

low impact development technical workshop series

Flow Control and Water Quality Treatment on Green Roofs

Topics

Mechanisms

Performance

Special considerations

WASHINGTON STATE UNIVERSITY EXTENSION

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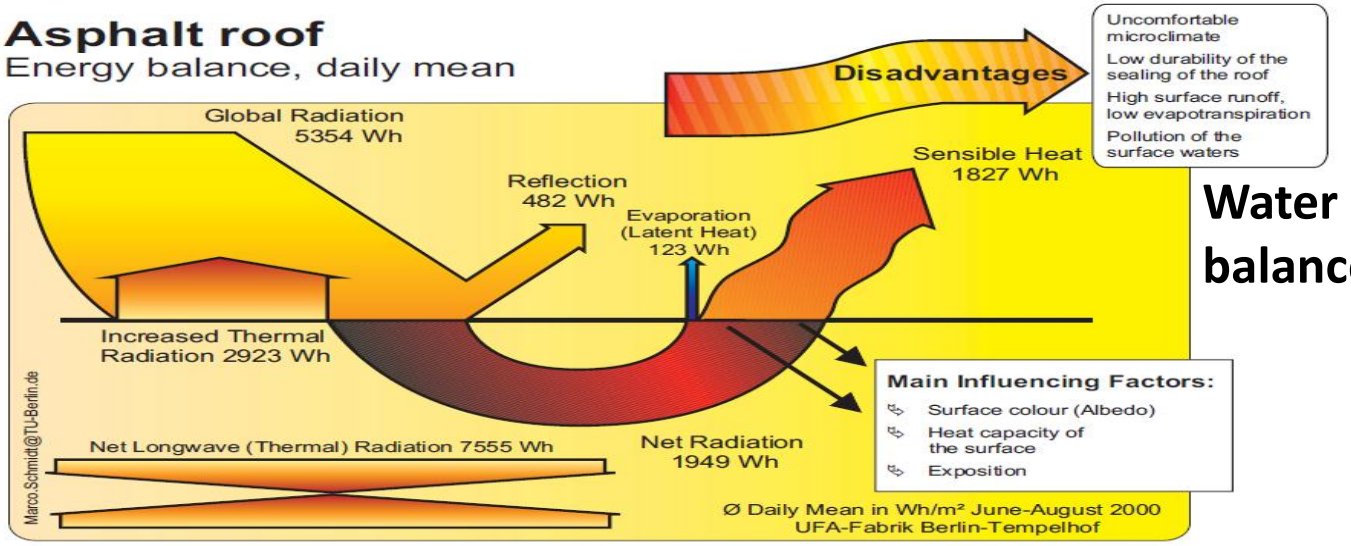
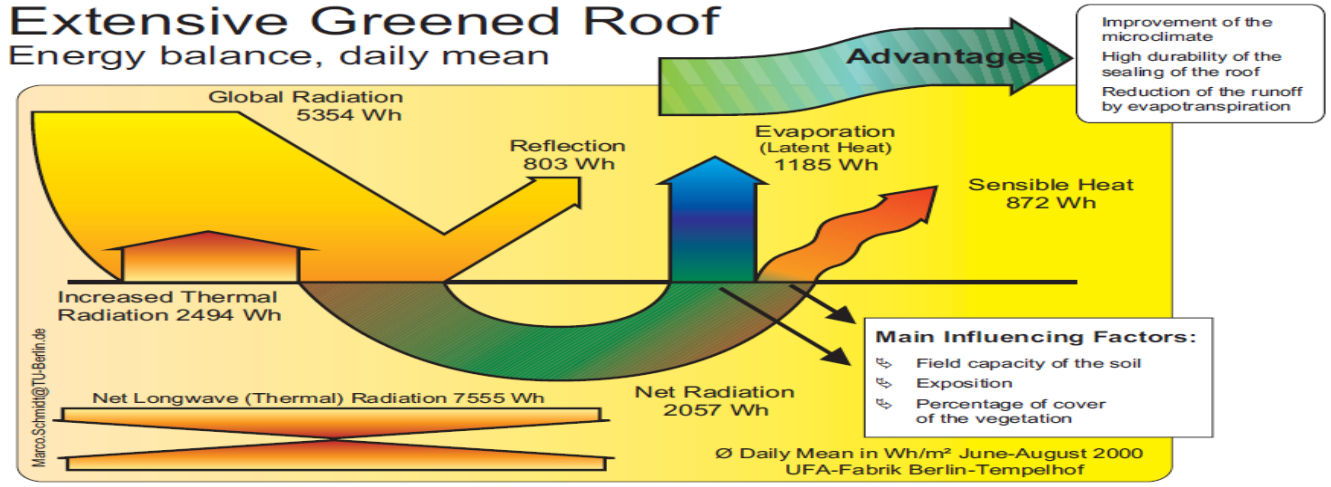
Water and energy balance on green roofs



