Facing the MUSIC: a review of bioretention performance

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Overview

Bioretention systems are widely used in urban stormwater management to improve stormwater quality.

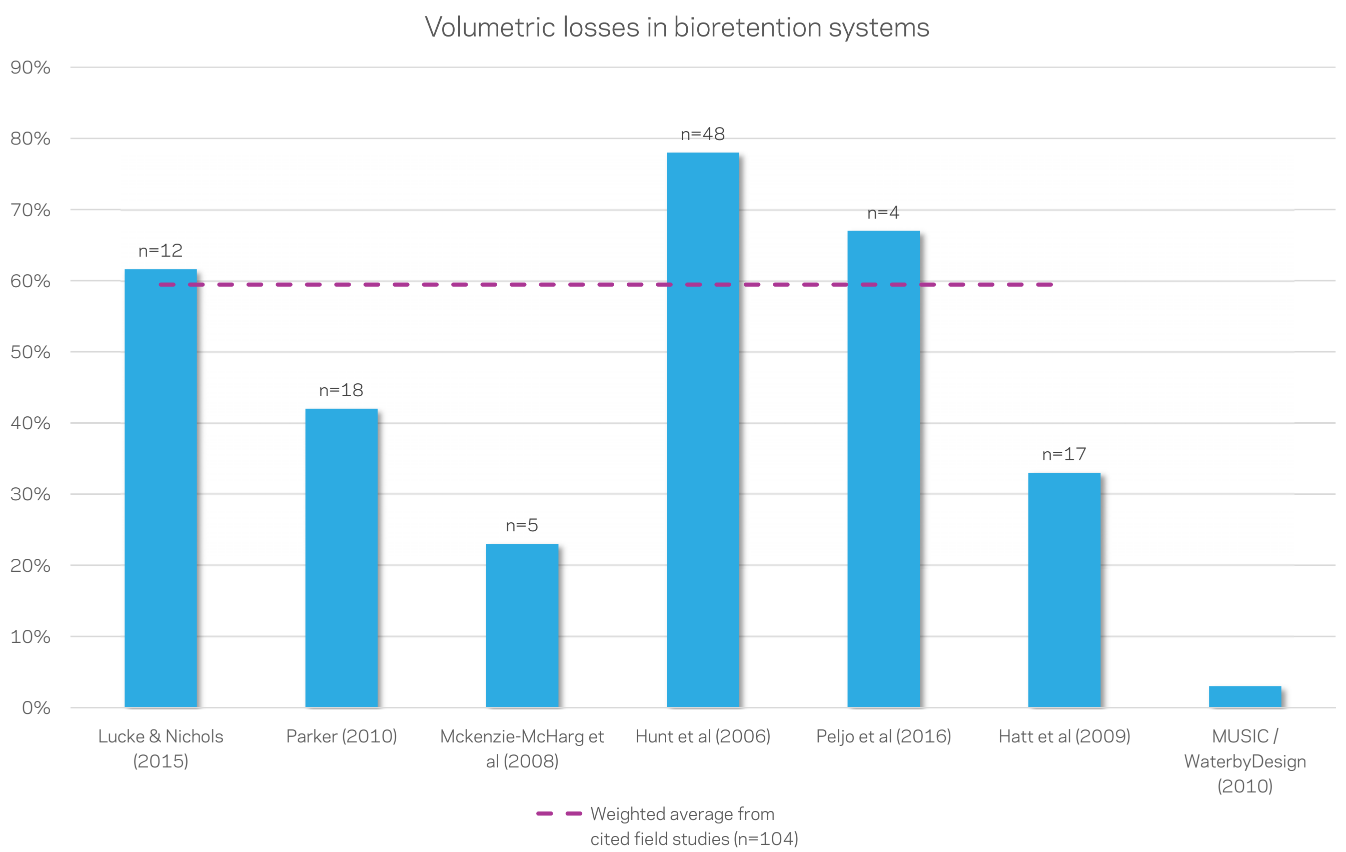
MUSIC has become the industry standard software for the simulation of bioretention system performance and, in Australia, most regulatory targets for stormwater quality are directly derived from MUSIC model predictions about the performance of reasonably sized bioretention systems.

We have undertaken a broad review of field studies on bioretention systems and found significant discrepancies between actual and modelled performance. Studies show bioretention systems act much more like a sponge than a filter, resulting in very large reductions in runoff volume (60% on average, a ten-fold increase on MUSIC estimates). Pollutant loads appear to be reduced primarily through volumetric loss, and multiple studies found no reductions in pollutant concentrations.

Interestingly, large losses have been observed for systems on heavy clays and with impermeable linings, and also for large storm events (including ~40% AEP scale events).

This has wide ranging implications for stormwater management.

This two-page summary is an extract from a longer paper being prepared for government and industry.



Overview of field studies

Study	Location	System details			Storm	No. Events	Volumetric Losses	Peak Flow Attenuation
		Lining	Size	Age				
Hatt et al (2009)	Vic, Aust.	Impervious liner	1%	4 yrs	Real storms	17	33% (15 - 83%)	80%
Hunt et al (2006)	NC, USA	Clay soils with very low permeability soils (0.0014-0.0042 mm/hr) with perched water table	5%	5 yrs	Real storms -1EY in magnitude. Rainfall events less than 6 mm were excluded from the analysis	48	78% (19% - 100%)	Not reported
Lucke & Nichols (2015)	Qld, Aust	Impervious plastic liner	1%	10 yrs	Controlled dosing to simulate 30min 39% AEP event	12	61.6% (32.7 - 84.3%)	79.5% - 93.6%
Mckenzie-McHarg et al (2008)	Qld, Aust.	Unspecified	5%	2 yrs	Controlled dosing, reflecting a 4EY storm (3kL)	5	23% (14 - 30%)	75%
Parker (2010)	Qld, Aust.	Clayey soils	4%	3 yrs	Real storms	18	42%	94%
Peljo et al (2016)	Qld, Aust.	Clayey soils	0.6% to 5%	2 yrs	Controlled dosing of four streetscape pods <50 m² each.	4	67% (39 - 87%)	Not reported

Implications

+ Stormwater management targets should be revised, with consideration given to an evidence-based approach to setting targets based on environmental needs.
+ Frequent flow objectives have been widely dismissed because, based on MUSIC modelling, it was assumed they could not be reasonably and practically achieved. There may now be scope to reintroduce frequent flow or volumetric targets to mitigate increased flows from urbanised catchments.
+ Minor storm events often influence the size of flood detention systems. Previous assumptions that bioretention systems only attended to very minor rainfall events and were insignificant in urban flood management are worth revisiting, especially given recent developments in *Australian Rainfall and Runoff 2016*. This may be particularly relevant for developments where measures are required to mitigate a potential downstream nuisance.
+ Bioretention filter media specifications should be revised with an increased emphasis on plant health and water retention. In terms of overall performance, increased organics are likely to be beneficial and previous concerns about excessive nutrient leaching, based on controlled laboratory studies, are likely to be overstated.
+ The high loss of water means bioretention systems are probably an inappropriate treatment measure wherever catchment yields are important, such as in stormwater harvesting schemes or in sustaining inflows to urban lakes.
+ In Queensland, the approaches recommended in *MUSIC Modelling Guidelines* (Water by Design 2010) are probably not leading to realistic performance estimates.
+ Given the significant quantity of bioretention systems being created across Australia, there is a case for increased and ongoing research and development into biofilter technology and design tools.
+ There are potential challenges for professional engineers who are required by some local authorities to design stormwater systems to current guidelines and also certify performance.

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