Management of Storm Water using Bioretention Filter Technique

Ruturaj Mali
UG student of Vidyavardhini's
College of Enggineering And
Technology
Mumbai University Mumbai, India

Dr. Sunil G. Kirloskar
Department of Civil Engineering
Mumbai University
Mumbai, India

Chinmay Thakur
UG student of Vidyavardhini's
College of Enggineering And
Technology
Mumbai University Mumbai, India

Yuvaraj Kokare
UG student of Vidyavardhini's
College of Enggineering And Technology
Mumbai University Mumbai, India

Nikhil Patil
UG student of Vidyavardhini's
College of Enggineering And Technology
Mumbai University Mumbai, Indi

***Abstract*- The ongoing development in various sectors of urban areas in recent times has let to several issues which has affected the sustainability of urban drainage systems. The decrease of pervious surface areas in urban regions hampers hydrology and water quality. Typical impacts to downstream hydrologic cycle include increased peak flows and runoff volumes, shorter lag times and reduced infiltration and base flow. Urban runoff leads to increase in the conveyance of pollutants and nutrients and thus degrading water bodies downstream from urban regions. Bioretention is one of the most used methods to lessen these impacts despite its large spread use, research on bioretention systems remains active, particularly in terms of mix design and nitrogen treatment. Recent research focusing on bioretention is reviewed herein. The use of mesocosms provides the ability to isolate particular treatment processes and replaced variability. Computational models have been adapted and applied to simulate bioretention, providing potential improvements to their maintenance, operations and design. Maintenance practices are important for sustained operation and have also been tested.**

Predicting maintenance is necessary for assessing lifecycle value. Due to these research recommendation are made for the future work and various gaps are explored.

NTRODUCTION:-

A bioretention cell is a type of under drained soil filter that collects, filters, and treats moderate amounts of stormwater runoff using conditioned planting soil beds, gravel under drained beds, and vegetation. The filter basin captures and retains runoff and passes it through a soil filter media that contains a mixture of silty sand and organic matter to remove a wide range of pollutants, including suspended solids, phosphorus, nitrogen, metals, hydrocarbons, and some dissolved pollutants. Once through the soil media, the runoff is collected in a perforated underdrain pipe system and discharged downstream. Bioretention basins are usually located in close proximity to the origin of the stormwater runoff and should be scattered throughout a residential area or along the downhill edge of smaller parking areas with a maximum drainage area to each individual filter.

LITERATURE REVIEW

General

Design guidance from the CSUS Office of Water Programs was selected for this project. The CSUS Office of Water Programs design guidance was selected because it provides details on the individual design components of the bioretention BMP for storm water treatment. The CSUS Office of Water Programs design guidance was partially adapted from Center for Watershed Protection (CWP).

Robert Kluge. Storm Drain Filtration System. March 2007.[1]

Bioretention is best applied when contributing slopes are between 1.5 to 4.5%. The proposed treatment area will be located in a natural depression to minimize the excavation. The surface of the filter bed should be flat so that allow flow to spread out and not concentrate in one area of the practice. However, for linear bioretention practices, such as those along roadways, the longitudinal slope has to be considered. A stepped multi-cell design can be used when a flat surface cannot be maintained along the length of a linear bioretention. Available Space: Designers should reserve open areas of about 15 to 25% of the size of the contributing drainage area. These are areas that would be typically set aside for landscaping. More space is required for designs with soft and shallow side slopes than those with hard, vertical edges.

David Alderete and Misty Scharff. The Design of a Bioretention Area to treat Highway Runoff and Control Sediment. February 2005.[2]

Pretreatment prevents premature clogging of bioretention facilities by capturing coarse sediment particles before they reach filter bed. In some cases, where drainage areas produce little sediment, such as rooftops, bioretention can function effectively without retreatment. A two- cell design that incorporates a forebay is recommended for bioretention with the available space and high sediment load drainage areas. Several pretreatment measures are feasible, depending on the method of conveyance and the drainage area: Two-cell design (channel flow): Forebay ponding volume should account for 25% of the water quality storage requirement and be designed with a 2:1 length to width ratio. This pre-treatment device is the most effective and can be designed for easy sediment- removal.Vegetated filter strip (sheet flow): Should ideally be a minimum of three metre in width. However, space constraints at some bioretention sites prohibit this width. If smaller strips are used, more frequent maintenance of the filter bed can be anticipated. See Section 4.6 for additional detail about vegetated filter strips. Gravel diaphragm (sheet flow): A small trench filled with pea gravel, which is perpendicular to the flow path between the edge of the pavement and the bioretention practice will promote settling out of sediment. It also acts as a level spreader, maintaining sheet flow into a facility. If the contributing drainage area is steep, then larger stone should be used in the diaphragm. A drop of 50-150 mm into the gravel diaphragm can be used to dissipate energy and promote settling. Rip rap and/or dense vegetation (channel flow): These energy dissipation techniques are acceptable pretreatment on small bioretention cells with a drainage area of less than 100 square meters. Gutter screens: Screens are appropriate for pretreatment of runoff from roof leaders.