Reduced evapotranspiration in urban areas converts up to 95% of net radiation to sensible heat and increases the thermal radiation



Extensive greened roofs transfer 58% of net radiation into evapotranspiration during the summer months, UFA Fabrik in Berlin, Germany

Temperatures on conventional and green roofs

National Research Council of Canada, Ottawa

For the study period of 660 days temperatures recorded greater than:

Conventional
50C (122F): 219 (33%)
60C (140F): 89 (13%)
70C (158F): 2 (0.3%)

Green
50C: 0
60C: 0
70C: 0

Several pathways for removing pollutants from storm flows are active on green roofs

Stormwater volume reduction.

Filtration.

Phytoremediation.

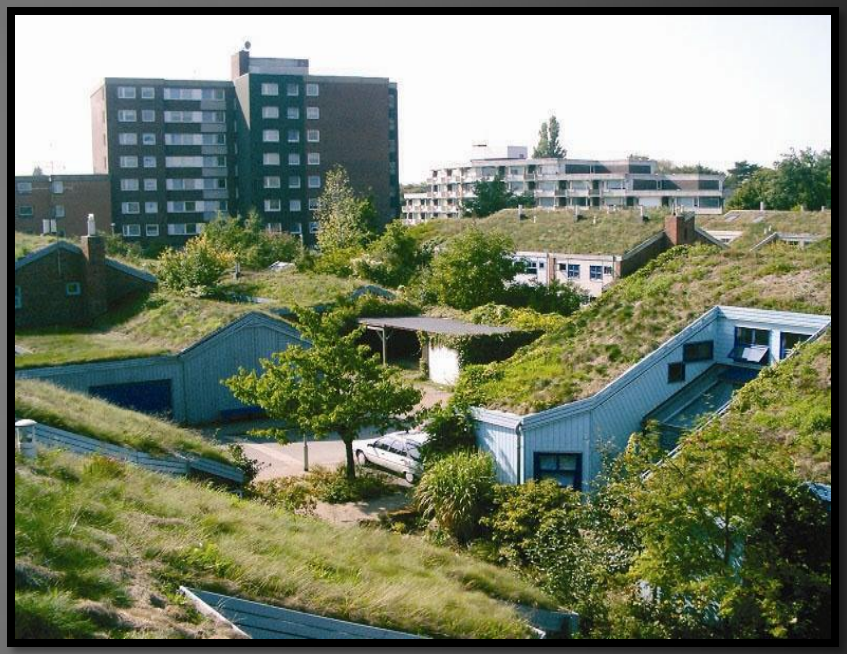
Thermal attenuation.

Adsorption.

Volatilization.

Some characteristics of roof top contribution

- Atmospheric contribution of pollutants including (but not limited to) nitrogen, sulfur, metals, PAH's can be significant.



