Keeping Sediment and Nutrients out of Streams in Arid/Semi-Arid Regions: Application of BMPs/LID/GI Practices

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Introduction

- **Best Management Practices (BMPs)/Low Impact Development (LID)/Green Infrastructure (GI) are widely used for their benefits in reducing stormwater runoff and nonpoint source pollution, particularly in regions where rainfall is abundant.**
- **Do arid/semi-arid regions with low annual precipitation need BMPs/LID/GI?**
- **Are any successful practices available to arid/semi-arid regions?**

Rainfall/Runoff Characteristics

- **In arid/semi-arid regions, precipitation mainly occurs during two periods: long-duration, low-intensity rainfall in winter; and short-duration, high-intensity rainfall in summer.**
- **Watersheds in arid/semi-arid regions often release water almost immediately after a storm due to sparse vegetation, steep topography, complex soils and rapid land development changes.**

Nonpoint Source Pollution

- **Excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas.**
- **Bacteria and nutrients from livestock, pet wastes and faulty septic systems.**
- **Sediment from improperly managed construction sites, crop lands, and eroding stream banks.**
- **Although the rainfall is episodic, studies indicate that soil erosion and sediment from semi-arid uplands and hill slopes, in response to rainfall, results in elevated streamflow solute concentrations and sediment transport.**

Objective

- **To review field performances of BMPs/LID /GI practices in arid/semi-arid regions, particularly their effectiveness on nutrients and sediment control.**

BMPs vs. LID

- Previous efforts have focused on using Best Management Practices (BMPs) (flow controls, vegetative stabilization, bioengineering, and filtration practices) to mitigate deleterious impacts of runoff water.
- Low-impact development (LID) techniques are an attractive alternative to BMPs.
- LID techniques offer decentralized designs for controlling runoff at the source.
- Examples of LID techniques are permeable pavements, rain water harvesting, infiltration swales, roof gardens and bioretention areas.

Examples of BMPs

- **Brush layer (mattress) to prevent stream bank erosion.**
- **Constructed wetlands provide valuable water quality benefits and environmental services.**
- **Construction site management involves planning and implementation activities before, during and after a construction project.**
- **Cross-vane weir diversion, a diversion dam, channels water to an alternate waterway such as an irrigation canal.**
- **Detention basins collect and temporarily store water or waterborne debris or sediment.**

Examples of LIDs

- Rainwater Harvest System
- Detention pond - dry
- Retention pond
- Rain garden
- Media filter
- Porous pavement
- Vegetated Swale, Buffer, and Strip
- Green Roof
- Infiltration Basin/Trench

Rainwater Harvest System

- **Rainwater harvest (RWH) systems collect and store rainfall for later use.**
- **RWH is designed to slow and reduce runoff, as well as provide irrigation water, reduce water bills and conserve municipal water supplies. They may be particularly attractive in arid/semi-arid regions to reduce demands on increasingly limited water supplies.**
- **The system includes actively storing collected water in a receptacle or changing surface topography to slow/capture runoff that increases water storage for sediments.**

Detention Pond-Dry

- **Dry detention ponds (also known as dry ponds or extended detention basins) are ponds whose outlets have been designed to detain stormwater runoff for a minimum of 24 hours to allow particles and associated pollutants to settle. Unlike wet ponds, they do not have a large permanent pool of water.**
- **Dry detention ponds are relatively effective in removing sediment and other pollutants associated with particulate matter.**
- **Dry detention ponds can protect the downstream channel if appropriately designed.**

Retention Pond

- **Retention ponds (RPs), (also known as wet retention ponds, wet extended detention ponds, or wet basins), are constructed basins that have a permanent pool of water throughout the year, or at least through the wet season.**
- **RPs are often used for water quality treatment purposes and for temporary runoff storage.**
- **RPs treat incoming stormwater runoff by allowing sediment particles to settle and algae to take up nutrients.**
- **RPs are difficult to justify in arid regions where water is scare because any supplemental water is needed to maintain a permanent pool.**