Allen Davis, Robert G. Traver and William Hunt. Improving Urban Stormwater Quality: Applying Fundamental Principles. December 2010.[3]

Media is a key factor in bioretention design. Selection criteria are intended to improve runoff reduction and pollutant removal performance of bioretention and address local conditions. Examples of selected specifications from Virginia Department of Conservation; Maryland Department of the Environment; and Delaware Department of Natural Resources and Environmental Control and Recreation are compared for hydrologic management effectiveness, pollutant removal efficiency, construction and maintenance costs, and constructability. In general, a typical bioretention ideally contains approximately 50%–60% sand and 40%–50% mix of loam/sandy loam/loamy sand on a per volume basis. Clay content should be minimized to maintain proper cell hydrology, ideally in the range of 5%–8% . A media with too much clay may reduce infiltration into the media. There are a wide variety of bioretention blends.

Thomas R., Claytor R. Maryland Stormwater Design Manual. January 2000.[4]

Only needed where native soil infiltration rate is less than 15 mm/hr (hydraulic conductivity of less than 1x10-6 cm/s). Should consist of a perforated pipe embedded in the coarse gravel storage layer at least 100 mm above the bottom of the gravel storage layer. HDPE or equivalent material perforated pipes with smooth interior walls should be used. Pipes should be over-sized to accommodate freezing conditions. A minimum 200 mm diameter underdrain is recommended for this reason. Underdrains should be capped on the upstream end(s). A strip of geotextile filter fabric placed between the filter media and pea gravel choking layer over the perforated pipe is optional to help prevent fine soil particles from entering the underdrain.

Terry Lee Siviter, Larry S. Coffman and Brain Richard Hofe.
Stormwater Bioretention Filteration System With Overflow/Bypass Capability. September 2008.[5]

Bioretention requires routine inspection and maintenance of the landscaping as well as periodic inspection for less frequent maintenance needs or remedial maintenance. Generally, routine maintenance will be the same as for any other landscaped area, weeding, pruning, and litter removal. Routine operation and maintenance tasks are key to public acceptance of highly visible bioretention units. Periodic inspections after major storm events will determine whether corrective action is necessary to address gradual deterioration or abnormal conditions. For the first two years following construction the facility should be inspected at least quarterly and after every major storm event (> 25 mm). Subsequently, inspections should be conducted in the spring and fall of each year and after major storm events. While maintenance can be performed by landscaping contractors who are already providing similar landscape maintenance services on the property, they will need some additional training on bioretention needs. This training should focus on elevation differences needed for ponding, mulching requirements, acceptability of ponding after a rainstorm, and fertilizer requirements. The planting plan should be kept for maintenance records and used to help maintenance staff identify which plants are weeds or invasive. Aside from homeowner-initiated rain garden projects, legally binding maintenance agreements are a necessity for bioretention facilities on private property. Agreements should specify the property owner's responsibilities and the municipality's right to enter the property for inspection or corrective action. Agreements must require regular inspection and maintenance and should refer to an inspection checklist. The construction contract should include a care and replacement warranty to ensure vegetation is properly established and survives during the first growing season following construction.

Methodology

The original bioretention design consists of the following components: (1) pretreatment;
(2) ponding area; (3) organic layer; (4) planting material; (5) planting soil; (6) sand bed layer;
(7) underdrain collection system; and (8) bypass structure.[2]

Pretreatment

There are two pretreatment components selected for this design project: a bioswale and a litter removal device (LRD). The purpose of the bioswale is to reduce the amount of sediment that enters the bioretention area. The LRD serves two functions:

(1) concentrate the gross solids to one point for ease in cleaning; and

(2) provide energy dissipation.

