WSC Webinar

Water Quality Treatment and Permeable Pavement

Topics

Treatment Mechanisms

Initial and Long-term Performance

HERRERA

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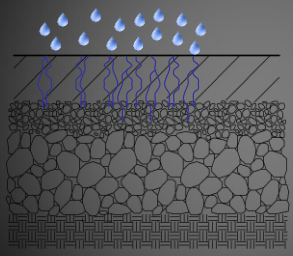
Permeable pavements provide several pollutant removal mechanisms inherent to the paving structure



- Stormwater volume reduction.
- Reduced spray and vehicle wash off.
- Biological degradation.
- Filtration.
- Adsorption.
- Volatilization.

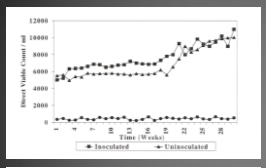
water quality treatment

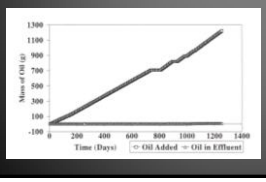
Typical Stormwater Pollutants from Pavement

- Hydrocarbons (oil, grease and gasoline).
- PAH's.
- Metals (Pb, Cu, Zn, Cd, Cr).
- Sediment.
- Nutrients.
- Chloride.
- Bacteria.

water quality treatment

Permeable pavements appear to be highly effective for hydrocarbon biodegradation

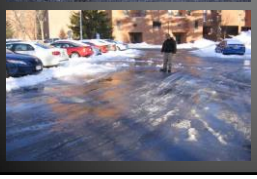




- 97-99% removal capability.
- A diversity of microbes (flagellates, amoeba, rotifers colonize permeable pavement.

water quality treatment

UNH Stormwater Center finding significant reduction of deicing salts for permeable paving compared to conventional paving



- May reduce salt use by 70% by allowing snowmelt and rain to infiltrate rather than freeze on pavement surface.

water quality treatment

Mean Concentrations for Nine Test Parking Stalls in Renton WA (2001-2002, 9 storm samples)

	Cu (µg/L)	Pb (µg/L)	Zn (µg/L)	Motor Oil (mg/L)
Gravelpave	0.89 (66%<MDL)	ND	8.23 (66%<MDL)	<MDL
Grasspave	<MDL	ND	13.2	<MDL
Turfstone	1.33 (44%<MDL)	ND	7.7 (33%<MDL)	<MDL
EcoStone	0.86 (77%<MDL)	ND	6.8 (33%<MDL)	<MDL
Conventional Asphalt	7.98	--	21.6	0.164

- MDL: motor oil 0.10 mg/l, Cu 1.0 (µg/L), Zn 5 (µg/L)
- Permeable paving sections ~10 cm deep. 90-100% occupancy during business hours. Test plots 6 years old. Dissolved metals.
- Conventional asphalt section exceeded WA surface flow WQ standards for Zn in all but one sample (acute and chronic).

water quality treatment

WSU Porous Asphalt WQ Study Objectives

- Assess pollutant capture capability of porous asphalt wearing course.
- Assess the pollutant capture capability of a typical aggregate base material in relation to the wearing course.
- Conduct replicated full-scale research.

Experimental Design

- Dose cells with synthetic stormwater.
- Apply roof stormwater at known volumes and rates.
- Apply street dirt.
- Apply dissolved contaminants.
- Collect flow weighted sample from under-drain and whole sample from elevated drain.

Dosing Inputs

- Experiment volumes and rates
  - ~ 1700 liters/cell, ~ 850 liters/hr/cell
  - ~32 mm application depth
  - Contaminant application: street dirt (particulate), standard solutions (dissolved), roof stormwater

Analyte	Analyte Concentration in Std Solution (mg/mL)	mL Applied/Cell	Analyte Applied/Cell (mg)	Cell area (m2)	Analyte load (mg/m2)
P	43.24	10	428	52.17	8.21
NO3	25.94	66	1704	52.17	32.66
Cd	0.26	2	1	52.17	0.01
Cu	17.3	2	35	52.17	0.66
Pb	0.63	5	3	52.17	0.06
Zn	60	4	244	52.17	4.67

