ECOLOGICAL AND COST-FRIENDLY STRATEGIES FOR KHARE MALA NALA STRETCH AT SHIRUR BY IMPLEMENTATION OF BIOSWALE

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Abstract— **This research focuses on the implementation of bioswales as an ecological and cost-effective strategy to enhance water quality, manage stormwater runoff, and promote sustainable urban drainage. The study assesses the current condition of the Khare Mala Nala stretch, identifying key environmental challenges and evaluating the feasibility of bioswale integration. Additionally, the study explores the ecological benefits of bioswales, such as habitat creation and urban beautification. By implementing bioswales, this research proposes an innovative approach to restoring the ecological balance of the Khare Mala Nala stretch while ensuring long-term cost efficiency and environmental sustainability. The study's conclusions can be used as a template for other urban water bodies facing similar challenges.**

Index Terms— **Bioswales, Construction, Cost-effective solutions, Ecological restoration, Runoff, Stormwater management, Sustainable Drainage, Water Quality Improvement, etc.**

I. INTRODUCTION

Urban water bodies are vital for sustaining life and preserving ecological balance. biodiversity. However, rapid urbanization, poor waste management, and inefficient drainage systems have led to the severe degradation of many urban streams and canals. The Khare Mala Nala in Shirur is a prime example of such environmental deterioration. As depicted in the images above, the nala faces multiple challenges, including bank erosion, water pollution, solid waste dumping, ecological threats, choking of flow, and unpleasant odors, making it a critical concern for urban sustainability and public health.

The current conditions of the Khare Mala Nala result from unchecked waste disposal, poor drainage infrastructure, and lack of ecological interventions. This leads to flooding, loss of aquatic life, groundwater contamination, and reduced urban aesthetics. Addressing these issues requires a sustainable and cost-effective solution that not only improves water quality but also enhances the ecological resilience of the area.

This research focuses on the implementation of bioswales as an innovative, cost-efficient, and eco-friendly strategy to restore the nala. Bioswales, which integrate vegetation, engineered soil, and natural filtration mechanisms, help in pollutant removal, stormwater management, and habitat restoration. The study aims to assess the feasibility of bioswale integration in different zones of the nala, ensuring long-term sustainability, urban beautification, and enhanced water quality.

By implementing bioswale-based interventions, this research seeks to provide a replicable model for improving the Khare Mala Nala while addressing both environmental and economic concerns. The findings will help achieve the more general objective of sustainable urban water management and serve as a reference for other urban water bodies facing similar challenges.

II. LITERATURE REVIEW

A. Wilmoth, Lebrun, and Jaros (2019) discuss how bioswales and green infrastructure serve as natural methods for purifying polluted water:
Describe and evaluate the bioswale method of purifying water and the consequences for the environment. Because bioswales may prevent floods and the plants within can both clean water and absorb carbon dioxide from the atmosphere, this purification technique can be highly advantageous for metropolitan settings

B. Palkar (2024) explores the use of bioswales as a sustainable method for enhancing surface groundwater recharge in urban settings such as Mumbai:

This study evaluates the suitability of bioswales for groundwater recharge in Mumbai, highlighting their role in conserving water, improving quality, reducing pollution, and enhancing urban biodiversity.

C. Jokerst et al. (2011) evaluated how seasonal changes affect the efficiency of an outdoor constructed wetland used for graywater treatment in a temperate climate:

This study evaluated a wetland system built on a prototype scale over a year, focusing on its efficiency in treating graywater across different seasons. The findings demonstrated that the system significantly diminished multiple pollutants during autumn, spring, and summer, there was a noted decrease in removal efficiencies during winter. Despite this seasonal variation, the system remained active even at low temperatures, demonstrating its year-round utility.

D. Chandgude et al. (2021) review the need and feasibility of bioretention basins:

This review provides insights into the requirements, design considerations, and cost aspects of bioretention basins, which share functional similarities with bioswales, offering guidance on their implementation in urban areas.

E. Ganvir et al. (2020) examine stormwater management using bioswales:

Ganvir et al. (2020) emphasise bioswales as an eco-friendly and economical approach to stormwater management, mitigating runoff, purifying pollutants, and promoting groundwater recharge. The study reviews bioswale design, implementation, and benefits, reinforcing their role in urban flood mitigation and water quality improvement.