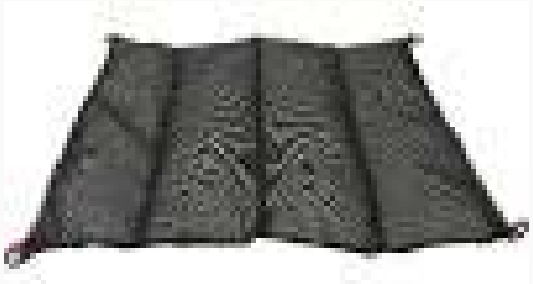
Retention Pond

Bioretention (Rain Garden)

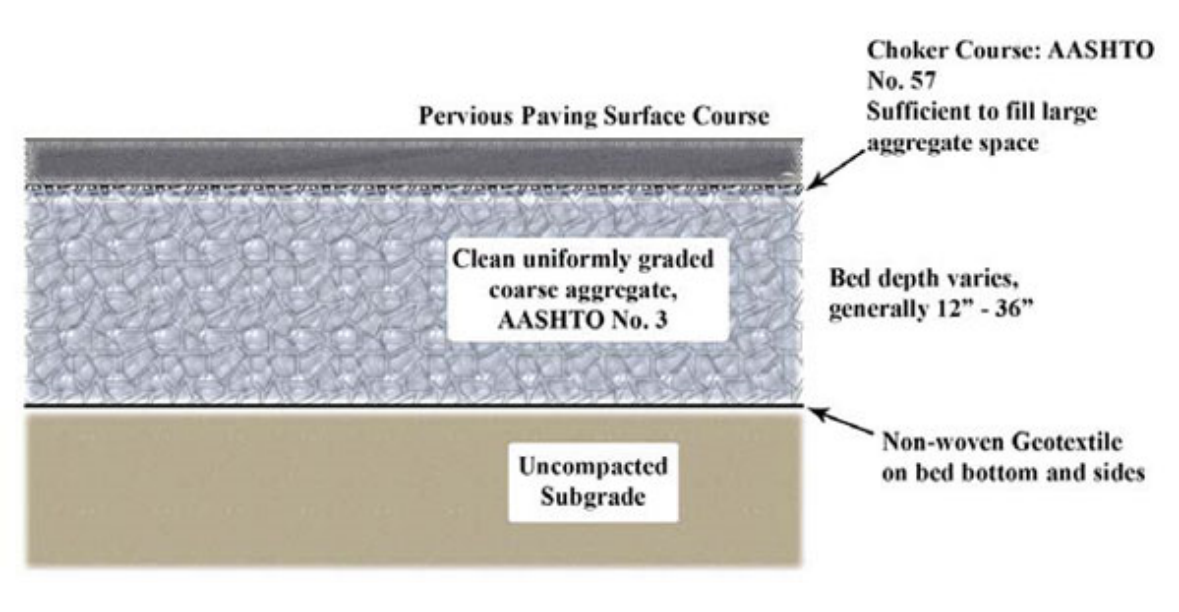
- **Bioretention (BR) or rain gardens are landscaping features adapted to provide on-site treatment of stormwater runoff.**
- **Rain gardens are commonly located in parking lot islands or within small pockets of residential land.**
- **Rain gardens direct surface runoff into shallow, landscaped depressions which are designed to incorporate many of the pollutant removal mechanisms operating in forested ecosystems.**

Media Filter

- **Stormwater media filter (MF) systems capture and temporarily store the stormwater and pass it through a filter bed of sand, organic matter, soil, or other media.**
- **Filtered runoff may be collected and returned to the conveyance system or allowed to exfiltrate partially into the soil.**
- **Filtering practices are generally adapted to provide pollutant removal, although exfilter designs provide some groundwater recharge.**
- **Sand filters are widely used in most regions of the country and on most site types (USEPA, 2000a).**