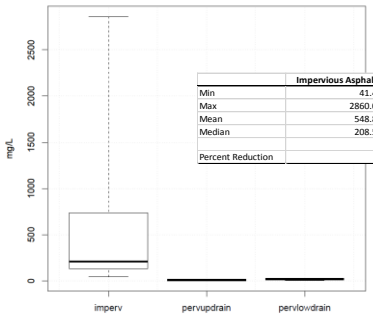
Contaminant	Street Dirt Concentrations (mg/kg)	Area/Cell (m2)	kg Applied/m2	Applications	mg Applied/m2
TP	5734	52.17	0.075	2	860.1
Total Cu	651	52.17	0.075	2	97.65
Total Pb	286	52.17	0.075	2	42.9
Total Zn	1377	52.17	0.075	2	206.55

Experimental Design

- Elevated- and under-drain.
- 10 cm wearing course.
- 46 cm aggregate base.

Spray apparatus.

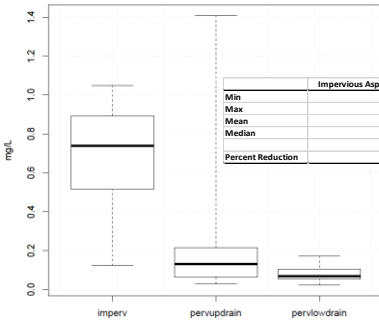
TSS



	Impervious Asphalt	Pervupdrain	Pervlowdrain
Min	41.4	2.4	2.9
Max	2860.0	19.0	27.9
Mean	548.8	8.1	14.9
Median	208.5	7.0	17.2
Percent Reduction		96.64	91.77

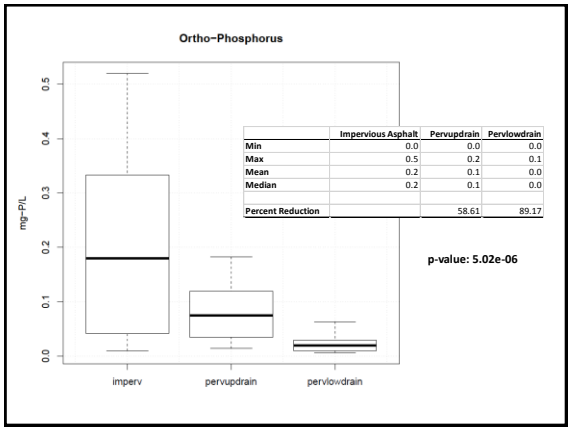
p-value: 2.83e-11
(2-way ANOVA on ranks)

Total Phosphorus



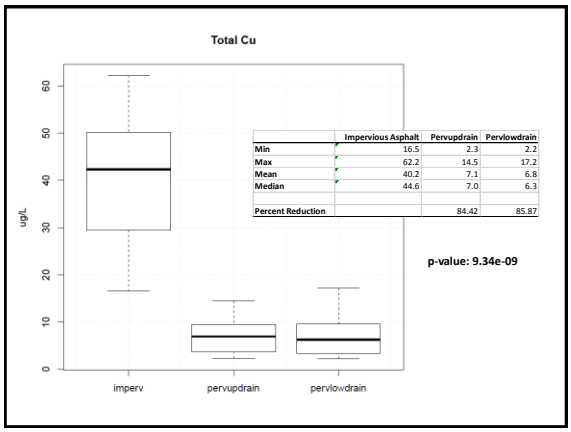
	Impervious Asphalt	Pervupdrain	Pervlowdrain
Min	0.1	0.0	0.0
Max	1.1	1.4	0.2
Mean	0.7	0.2	0.1
Median	0.7	0.1	0.1
Percent Reduction		82.27	90.60

p-value: 9.35e-09



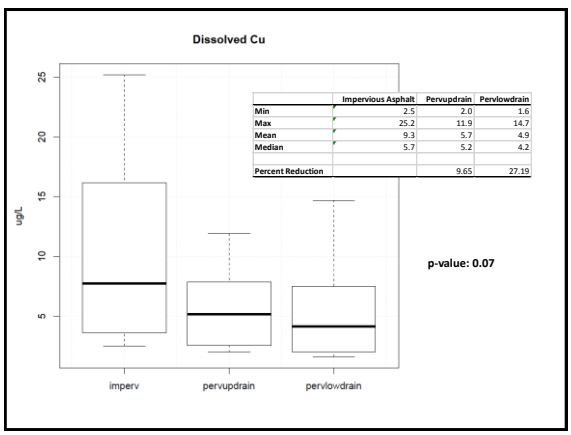
	Impervious Asphalt	Pervupdrain	Pervlowdrain
Min	0.0	0.0	0.0
Max	0.5	0.2	0.1
Mean	0.2	0.1	0.0
Median	0.2	0.1	0.0
Percent Reduction		58.61	89.17