The bioswale will be 15 m (49.2 ft) long and 610 mm (24 in) deep. The slope is set at 1.5 percent. The LRD will be placed in the bioswale. The LRD is 8.2 m (27.0 ft) long with a 600 mm (24 in) diameter. The LRD utilizes modular well casings with 5 mm x 64 mm (0.2 in x 2.5 in nominal) louvers to remove trash from storm water runoff.[2]

Ponding Area

The ponding area provides surface storage for the WQV. Sediments not removed in the pretreatment components will settle out within the ponding area. Storm water runoff will be ponded to a depth of 152 mm (6 in). The surface area is designed at 0.09 ha (0.22 ac).[2]

Organic Layer

An organic layer consisting of fine shredded hardwood mulch will be applied over the top of the bioretention area. The purpose of the organic layer is to filter finer particles from the storm water runoff and maintain soil moisture in the planting soil. The mulch layer should be: well- aged, stockpiled or stored for at least 12 months; uniform in color; and free of other materials, such as weed seeds, soil, roots, etc. The mulch should be applied to a maximum depth of 76.2 mm (3 in).[2]

Planting Material

The purpose of the planting material is to encourage diverse biological and bacteriological activity in the soil and to establish a diverse plant cover that will aid in the treatment of storm water runoff through the uptake of

Under drain Collection System

The under drain collection system collects the storm water runoff that has filtered through the planting soil. The underdrain collection system consists of 150 mm (6 in) perforated PVC pipe laterals placed in a 305 mm (1 ft) gravel layer. The PVC laterals are perforated every 152 mm (6 in) with three holes evenly spaced around the pipe circumference. The PVC laterals are typically spaced at a maximum of 3 m (10 ft) in the underdrain gravel.[2]

pollutants.

Vegetation selection also requires adaptation to the highway environment. Vegetation must be able to withstand periods of saturation and drought. Where possible, plants native to the area of the project site were selected for use.[2]

Planting Soil

The planting soil provides bedding and nutrients for the planting material in the bioretention area. The planting soil will have the characteristics presented in Table 3.1

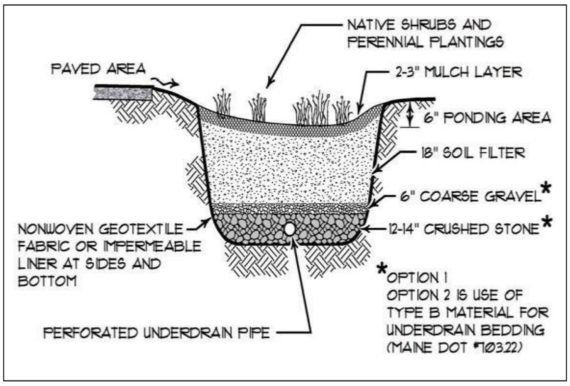
Parameter	Value
pH range	5.2 to 7.0
Organic Matter	1.5% to 4.0%
Magnesium	39.2 kg/ha (35 lb/ac), Minimum
Phosphorus (P2O5)	84.0 kg/ha (75 lb/ac), Minimum
Potassium (K2O)	95.3 kg/ha (85 lb/ac), Minimum
Soluble Salts	500 ppm
Clay	10% to 25%
Silt	30% to 55%
Sand	35% to 60%
Permeability	0.31 m/d (1.0 ft/d)

Table 3.1 Planting Soil Characteristics.

Table 3.2 - Sandy Loam to Fine Sandy Loam Specifications	
Sieve #	**% by Weight**
4	75-95
10	60-90
40	35-85
200	20-70
200 (clay size)	< 2.0

Bypass Structure

Bioretention areas can be constructed as either on- line or off-line treatment systems. For an off-line treatment system, storm water runoff flows in excess of the design storm are routed around the bioretention area through a diversion structure. For an on-line treatment system, storm water runoff flows in excess of the design storm are routed into the bioretention area but through a bypass structure. The bypassed flows are not treated. A bypass structure routes storm water in excess of the WQV into a 900 mm (36 in) reinforced concrete pipe (RCP). The bypass structure will be fitted with a debris rack/litte.[2]



Maintenance

The bioretention basin should be inspected semi- annually and following major storm events. Debris and sediment buildup should be removed from the forebay and basin as needed. Any bare area or erosion rills should be repaired with new filter media, seeded and mulched.

- *Maintenance Agreement:* A legal entity should be established with responsibility for inspecting and maintaining any filter basin. The legal agreement establishing the entity should list specific maintenance responsibilities (including timetables) and provide for the funding to cover long-term inspection and maintenance.
- *Drainage:* The filter should be draining within 48 hours following a one-inch storm or greater. If the system drains too fast, an orifice may need to be added on the underdrain outlet or may need to be modified if already present.
- *Sediment Removal:* Sediment and plant debris should be removed from the pretreatment structure at least annually.
- *Remedial Cover:* The organic mulch should be removed and replaced with a 2-3 inch layer of fresh mulch annually or as needed.
- *Soil Filter Replacement:* The mulch shall be replaced with fresh material on a yearlybasis.
- *Fertilization:* Fertilization of the filter area should be avoided unless absolutely necessary to establish vegetation.
- *Harvesting and Weeding:* Harvesting and pruning of excessive growth should be done occasionally weeding to control unwanted or invasive plants may also benecessary.
- *Planting:* Maintaining a healthy vegetative cover will minimize clogging with fine sediments. If ponding exceeds 48 hours, the top of the filter bed should be rototilled to reestablish the soil's filtration capacity.
- *Soil Filter Replacement:* The top several inches of the filter can be replaced with fresh material if water is ponding for more than 72 hours.

