Bioswales: Green Alternative for Storm Water Management & Flash Flooding

Srishti Chavan

Dept. of Civil Engineering, Vishwakarma Institute of Information Technology, Pune, Maharashtra, India.

Abstract - *Flash flooding and storm water management are two of major concerns faced in urban settlements in relation with water channeling and management. As the requirement of land will keep on increasing, more land will be used for construction and paving thus making it impervious. This will lead to comparatively less surface area on the ground for percolation of water. Urbanization also causes pollution of storm water as it passes through the city to nearest water body by gravitational force. This degrades the quality as well as quantity of storm water that percolates into the ground water table. The purpose of this paper is to explore the concept of bioswales and how they can be effectively used to percolate maximum pure storm water in the water table. In general, we can say that bioswales are effective in removing water pollutants in urban areas. Bioswales are very sustainable, cost effective, environmentally friendly and easy to construct. They are an excellent example of green infrastructure.*

Key Words: bioswales, storm water management, vegetated swales, green infrastructure, water harvesting structure, potential recharge

1.INTRODUCTION

A flash flood can be defined as: "a flood that rises and falls quite rapidly with little or no advance warning, usually as a result of intense rainfall over a relatively small area". Despite the increase in advanced technologies, society is still vulnerable to flash floods. People are exposed to higher risks as cities are expanding at an accelerated pace and economies are fueled by urbanization. Flash floods continue to claim the lives of many people all around the world. They also cause damage to property and infrastructure and incur economic losses. Flash floods severely affect the surrounding environment. Nowadays, there is a strong demand for land for buildings, along with agricultural land and sites for various industrial projects. The land that is used for urbanization and industrialization has impervious surface. This leads to decrease in the land surface for surface runoff and water channeling in the urban areas.

This study looks into the topic of bioswales and specifically its possible use in metropolitan areas. The development done has lasting consequences on the urban landscape, with one of the most notable elements of transition being urban densification and loss of public open space/green areas. Urban densification and increased paved surfaces have major environmental consequences, including flash flooding, water pollution, and habitat destruction. Traditional storm water systems are frequently insufficient to absorb and treat all surplus water runoff, resulting in flooding in diverse urban areas. Modern storm water management measures, on the other hand, have yet to be adopted. This study believes that using bioswales as green infrastructure components could considerably improve storm water management. As a result, this study explores the key urban design concepts of bioswales, investigates typical urban environments that utilize these green infrastructure elements, and evaluates the feasibility of their application in urban areas.

2. LITERATURE REVIEW

1) BIOSWALES AS ELEMENTS OF GREEN INFRASTRUCTURE – FOREIGN PRACTICE AND POSSIBILITIES OF USE IN THE DISTRICT OF THE CITY OF NIŠ, SERBIA (Milena Dinić-Branković, Petar Mitković, Ivana Bogdanović-Protić, Milica Igić, Jelena Đekić)

Implementing bioswales as green infrastructure features can considerably improve storm water treatment as well as the architecture of diverse urban forms, resulting in more positive environmental consequences. This report proposed some potential locations where bioswales could be used as green infrastructure to remediate storm water runoff in a residential district of the City of Ni. Vegetated swales are low-cost and appealing, and they can provide wildlife habitat as well as visual advantages. Urban regions gain long-term sustainability by including bioswales into retrofit projects and new buildings.

2) PERFORMANCE OF TWO BIOSWALES ON URBAN RUNOFF MANAGEMENT (Qingfu Xiao, E. Gregory McPherson, Qi Zhang, Xinlei Ge and Randy Dahlgren)

This study looked at the effectiveness of two bioswales in Davis, California, eight years after they were built. The treatment bioswale was 9 m 1 m 1 m in length, width, and depth. The native loam soil was replaced with an engineered soil mix (75% native lava rock and 25% loam soil). After eight years, the bioswale with estimated soil mixtures was operating at full capacity. When compared to a standard control plot bioswale utilizing native soil, the bioswale using engineered soil mixes removed significantly more contaminants. The research shows that bioswales with engineered soil mixes can be quite useful in storm water management. Trees planted in engineered soil mixes flourished as well as trees planted in natural productive agricultural soil.