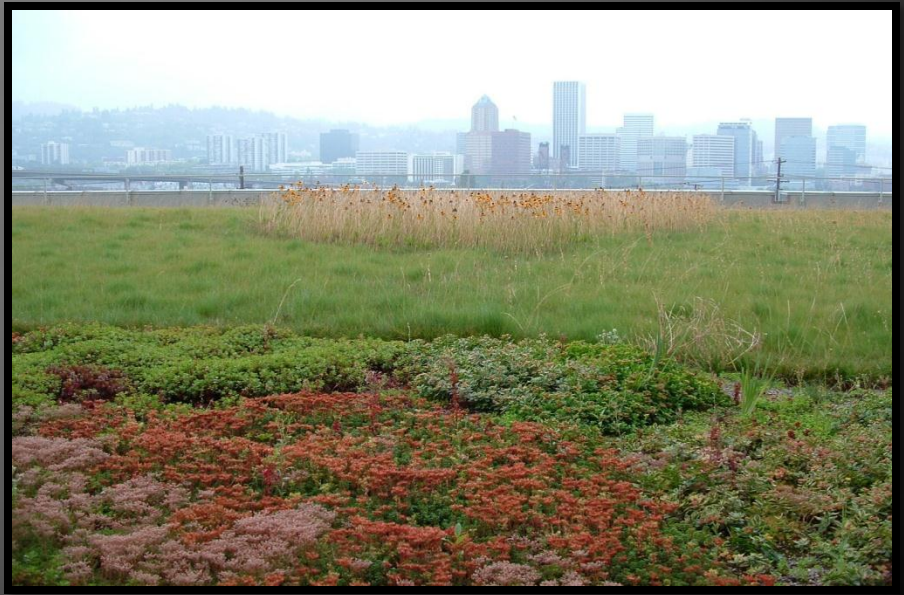
- pH and roofing condition important driver for effluent concentrations (Clark 2008).
- Roofing materials likely contain large reservoirs of metals that can be released long-term (Clark 2008).
- Roof water quality may not as good as we have assumed (Clark 2008).

Important drivers for green roof performance

- Rainfall pattern (duration, intensity and antecedent moisture condition).
- Growth media composition (Ksat, porosity, maximum moisture holding capacity).
- Growth media depth.
- Drainage layer material and design (transmissivity).
- Slope?

Annual flow volume reductions in green roofs

	Completed	GM Depth	Area	Volume Reduction (%)
PSU Broadway Building	2005-present	15 cm	500 m^2	41-48%
BCIT	2005	75, 150 mm	33 m^2	29%(75mm) 26%(150mm)
Multnomah	2004-2005	6 in	11,900 ft^2	30%
Hamilton (west roof)	2002-2005	5 in (~4”)	2,520 ft^2	56%
Zoonazium	2-4/2007	6 in	8,000 ft^2	38%



Seasonal flow volume reductions in green roofs

	Completed	GM Depth	Area	Volume Reduction (%)
PSU Broadway Building	2005-present	15 mm	500 m^2	60%(5-10), 43%(11-4)
BCIT	2005	75, 150mm	33 m^2	April-Sept 86%(75mm) 94%(150mm) Oct-March 18%(75mm), 13%(150mm)
Multnomah	2004-2005	6 in	11,900 ft^2	-144%(7-10), 40%(11-6)
Hamilton (west roof)	2002-2005	5 in (~4”)	2,520 ft^2	47%(11-4), 86%(5-10)