TDS & TSS TEST

Experimental Programme Testing of strom water sample.

CHLORIDE TEST

- Todetermine the chlorides of the storm water sample as per IS-3025 (part 32)
- Chloride present in sample:-8.9334mg/l

Todetermine the total dissolved and suspended solids in the storm water sample with the stipulation as per IS:-3025 (part 16&17)

PH & HARDNESS TEST

Figure 3.5-PH Test

SIEVE ANALYSIS OF SOIL SAMPLE

Figure 3.6-sieve analysis

EXPERIMENT OF MODEL ON BOTTLE

RESULT & DISCUSSION

TESTS PERFORMED	RESULTS
PH TEST	7.24
CHLORIDE TEST	8.9334mg/l
HARDNESS TEST	185mg/l
TDS & TSS TEST	TDS:- 800mg/l TSS:- 2000mg/l

content of the water was not appropriate for use of that water in day to day life .As the runoff water carry lot of impurities along its way. The bio-retention filter technique of filtering and fast percolation of storm water has great recognition in foreign countries and in India were stagnation of storm water and large no. of drought region it is very important to save and store the water we obtain naturally. Bio- Retention help us to store the runoff water as well as improve the bad condition of stagnation of water due to its capability of fast infiltration

Final Comment on work carried out

After the test perform on storm water we selected the appropriate filter media and size of the model obtain from research paper

The sample of water was again to be tested by passing it through filter media but due to the worldwide pandemic of COVID-19 and the lockdown announced by the Indian Government in this repercussions, the water sample could not be tested further.

Bio-retention system can be implemented to manage storm water by quality as well as quantity purpose to use it in future

Study can be carried out on the infiltration rate of water by passing it through filter media is yet to be determined

Future Scope

After performing the various test on the
following storm water obtained. We observed that the hardness and the oxygen

REFERENCES

1. Claytor. R. and T. Schueler (2009),[1] "New Jersey Storm water Best Management Practices Manual",(pg. no. 1-23) www.njstormwater.org
2. David Alderete and Misty Scharff (2005),[2] "The Design of a Bio retention Area to treat Highway Runoff and Control Sediment", (pg. no. 1-10).(International Erosion Control Association(IECA)).
3. Allen Davis, Robert G. Traver and William Hunt (2010),[3] "Improving Urban Storm water Quality: Applying Fundamental Principles",(Centre for Urban Greenery & Ecology, Singapore).
4. Robert Kluge (2007), [4]"Storm Drain Filtration System".(State Environmental Protection Key Laboratory of Microorganism Application and Risk Control (MARC)).
5. Terry Lee Siviter, Larry S. Coffman and Brain Richard Hofe.(2008)."Storm water Bio retention Filtration System With Overflow/Bypass Capability",(International Journal of Civil Engineering Research).
6. William F. Hunt, Bill Lord, Benjamin Loh and Angelia Sia (2015),"Plant Selection for Bio retention Systems and Storm water Treatment Practices",(pg. no. 7-20).
7. Thomas R., Claytor R. (2000). "Maryland Storm water Design Manual."(Research Journal of Science and Technology).
8. Davis, A., M. Shokouhian, H. Sharma, C. Minami and D. Winogradoff. 2003. Water Quality Improvement Through Bioretention: Lead, Copper, and Zinc Removal. *Water Environment Research.* 75(1): 73-82.
9. Ermilio, J. 2005. Characterization study of a bio-infiltration stormwater BMP. M.S. Thesis. Villanova University. Department of Civil and Environmental Engineering. Philadelphia, PA
10. Howard, K.W.F. and Beck, P.J. 1993. Hydrogeochemical implications of groundwater contamination by road de-icing chemicals. *Journal of Contaminant Hydrology*. Vol. 12. pp. 245-268.
11. Heasom, W., Traver, R., and Welker, A. 2006. Hydrologic Modeling of a bioinfiltration best management practice. *Journal of American Water Resources Association*. 42(5): 1329-1347.