

Bioswales: As an Alternative Technique for Surface Groundwater Recharge Treatment in Urban Areas like Mumbai

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Abstract:

The expeditious development and population growth in urban areas are connected to the environmental quality of the city, including the quality of water. Surface groundwater plays an immense role in the sustainability of urban areas. A variety of techniques are used and implemented for surface groundwater recharge treatment in urban areas. This study aims to **assess the suitability of bioswales as an alternative technique for surface groundwater recharge treatment in urban areas like Mumbai**. A bioswale is nothing but a narrow and shallow strip of a landscaped area that redirects and filters surface groundwater. It has a linear formation and is shallow in depth, and it is used to collect surface ground runoff water from non-porous surfaces such as structural rooftops of buildings, parking lots, tar and concrete roads, etc. The research methodology adopted is to study **bioswales as an alternative system to enhance storm sewers, and traditional stormwater pipes in urban areas like Mumbai**. These factors include **construction techniques and Design, application/ Installation and maintenance, and the economic feasibility of the Bioswales system**. The result indicates that bioswales can help by providing a way to conserve water, improve water quality, reduce pollution in waterways, and enhance biodiversity in urban areas like Mumbai.

Keywords: Bioswale, Alternative technique, Surface ground water, Urban area, Mumbai.

1. INTRODUCTION

As the population continues to boom along with rapid urbanisation and concentrates in metropolitan cities like Mumbai [1]. The growing need for accommodation, education, and employment opportunities has given rise to spaces like residential, institutional, commercial, etc. [2]. Because of the increasing population, people require more land and resources like water, which leads to increased demand for water [3]. Therefore, it has become important to use and manage water sustainably [4]. According to the India Metrological Department, Mumbai receives heavy rainfall. The problem lies in rainwater getting polluted and, hence, causing groundwater pollution [5]. In a city like Mumbai, with the continuous growth of building construction and urban development, the natural terrain is replaced by compact soil; for example, the roofs of industrial, residential, commercial, or other buildings, road networks, car parks, etc. [6]. Surfaces areas of such spaces doesn't let the rainwater to percolate into the ground. During rainfall, water which flows from the surfaces of buildings rooftops and paved areas, wash dirt, dust, and pollutants, thus making water contaminated. This runoff enters stormwater drains. (1Rajapriya R, 2021)[7]. When the rainfall water reaches these surfaces, almost 80% of this water flows to the waste-water disposal system or rivers, and only 20% soaks into the soil [8]. This leads to ecological damage such as floods, torrential

rain, the decline of subsoil water level, local soil dehydration, and the endangering of sensitive ecosystems [9]. These storm-water drains often lack maintenance and get choked during the monsoons because of the accumulation of garbage [10]. when this rainwater which flow through these drains accumulates on roads and cause water logging. (1Rajapriya R, 2021)[11] Hence, it is necessary to build and developed the artificial regulation of water circulation in nature, which contributes to the maintenance of ecological stability [12]. The implementation of a rainwater infiltration system like Bio-Swale can help reduce rainwater to a waste-water disposal system [13].

AIM:

To Study the suitability of bioswales as an alternative technique for surface groundwater recharge treatment in urban areas like Mumbai.

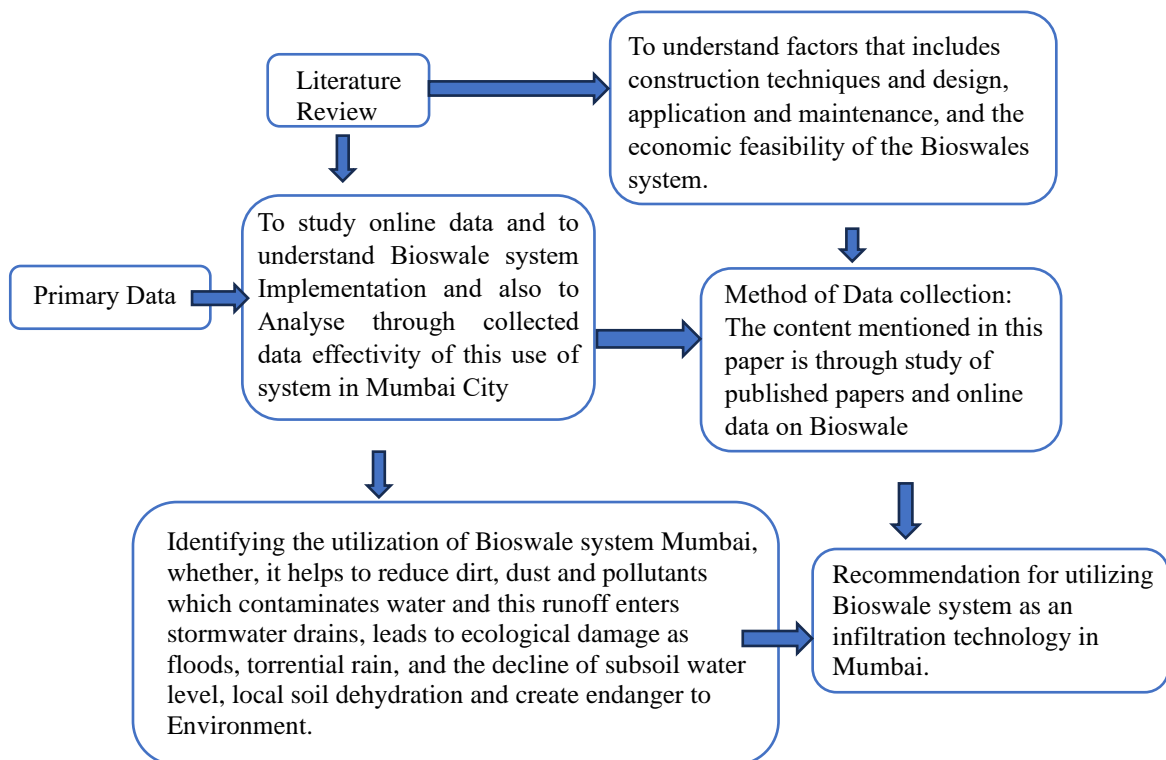
OBJECTIVES:

