection Limit

[b] Standard Deviation

[c] '<' indicates all values below detection limit