p-value: 5.02e-06



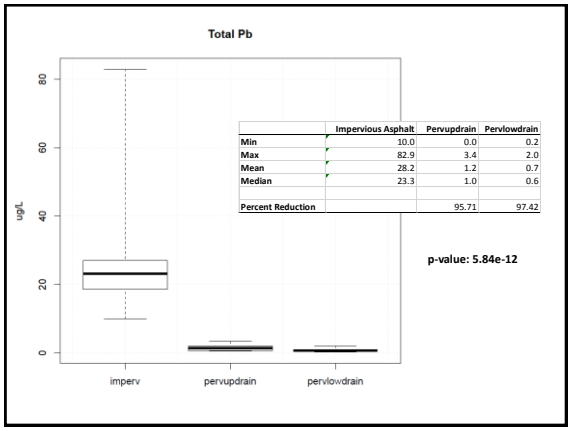
	Impervious Asphalt	Pervupdrain	Pervlowdrain
Min	16.5	2.3	2.2
Max	62.2	14.5	17.2
Mean	40.2	7.1	6.8
Median	44.6	7.0	6.3
Percent Reduction		84.42	85.87

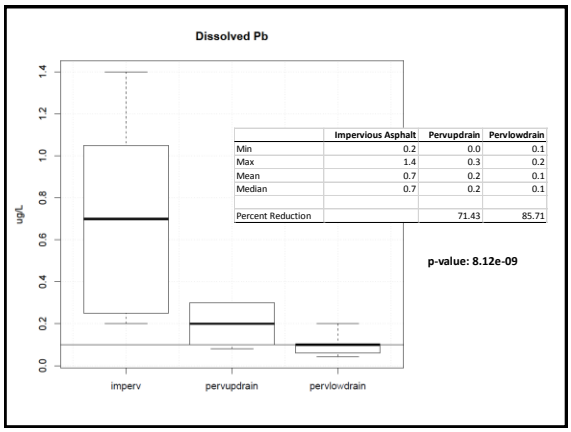
p-value: 9.34e-09



	Impervious Asphalt	Pervupdrain	Pervlowdrain
Min	2.5	2.0	1.6
Max	25.2	11.9	14.7
Mean	9.3	5.7	4.9
Median	5.7	5.2	4.2
Percent Reduction		9.65	27.19

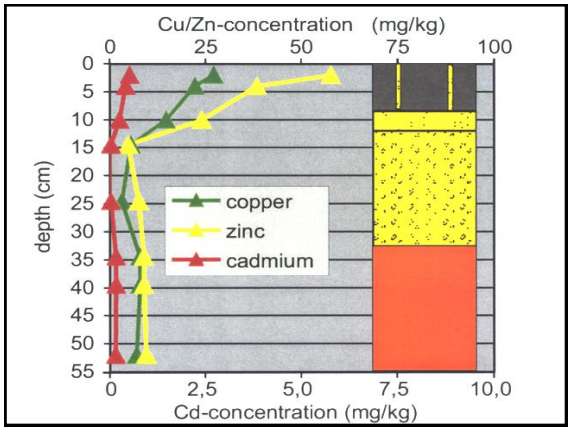
p-value: 0.07





Conclusions from WSU Study

- In general bulk of treatment occurs in the pavement wearing course for particulate contaminants.
- TSS an exception to particulate contaminant behavior (concentration increased from upper to lower drain) likely due to inputs from aggregate base.
- Increased capture from upper drain to lower drain for most dissolved contaminants (metals, nutrients, hydrocarbons and PAHs).
- Very good treatment for most contaminants except dissolved Cu (may be Cu inputs from aggregate base).


Cu/Zn-concentration (mg/kg)
0
25
50
75
100
depth (cm)
0
5
10
15
20
25
30
35
40
45
50
55
copper
zinc
cadmium
0
2,5
5,0
7,5
10,0
Cd-concentration (mg/kg)