3) EVALUATING THE WATER QUALITY BENEFITS OF A BIOSWALE IN BRUNSWICK COUNTY, NORTH (Rebecca A. Purvis, Ryan J. Winston, William F. Hunt, Brian Lipscomb, Karthik Narayanaswamy, Andrew McDaniel, Matthew S. Lauffer and Susan Libes)

Typical roadside planted swales do not always provide constant pollutant removal. Bioswales are constructed with an underlying soil media and an underdrain to promote infiltration and pollutant removal. Total suspended solids (TSS), total volatile suspended solids (VSS), enterococcus, E. coli, and turbidity were all measured in the samples. For all contaminants tested, underdrain flow was much cleaner than untreated road runoff. Filtration removed more than 55% of FIB and more than 85% of TSS, indicating that it is an effective removal mechanism for these pollutants. Bioswales can be built within existing rights-of-way, and the water that infiltrates the media is cleaner than surface flow for common pollutants. This case study shows that the function of bioswales should be investigated further as a function of the watershed size to bioswale length ratio, the impact of slope, drainage area features, soil media type, and so on. This will enable for the creation of design standards for bioswales.

4) BIOSWALES AND GREEN INFRASTRUCTURE: THE NATURAL PURIFICATION OF POLLUTED WATER (Lauren Wilmoth, Katherine Lebrun, Matthew Jaros)

Bioswales have the potential to replace and improve upon man-made methods of water purification. Bioswales and green infrastructure are low-cost, require a small number of resources, and can be constructed in nature without disturbing delicate ecosystems or displacing local population. Bioswales that use plants to purify water should only be implemented in areas where the plants are native to avoid invasive species and ensure effectiveness. Environmentally, bioswales combat water pollution, strengthen the presence of plant species in their native environments, and contribute toward a healthier ecosystem for all life. Bioswales relieve strain on neighboring grey infrastructure, lowering maintenance costs as well. Socially, bioswales make the world around them more beautiful and healthier. Water quality enhances quality of life, and access to green space boosts mood. At the moment, bioswales are not totally replacing grey infrastructure, but they can improve water filtration systems that are already in use in metropolitan areas. It is feasible that bioswales and other forms of green infrastructure will ultimately become widespread enough to gradually replace grey infrastructure.

3. METHODOLOGY

Before we begin studying the details of bioswales, it is imperative that we study how percolation works on different landscapes. In order to understand this, we are going to study the experiment conducted by Dr. Robert Thompson from the University of Reading's Department of Meteorology in the UK. This experiment demonstrates the dangerous effect that heatwaves can have on the ground's water percolation rate. In this experiment, a glass of water was upturned on wet grass, moist grass and parched grass. Wet grass took nine seconds to absorb the water, moist grass took 52 seconds and parched grass took approximately 15 minutes. The water given to the parched grass was also prone to puddling on top of the ground, rather than being absorbed into it. By comparing the time taken by each glass, the experiment demonstrates how heavy rainfall in a area with less to no vegetation can be hazardous and lead to flash flooding.

Figure 1: Effects of heatwaves on ground's water table

From this experiment, we can conclude that land covered with vegetation are comparatively better equipped to combat flash flooding than a regular channels used for storm water management.

A bioswale, also known as a vegetated swale, is a linear design for bio retention that is used to partially improve storm water runoff quality, reduce risk of flooding, and channel storm water away from vital infrastructure. Bioswales are gently sloping depressions that are planted with lush vegetation or grass to treat storm water runoff from rooftops, streets, and parking lots. The slope allows water to flow more effectively through the system. Bioswales absorb low-flowing runoff or transport it to storm sewer inlets or directly to surface waters during heavy rains. Bioswales can serve as an alternative or supplement to standard storm sewers as conveyance systems.

