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Management of Urban Stormwater Using Bio-retention Filter Technique

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Abstract**—***The continued development of urban areas in recent decades has caused multiple issues affecting the sustainability of urban drainage systems. Urban runoff is surface runoff of precipitation created by urbanization. This runoff is a major source of flooding and water pollution in urban communities worldwide. Impervious surfaces, such as roads, parking lots, rooftops and footpaths are constructed during land development. During rain storms and other precipitation events, these surfaces carry polluted stormwater to storm drains, instead of allowing the water to percolate through soil. Most municipal storm sewer system discharge stormwater without treatment to streams, rivers and other water bodies. Urban runoff carries a mixture of such pollutants as sediment, fertilizers, bacteria, metals and more. Effective control of urban runoff involves reducing the velocity and flow of stormwater, as well as reducing pollutant discharges. A variety of stormwater management practices and systems may be used to reduce the effects of urban runoff. Bioretention is the process in which contaminants and sedimentation are removed from stormwater runoff. Stormwater is collected into the treatment area which consist of a vegetation, sand bed, ponding area, organic layer or mulch layer and under drain collection system.*

Keywords—Bioretention, stormwater management practices, urban drainage systems, under drain collection system.

I. INTRODUCTION

1.1 General

A bioretention cell is a type of under drained soil filter that collects, filters, and treats moderate amountsof stormwater runoff using conditioned planting soil beds, gravel underdrained 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.

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1.2 Objectives

- To identify the area which frequently gets affected by stormwater.
- To design a bio-retention filter system using plantation, soil bed, engineering soil media, underdrained pipe system.
- To collect the stormwater, filter it and store for various purposes including groundwater recharge.

1.3 Scope of Study

This paper gives the information about the management of urban stormwater using bio-retention filter technique. Due to implementation of bio-retention filter we can remove various impurities such as nitrogen, phosphorous, chlorine etc. from the stormwater and will be able to use this water during the dry seasons and also for groundwater recharge. Large amount of stormwater gets wasted during rainfall also the water scarcity is the major problem in our country thus implementation of bio-retention filter technique can manage this stormwater by quality as well as quantity purpose to use it in future.

II. MATERIAL AND METHOD

2.1 Materials

Under Drain Collection System
The underdrain 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.

Underdrain Gravel
Gravel of size 10 mm to 20 mm will be used and gravel layer will be of 305 mm.

Sand Layer
Fine sand of size 0.5 mm to 1 mm will be used. Depth of sand bed will be 305 mm.

Planting Soil
The planting soil provides bedding and nutrients for the planting material in the bioretention area.

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).
Plantation
Vetiver Grass
Maximum height: 1.5m
Water preference: Moderate Water
Origin: Tropical India
Percentage of Nitrate Removal: 93%
Garden Croton
Maximum height: 3 m
Water preference: Moderate Water
Origin: South India
Percentage of Nitrate Removal: 67%
Lemon Grass

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Maximum height: 1.2m- 1.8m
Water preference: Moderate Water
Origin: Southern Asia
Percentage of Nitrate Removal: 95%

2.2 Methodology

The project is basically divided into two main stages.
1. Initial stage
2. Final stage

In initial stage the stormwater is collected from surface runoff and tested in lab without filtering the water. According to Maharashtra Pollution Control Board (MPCB) nine water quality parameters are selected for calculating the water quality index are as follows,

- Dissolved Oxygen (DO)
- Fecal Coliform (FC)
- pH
- Biochemical Oxygen Demand (BOD) (5-day)
- Temperature change (from 1 mile upstream)
- Total phosphate
- Nitrate
- Turbidity
- Total Solids

The expression for calculation the NSFWQI is expressed as;
$NSFWQI = \sum_{i=1}^{p} WiIi$
Where;
Ii= sub index for i^{th} water quality parameter
Wi= weight (in terms of importance) associated with water quality parameter
P= number of water quality parameters

Weights for computation of WQI based on DO, FC, pH and BOD, Sub index equation used to calculate NSF WQI for DO, FC, pH and BOD, Water Quality Classification and Best Designated use are calculated as per given BIS 10500, (2004-2005)

In final stage of project, the same stormwater is tested in lab again but this time the water is filtered through bioretention filter constructed using the materials used.
Relative Weight of chemical parameters used for calculating WQI for Ground water can be calculated using BIS 10500
Thus, after calculations the water quality can be determined using the ground water classification based on water quality index given in Water Quality Status of Maharashtra 2018-2019.

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III. RESULTS AND CALCULATION

Due to implementation of Bioretention filter we can collect the stormwater which gets wasted due to lack of stormwater management techniques. Bioretention filter helps to collect, filter and store the stormwater and use the same in dry season. This water can be used for groundwater recharge, floor cleaning in malls, gardening and household purpose.

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