III. TECHNICAL ASPECTS OF BIOSWALE

A. Design and construction of bioswale

A bioswale is a shallow, landscaped channel with a trapezoidal cross-section, designed to manage rainwater runoff from parking lots, sidewalks, buildings' roofs, and roadways. A bioswale consists of four distinct layers, each playing a crucial role in stormwater management. The top layer comprises dense vegetation, which maximizes surface contact with runoff and enhances pollutant filtration. Native plant species with high nutrient uptake capacity are preferred for optimal performance. Beneath this, a thick sand layer acts as an absorbent medium, facilitating water infiltration while preventing the accumulation of contaminants. Long-term effectiveness is ensured by the geotextile fabric protecting this layer from silt and plant roots.. Additionally, large voids created by the geotextile material aid in effective rainwater drainage. At the base, an infiltration drainage pipe with perforations is installed to prevent overflow during heavy rainfall events. Once constructed, bioswales require minimal maintenance, as they demand less water and do not require fertilizers, rendering them a sustainable and economically viable solution for stormwater management.

B. Geometric design principles

Longitudinal Slope: A bioswale should have a longitudinal slope of one to two percent.

Water Velocity: For the design storm regarding water quality, the speed must not go over 1.5 feet per second; for the design storm of peak flow, it needs to stay under 5 feet per second or the channel's erosion velocity.

Swale Cross Section: (Shape) The most popular shape for bioswales is trapezoidal cross sections because to its ease of construction, strong hydraulic performance, ease of maintenance, and aesthetic appeal.

Dams/Weirs Check: Several check dam designs include stone check dams, board check dams and notched concrete weirs.

Bottom Width: In order to prevent gullying and riling and to guarantee sheet flow, the bioswale bottom's maximum free width should be fewer than eight feet.

Inlet: It is simple to do by removing curbs adjacent to parking lots and roadways. Bioswales are planted, shallow channels with a trapezoidal cross-section that are used to control stormwater runoff from parking lots, roadways, footpaths and building roofs.

Depth: Six inches deeper than the maximum design flow depth.

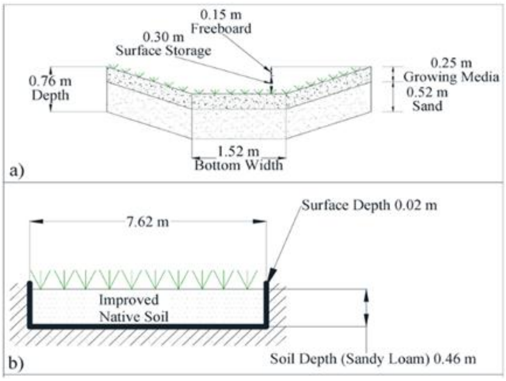

Figure 1: Bioswale cross section

C. Benefits, maintenance and vegetation

a) Benefits: Bioswales reduce runoff by up to 25%, filter pollutants through vegetation and soil, and enhance groundwater recharge. They lower maintenance costs, improve energy efficiency, and support biodiversity as aesthetic landscape features. Even in low-permeability soils, they effectively manage stormwater while serving as multifunctional drainage systems.

b) Maintenance: Regular maintenance of swales involves inspecting for bank slumping and erosion, replanting bare areas, mowing to maintain vegetation height, and removing debris. Sediment should be cleared once it reaches 25% of the swale's design volume to ensure proper function. These practices help maintain the swale's effectiveness in managing stormwater and preventing environmental degradation.

c) Vegetation: Bioswales use diverse vegetation for stormwater management. Grasses like Vetiver and Lemon Grass control erosion, while wetland plants such as Canna Lily and Cattail filter pollutants. Shrubs and trees like China Rose and Neem enhance aesthetics and biodiversity, and ground covers like Creeping Daisy prevent soil erosion. Native trees aid in long-term stability and rainwater absorption. Maintenance includes vegetation trimming, sediment removal, drainage inspection, soil monitoring, and water quality testing to ensure efficiency.