Important drivers for green roof performance

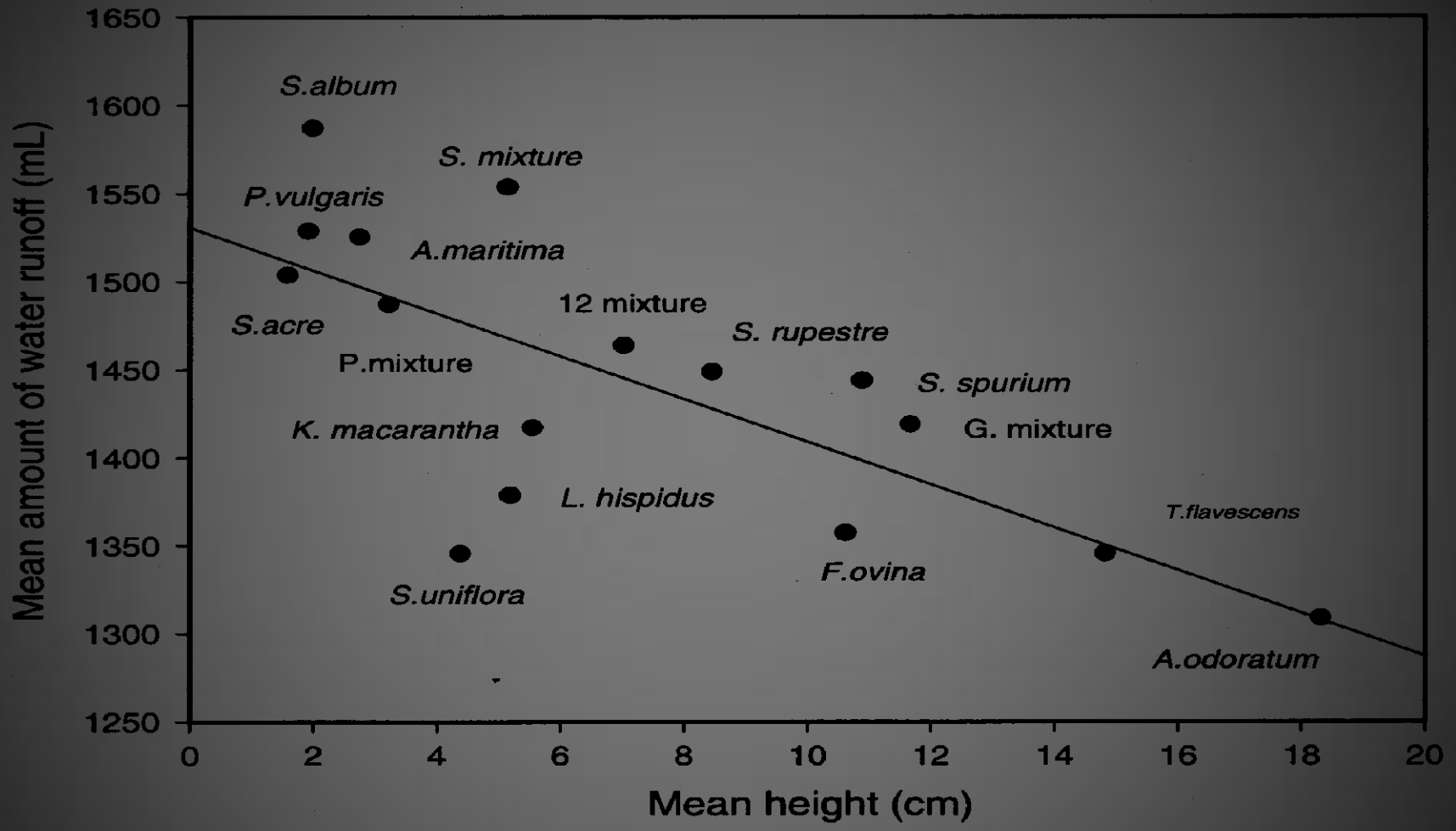


Fig. 6 The relationship between mean height and amount of water runoff (mL) in heavy rain (y=1,531−12.19x, F=15.92, df=1,14, P<0.01)