- To understand **working of Bioswale** Surface runoff water infiltration techniques
- To study whether **bioswales as an alternative system** to enhance storm sewers, and traditional stormwater pipes in urban areas like **Mumbai**.
- To understand factors that includes **construction techniques, application/ Installation and maintenance, and the economic feasibility** of the Bioswales system.
- To find, whether Surface runoff water infiltration techniques are suitable option in Mumbai.

2. METHODS

2.1.Secondary Data and Analysis

2.1.1. Methodology Flowchart



2.1.2 Literature Review

Bioswale – as a surface water runoff technique

A bioswale is a shallow depth stretch which is landscaped and its shape is trapezoid in cross-section and it is used for stormwater runoff from streets, pathways, Vehicle parking areas in the site and roof tops of buildings. (An Introduction To Bioswales, 2015)

Function of Bioswale is to reduce down flow of surface water runoff which is collected from storms and letting it to percolate underground instead of direct discharge of water through a storm water pipe or gutters to main municipal sewage line. This curtails down the possibility of flooding which takes place due to improper filter and drainage overflow. and its help to removal contaminants in stormwater.(An Introduction To Bioswales, 2015)

Construction techniques and Design of Bioswales

Bioswale systems are generally preferable for areas with permeable grounds and comparatively low groundwater levels. The construction technique which is needed is the excavating and creating a linear depression in slant shape. Parabolic or trapezoidal shapes are preferred with side slopes. Bioswale is divided into 4 different layers. The top layer of a bioswale is the compact vegetation that provides a huge surface area for contact with stormwater. The bioswale can filter out the pollutants effectively if vegetation is thick and extensive. local plants are considered with high nutrient uptake ability for bioswale construction. A thick layer of sand is laid beneath the plants and grass which act like an absorbent, this controls dirty and contaminated water to gather into larger masses and water infiltration takes place. This layer is protected with geotextile fabric to protect the layer from clogging due to sludge or plant roots. Further due this material large clear voids are provided to drain off rainwater. An infiltration drainage pipe with voids on surface of the pipes are installed below the second layer. Which help to avoid overflow of water during heavy rainfall. less maintenance is required once construction of bioswales is done since it required less water and fertilizes are not required. (1Rajapriya R, 2021)

Application and maintenance / Installation of Bioswale

Bioswales is one of the effectual Method for treating stormwater runoff from project areas which get collected from roadways, pathways, parking areas, etc. Bioswales are landscaped, generally in trapezoidal channels. (1Rajapriya R, 2021) Pollutants which are collected on surface of bioswales are removed by filtration through the vegetation, deposition, surface assimilation to soil particles, and infiltration through the soil. Pollutant removal capability depends on bioswale channel dimensions, longitudinal slope, and type of plants. Bioswales are efficient at trapping surface pollutant, soil particles, and specific metals etc. (1Rajapriya R, 2021)

Operation and maintenance

It is mandatory to maintain and inspect Bioswale on regular bases. Due to collection of pollutants and debris on the surface of bioswale periodical cropping of vegetation, scrutinize soil infiltration capacity is essential to avoid soil choking. (Mark Clark, 2008)

Economic feasibility

As compared to gutter or underground storm sewer Bioswales need less maintenance and due to usage of vegetation and soil construct charges reduces. And also act as a part of landscape. Which makes the bioswale system on the cost effective and economically feasible. (An Introduction To Bioswales, 2015)

Benefits of incorporating Bioswale as an Infiltration Techniques

Bioswale design focuses on providing two primary functions firstly it is Effective stormwater surface runoff and moreover it also collect Sludge which can be removed seasonally and treat contaminant in urban areas stormwater runoff. (Sujit A. Ekka a b, 2021)

2.1.3 Whether Surface runoff water infiltration techniques are suitable option in Mumbai city for surface groundwater recharge treatment specially in rainy season? Since from past few decades Mumbai facing problem of flooding in rainy season.