Porous Pavement



Vegetated Swale, Buffer, and Strip

- **Vegetated Swales (also known as grassed channel, biofilter, or bioswale) refer to vegetated, open-channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume (USEPA, 2000a).**
- **As stormwater runoff flows, it is treated by vegetation slowing the water to allow sedimentation, filtering through a subsoil matrix or infiltrating underlying soils. Swales are well-suited to treating highway or residential road runoff because they are linear practices (USEPA, 2000a).**

Green Roof

- **A green roof is a building rooftop partially or completely covered with vegetation over high quality waterproof membranes. It compensates for vegetation that was removed when the building was constructed (USEPA 2000b).**
- **It can be effectively in reducing stormwater runoff from commercial, industrial, and residential buildings; it also helps mitigate urban "heat island" effects.**

Infiltration Basin/Trench

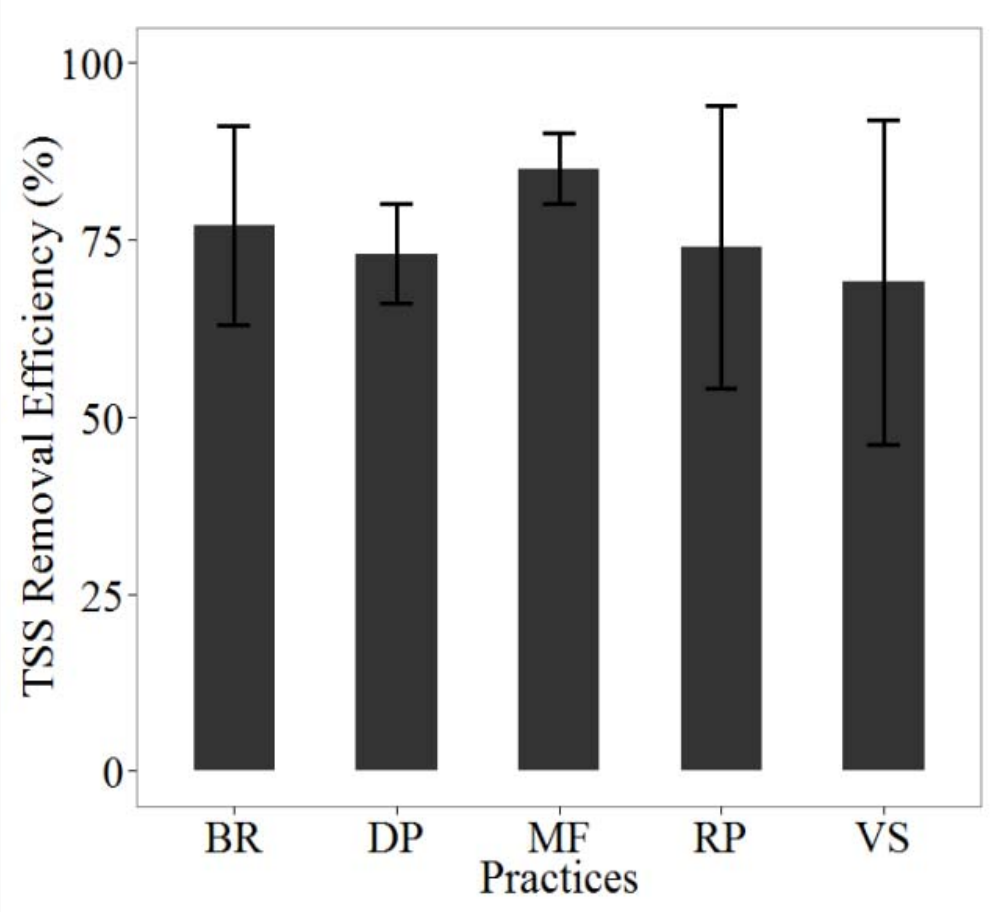
- **An infiltration basin/trench (also known as infiltration galley) is a rock-filled trench that receives stormwater runoff and has no outlet. It is designed to infiltrate stormwater into the soil.**
- **Stormwater runoff passes through some combination of pretreatment measures such as a swale and detention basin, and into the trench. Within the trench, runoff is stored in the void between the stones and infiltrates through the bottom into the soil matrix. (USEPA, 2000a).**