Dunnett et al. 2008

flow and water quality treatment

Important drivers for green roof performance

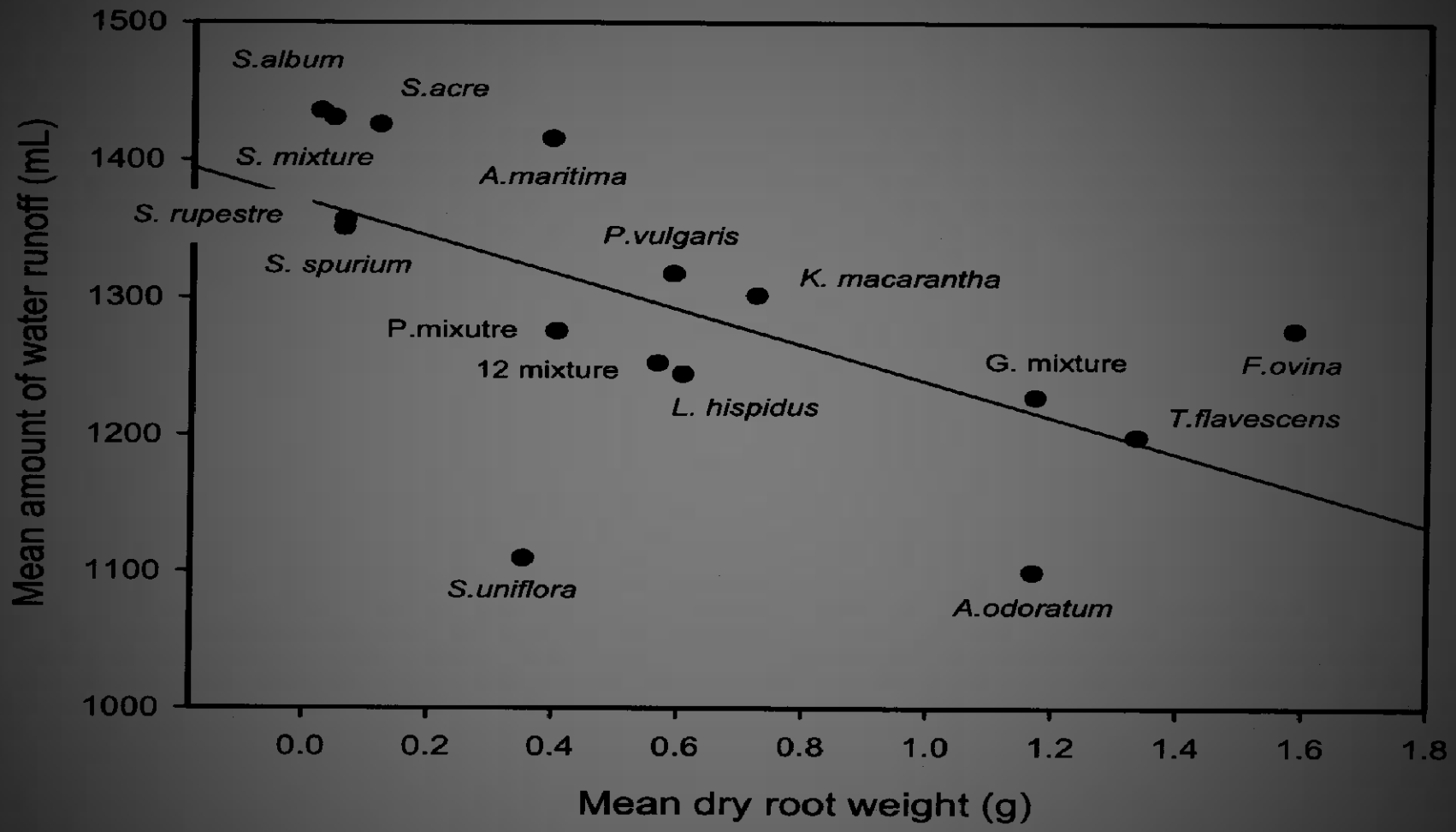


Fig. 7 The relationship between dry root weight (g) and amount of water runoff (mL) in heavy rain. (y= 1,370−132x, F=8.78, df=1,14, P<0.05)

Dunnett et al. 2008

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Water quality of conventional roof effluent

	Zn µg/L	Cu µg/L	Pb µg/L	Al µg/L	PO4 mg/L	NO3 mg/L
PSH (Clark et al 2008)						
Galvanized metal	5,000-30,000					35 (day 50)
Painted Al-Zn alloy	<250					
Western WA (Good 1993)						
New anodize Al (total)	297	25	10			
Old metal roof/Al paint (total)	12,200	20	302			
Texas (Chang et al 2004)						
Wood shingle (median)	9,717	22	25	224		
Galvanized steel (median)	8,219	20	25	194		
WI (Bannerman 1994)						
Residential	149	15				
Commercial	330	9				