As the world population is escalating drastically, due to migration of people from rural to urban areas in need of job, commercial relates activities, education, transportation etc. land usage has also increased to accommodate huge population. (P.E. Zope, 2015)

City Mumbai, located in Maharashtra state and India's financial capital, faces the problem of floods especially in rainy season creates huge damage and loss of life, property for which immense capital is invested for the recovery of the damage caused by the floods.(Prof. P. T. Kadave, 2016)

Mumbai city is extremely prone to natural hazard like flooding being a coastal city also having low-lying and hilly areas. The risk increases due to human act of reclaiming land, a high population density and encroachment in the eco sensitive areas. (Namrata Gaurkhede 1*, 2021)

The land surface runoff and storm water drainage of the river is invaded with large number of slums, processing industries and disposal yards situated along its banks. These settlements make it difficult even to define the path of the river. Direct discharges of the raw sewage, wastewater, garbage from the illegal settlements and industrial effluents flow into the river's course results in clogging, thus raising the level of water during heavy rains. Also, the encroachment land along the banks of the river has decreases the width along the run of the city causing minimization of discharge and overflow of water. (Chirag Ramesh Gudhka, 2021)

2.1.4 Following are the reasons for flooding, the effects and the solutions there on

Reasons for Floods in Mumbai.

High rainfall experienced duration rainy season, sea-level rise, and tidal variations which Increases the rise in stormwater volume (Namrata Gaurkhede 1*, 2021)

Huge Reclamation It is evident from the city's planning history, that in the process of housing construction and setting up industries, the waterways that allowed the accumulated rain water to drain out, have been drastically reduced. The reclamation that was carried out originally only to link the seven islands of Mumbai was eventually performed to a greater extent to accommodate the expanding population of the city large slum colonies as well as planned constructions are being developed on the land reclaimed from the sea. However, some of this development has extended further to encroach upon the city's existing storm water drains, in order to meet the housing demand of the city's growing population. (Chirag Ramesh Gudhka, 2021)

Improper development regulations and lack of enforcement of the plans, zoning regulations leading to rapid urbanization, encroachments on hills, drains, water bodies, mangroves, etc. Loss of natural water holding areas; coming up of dense areas in restricted zones, increasing vulnerability; increased runoff

coefficient; hampered natural stormwater drainage system; the increased load on city's infrastructure. (Namrata Gaurkhede 1*, 2021)

Dilapidated and faltering drainage system with incapable stormwater drains results in Insufficient drainage cross-section to carry floodwaters, leading to chronic waterlogging (Namrata Gaurkhede 1*, 2021)

Encroachment on river basins results in reduction in the catchment area of rivers (reduced cross-section of the river), hampering natural drainage system and choking up the natural and manmade drains (Namrata Gaurkhede 1*, 2021)

Combined sewage and stormwater drainage system and Garbage dumping in drains by irresponsible citizens has resulted in choking of drains due to sillage/ sewage inflows Obstruction due to crossing of utility line. And obstructing the water flow during rains (Namrata Gaurkhede 1*, 2021)

Multiple administrative and development agencies leading to uncontrolled and unplanned development has also disturbed the rainfall run-off. (Chirag Ramesh Gudhka, 2021)

The drainage system mentioned above are not limited to the issue of the design capacity of the drainage system. It calls for an integrated water management solution to handle flood issues in Mumbai.

3. Results

The results of this research paper suggest that well-maintained Bioswales are the best options for runoff volume reduction and removal of sediment and heavy metals. It can create sponge areas and provides an opportunity to capture and treat runoff by intercepting, filtering and degrading pollutants and reducing potentially contaminated runoff volume. Other advantages of bioswales include increased water quantity, improved water quality by preventing pollution and increased biodiversity through the introduction of new ecosystems. Relevant pre-design, site investigations, and consideration of future maintenance during design are critical to successful long-term Bioswale performance.

4. Discussion

It has been determined that, in the current situation, surface rainwater is getting directly into the gutter, the drainage line of the city and eventually entering into the Arabian Sea. Introducing Bioswale instead can help to percolate water underground, which can lead to maintain the underground water table and vegetation around it and layers of soil can help to remove pollutants and dirt which come along with water by providing a way to conserve water, improve water quality, reduce pollution in waterways, and enhance biodiversity in urban areas like Mumbai.

5. Conclusion:

From the research paper it is concluded that bioswales are an effective method to remove surface runoff water pollutants in urban areas. Bioswale functions as a sustainable method, as it is economically feasible, environmentally and User friendly, and also can be constructed easily. Study is limited to secondary data study and quantitative research. Further experimental research can be conducted to achieve experimental investigation of Bioswales and the process of water purification through a bioswale by testing Soil, Plant and Water.

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