Infiltration Basin/Trench

Comparison of Runoff Reduction

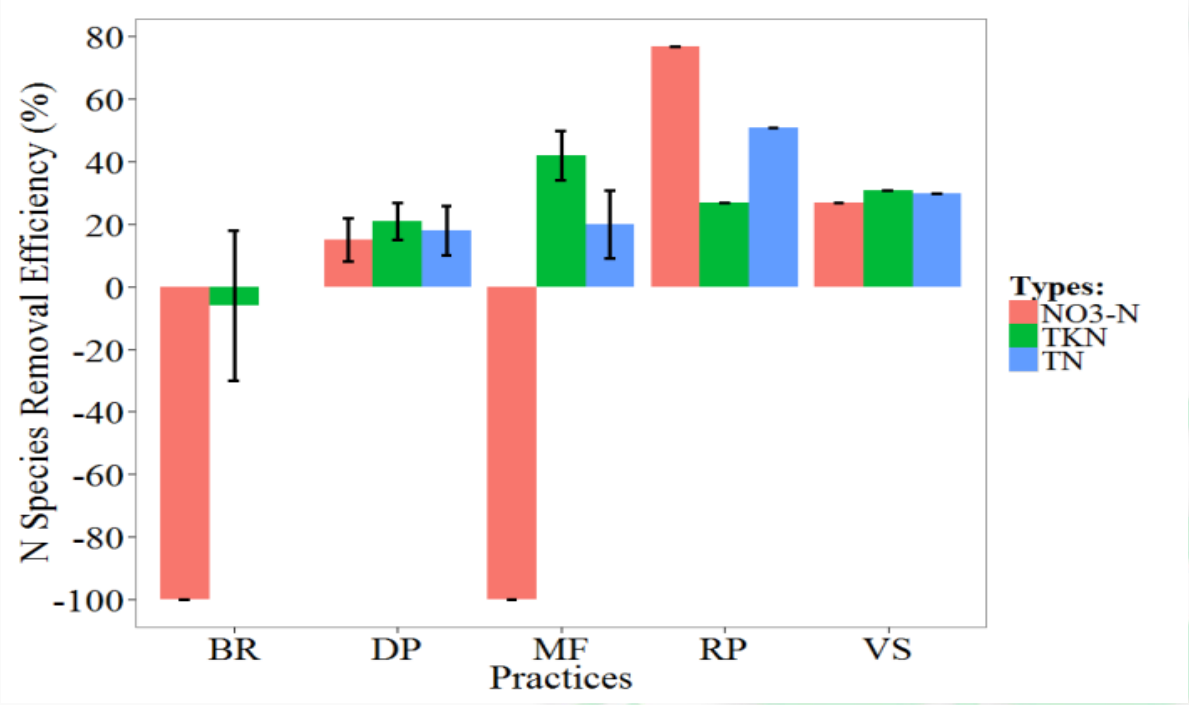
Practices	Rainwater Harvest (RWH)	Bioretention (Rain Garden) (BR)	Porous Pavement (PP)	Green Roof (GR)	
Median Runoff Volume Reduction*(%)	75	53	33-38	68.7	80
Location	Denver, Colorado	Lakewood, Colorado	Denver, Colorado	Denver, Colorado	Denver, Colorado
Rainfall	NA	Depths of studied event rainfalls ranged from 0.1 to 2.3 inch, with an average of 0.5 inch	NA	Depths of event rainfalls ranged from 0.1 to 1.9 inch, with an average of 0.5 inch	NA

Comparison of TSS Removal Efficiency of Different Practices



- **BR – Bioretention**
- **DP – Detention Pond**
- **MF – Media Filter**
- **RP – Retention Pond**
- **VS – Vegetation Swale**