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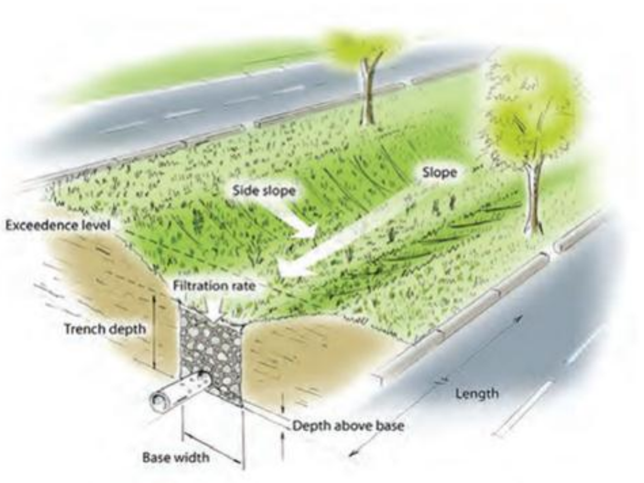

Figure 2: Bioswale and its components

Design of Bioswales: Bioswales are usually trapezoidal or parabolic shaped channel which is designed to treat and infiltrate incoming storm water. This water is used to help direct large storm water flow volume from a large catchment area to a connected discharge point and further to a bioswale. The maximum design capacity of a bioswale is of drainage areas up to 1 acre. The ideal design of bioswale has 1 to 2 percent slope up to maximum 5 percent. Check dams can be used in case of steeper slopes in order to reduce storm water velocity and prevent erosion. The filter media used in the bioswale is a blend of loam, sand, and compost specifically engineered to meet the required infiltration rates and porosity needed for storm water filtration and enhanced water quality for supporting plant life in bio retention areas.

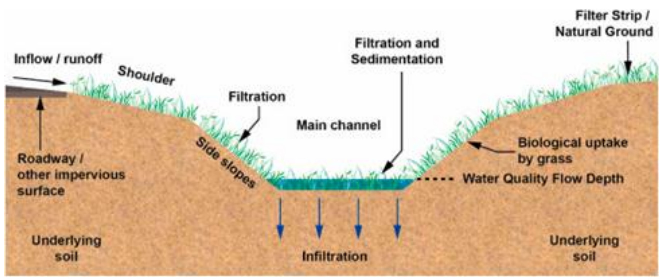

Figure 3: Section of Bioswale

While there are very few specific calculations which need to considered while designing a bioswale, there are some details that should be taken into considered that are as follows:

i. Bioswales are usually built surrounding or towards the sloping end of high volume water flow areas like parking lots, highways, large open spaces, etc.

ii. The bioswales need to be designed to address a certain storm event such as the two year or ten year 24-hour storm event.

iii. The effectiveness of bioswales is dependent upon the retention time of the storm water in the bioswale. The longer the retention time, generally, the higher the removal efficiency.

iv. The type of vegetation and the life cycle that the vegetation also effects the pollutant removal rate. Native species should always be preferred for plantation in bioswales as they require less maintenance.

v. The vegetation used in bioswale must provide a dense cover and roots that holds the soil in place in order to resist erosion and during heavy runoff flow, it must stand upright in order to provide maximum retention time and pollutant removal.

vi. Vegetation should tolerate a bioswales' soil conditions (pH, compaction, composition) and tolerate periodic flooding and drought.

vii. Vegetation used should be perennial and must be active during the entire period of the year so that the impurities are treated properly.

v. Since bioswales are primarily used for storm water channeling, it is imperative that the contours of the area are studied while deciding the path of the bioswale.

4. CONCLUSIONS

The studies have shown that bioswales can indeed be a sustainable option for storm water management and river basin channeling. If done on a wider scale, it can help in reducing the impact of flash flooding on a large scale. The main objectives of building bioswales are storm water management and purification of storm water runoff. While at the current stage, bioswales cannot completely replaced the gray infrastructure which is used but it can be supplementary in the purification process as bioswales can help in immobilizing or breaking down a large number of contaminants found in storm water runoff. It has achieved high levels of removal of suspended solids (TSS), turbidity, and oil and grease as found in various studies conducted. They can also eliminate a modest percentage of metals and nutrients in runoff.

Bioswales have been implemented as pilot projects in various parts of the world such as California, Serbia, etc. The results have proven bioswales to be effective in managing storm water runoff as well as reducing the impurities in the runoff to a large extent. They are environmentally sustainable and cost-effective as compared to the currently used infrastructure for managing storm water runoff on small scale.

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