Units: 1L = 1 kg; 1 mg/L = 1 mg/kg = 1 part/million; µg/L = 1 part/billion

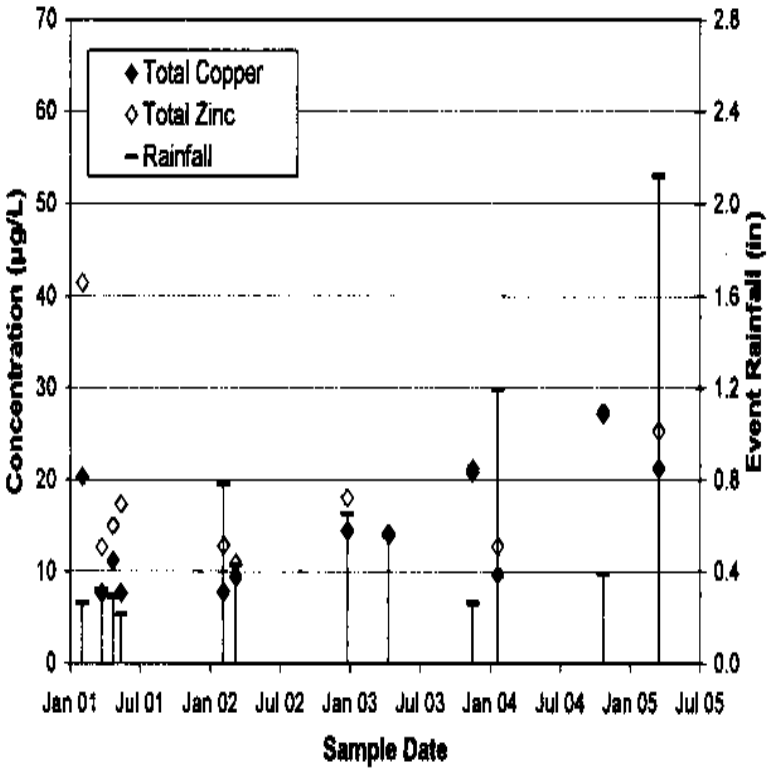
Clark 2008: rainfall pH 3.7-6.0; Chang 4.2-7.03

Water quality for the Hamilton green roof in Portland

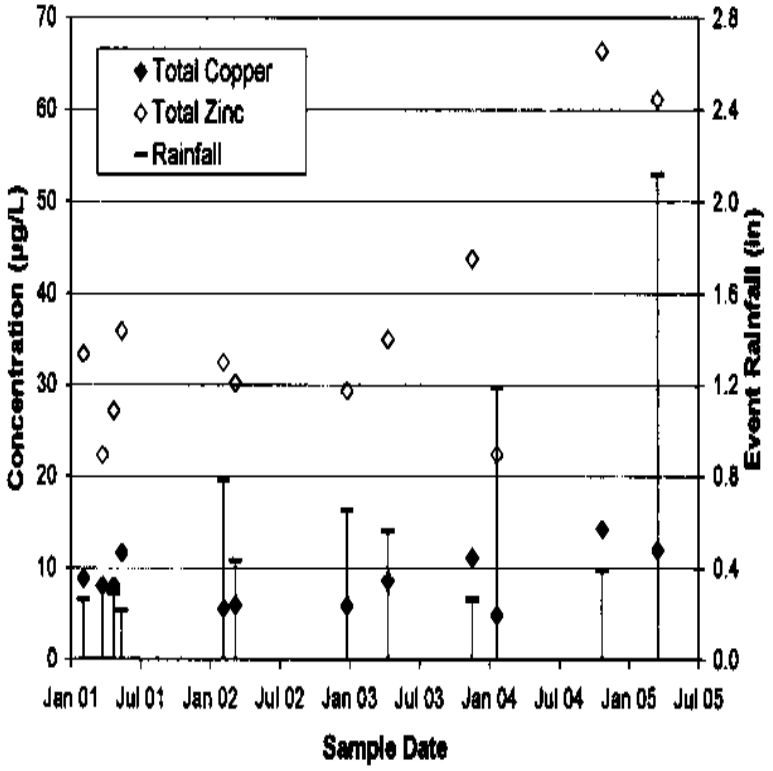
	Soil Concentrations		*Effluent Concentrations	
	West Roof	East Roof	West Roof	East Roof
Copper (total)	30.3 µg/L	17.5 µg/L	14.2 µg/L	8.7 µg/L
Lead (total)	64.9 µg/L	5.57 µg/L	0.51 µg/L	0.40 µg/L
Zinc (total)	146 µg/L	48.2 µg/L	19.1 µg/L	36.6 µg/L
TKN	12,800 mg/kg	1,900 mg/kg	--	--
Ammonia	28.6 mg/kg	2.7 mg/kg	0.041 mg/kg	0.033 mg/kg
Total Phosphorus	2,510 mg/kg	958 mg/kg	0.57 mg/kg	0.31 mg/kg
Ortho-Phosphorus	325 mg/kg	100 mg/kg	0.47 mg/kg	0.25 mg/kg

*Avg. for 2001-2005

Effluent metal concentrations trending upward for Hamilton green roof



West Roof



East Roof

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