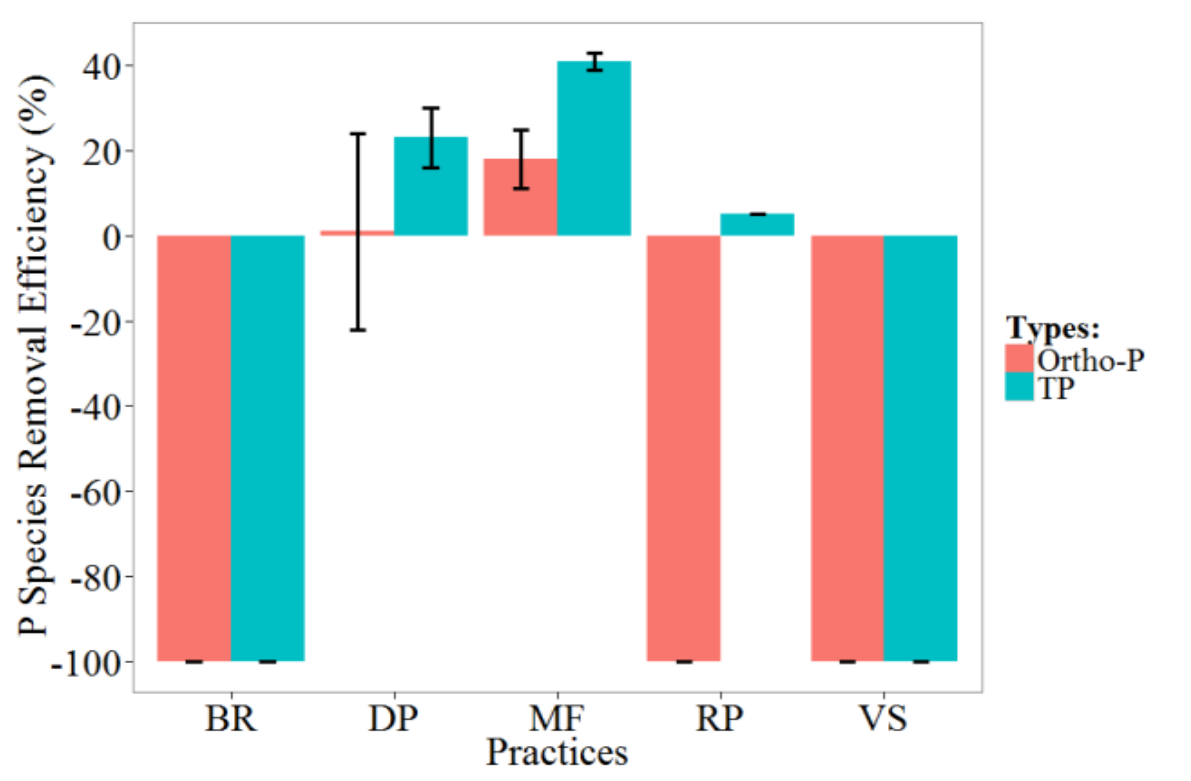
Comparison of Nitrogen Removal Efficiency of Different Practices



- BR – Bioretention
- DP – Detention Pond
- MF – Media Filter
- RP – Retention Pond
- VS – Vegetation Swale

- Bioretention and media filters both indicated export of NO_3-N, which might be related to the media itself.

Comparison of Phosphorous Removal Efficiency of Different Practices



- **BR – Bioretention**
- **DP – Detention Pond**
- **MF – Media Filter**
- **RP – Retention Pond**
- **VS – Vegetation Swale**

- **Detention pond and media filters showed moderate removal of TP and Ortho-P.**

Summary and Future Work

- **Reviewed LIDs are effective in removing TSS.**
- **Detention pond, vegetation swale and retention pond showed moderate removal of nitrogen, but bioretention and media filters indicated export of NO_3-N, which may be related to the media itself.**
- **Detention pond and media filters showed moderate removal of TP and Ortho-P, but bioretention, retention pond and vegetation swale showed export of phosphorous.**
- **Long-term field data are needed to better assess effectiveness of LIDs, particularly on nutrients.**

Thank you!

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