IV. METHODOLOGY

A. Data collection through site visit, surveys, case studies

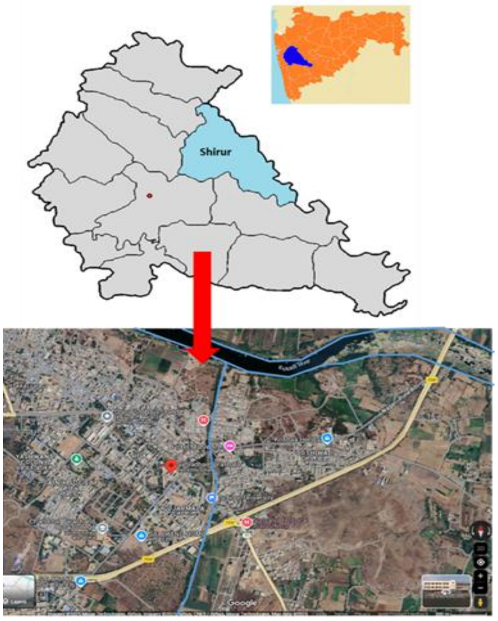

Figure 2: Location of Khare mala nala, Shirur

The project addresses multiple challenges, including ecological degradation, water pollution, drainage line leakage, and flow obstruction. Similarly, the Khare Mala Nala, located in Shirur, Maharashtra, is a vital drainage channel within the Ghod Nadi watershed, spanning 4.42 sq. km with a total stream length of 1.4 km. Passing through public, residential, and recreational zones, it plays a significant role in urban water management but faces severe issues such as bank erosion, water pollution, waste dumping, and choked water flow, leading to foul odors and ecological decline. These factors contribute to poor water quality and increased urban flooding risks. Surveys with different landscape architects and Shirur Nagar Parishad highlighted these challenges and explored the implementation of bioswales and other stormwater management techniques. Through geomorphological, ecological, and hydrological assessments, project aim to integrate sustainable solutions like stream bank stabilization, bio-engineering techniques, and bioswale implementation to enhance water flow efficiency and restore ecological balance. The initiative focuses on long-term sustainability, improving water quality, and integrating green infrastructure for a healthier urban environment. Hence there is no separate dedicated drainage stormwater and sewage water both the water flows the same stream which causes difficulties. To overcome this problem as there is restriction for no RCC construction in the area. The tool bioswale used for natural runoff of water.

B. Case study: Moti nala, Shirur

Location: Shirur
Construction Completed: Ongoing
Project Description

The Restoration of Moti Nala at Shirur for Shirur Nagar Panchayat, Tal Shirur, Dist Pune is a crucial environmental initiative aimed at revitalizing a degraded water channel. The site faces multiple challenges, including ecological threats, water pollution, flow blockages, and drainage line leakage, which have led to significant environmental degradation. The project involves geomorphological, ecological, and hydrological assessments to design an effective restoration plan. Key interventions include stream bank stabilization, embankment protection using bio-engineering techniques, water pollution assessment and monitoring, and identification of pollution sources for remediation strategies. Additionally, surrounding land uses are being studied to mitigate further degradation. The project, aims to enhance water quality and restore the ecological balance of the nala, ultimately contributing to sustainable urban water management and biodiversity conservation.

Figure 3: Location of Moti Nala, Shirur

V. RESULT AND DISCUSSION

A. *Economical efficiency*

In comparison to conventional gutters or underground storm drains, bioswales demand less upkeep and result in reduced construction expenses because of their incorporation of plants and soil. Additionally, bioswales enhance the landscape, making them a cost-effective and economically feasible solution for stormwater management.

B. *Comparison of bioswale and normal drainage system.*

Feature	Bioswale	Traditional Drainage System
Water Management	Absorbs, filters, and slows runoff	Directs water rapidly to sewers or drains
Flood Control	Reduces peak flow, prevents flash floods	Can overwhelm drainage systems, causing flooding
Water Quality	Filters pollutants, improves groundwater recharge	Does not treat water, pollutants flow into water bodies
Environmental Impact	Supports biodiversity, enhances green spaces	Lacks ecological benefits, can cause habitat destruction
Maintenance	Requires periodic vegetation management	Needs regular cleaning and infrastructure repairs
Aesthetic & Urban Design	Enhances urban greenery and landscape	Often concrete-based, less visually appealing

Table 1: Comparison of bioswale and normal drainage system

VI. CONCLUSION AND RECOMMENDATIONS

This study demonstrates that bioswales offer an economically feasible and environmentally sustainable alternative to conventional stormwater management systems. Through their natural filtration process, they reduce maintenance costs while enhancing urban aesthetics and ecological health.

A normal conventional RCC retaining wall and construction for this type of project is very costly and time consuming. Reinforced soil and gabion walls are flexible, cost-effective, and eco-friendly retaining solutions. They support vegetation, prevent erosion, and reduce construction costs by up to 80%, ensuring durability for up to 120 years. For cost friendly construction can use a Soil bags and HDPE Uniaxial Geogrid Soil net, make bunding at regular intervals in the nala for Rain Water Harvesting, use bio-degradable soil-filled bags mixed with grass / verdelia seeds so that in the monsoon season, seeds sprout and start to cover the Re-Soil Wall. Bioswale implementation can significantly mitigate urban flooding and water pollution, contributing to resilient urban infrastructure.

Bioswales offer a green and sustainable solution by utilizing readily available materials, eliminating the need for reinforcement steel and cement. This approach reduces construction time, cost, and energy consumption while minimizing transport emissions. Environmentally friendly, bioswales enhance water management and promote ecological balance.

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