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RETHINKING SUSTAINABLE RIVERSIDE WASTE MANAGEMENT SYSTEM: A STUDY ON MAYUR RIVER, KHULNA CITY

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ABSTRACT

The inadvertent disposal of waste near riverbanks has adverse environmental effects threatening the water resource. As a developing country, Bangladesh is currently dealing with the lack of waste management systems on the riverbank which causes contaminated surface water sources, "dying" rivers, or lowering the river depth. As the Mayur River faces a major threat with waste management issue, it is one of the most threatened waterbodies in Khulna. The paper focuses on waste management of surrounding settlements of the Mayur river. The objective of this study is to identify the problems in the Mayur River by observing the activities on the riverside caused by the absence of waste management systems. Data were evaluated through the mixed approach of primary and secondary data collection including observations and mappings. From these findings, waste dumping on water bodies will be controlled by providing case study, design recommendations and proper planning of the riverside.

INTRODUCTION

Rivers are an important natural resource in supporting the life of cities as they perform functions of water channels, sources of water supply, and biologically diverse areas. However, the increasing rate of urbanization and improper disposal of wastes have taken their toll on the rivers and made most of them a source of polluted water which affects the ecological system and the people living nearby. An example of this problem is the Mayur River in Khulna City, Bangladesh. Originally a source of life for the region, the Mayur River has been subject to severe pollution through encroachment, industrial effluents and poor waste management (Akber et al., 2017). This has not only damaged the biophysical conditions of the basin but also affected its drainage function for the cities' flood problems and health risks. This paper aims at identifying appropriate sustainable waste management measures in the riverside setting of Mayur River. Therefore, in this study, the author seeks to present a model that challenges the traditional models and combines ecological restoration with community-based efforts to promote sustainable development of urban areas. The study aims at the need to rehabilitate the river's functions by employing efficient waste disposal technologies such as recycling, waste disposal, and green infrastructure.

This study is relevant to the environmental conditions of Khulna City and the general literature on sustainable urban planning and waste management. Through lessons from best practices and contextualized strategies from this research, it is clear that the future of waste management systems for such rivers including the Mayur needs to be made viable for future generations.

LITERATURE REVIEW

Overview of Mayur river

Khulna, Bangladesh's third largest city, is located at the intersection of the Bhairab and Rupsha rivers, with the Mayur, a tributary of the Rupsha River, flowing through it. Khulna City is now coping with a lack of a waste management system on the riverside as a result of difficulties such as polluted surface water sources, almost dyeing streams and reduced river depth (Ahmed, 2011). Emdadul Haque (2022), deputy director of the Department of Environment's Khulna office, stated that the water is currently the most polluted sector in Khulna and the degree of pollution in the Mayur River is quite high in comparison to other rivers. As a result, the Mayur River, often known as the "forgotten river," has been the most affected because of not enough management system for saving waters and a decline in water levels.

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Even 30 years ago, the Mayur River was a dynamic and vibrant waterway utilized by individuals for fishing and drinking, as well as by trawlers and boats for passing through the river. The Mayur flows through Alutola, Nirala,Gallamary, Boyra, Dayana, Arongghata, Bildakatia and supplier of water for many citizens. According to Md. Ali Akber Khan et al., (2009), share about the geomorphological changes of Mayur river and declining rate of depth and width of the river as well as the river flow. Because of the salinity in water, in 1982-1983, The Bangladesh Water Development Board (BWDB) built a channel alongside the Mayur the surrounding area. A sluice gate was erected in the Alutala district of Batiaghata in 1986 to protect agricultural areas from salinity and tidal waves, however it has recently been unable to drain water, only lowering the water level. Since then, the river has seen tidal water movement from downstream (Alutola) to upstream (Hamidnagar) during dry seasons (Akber et al., 2017).

Quality of river water

Furthermore, the majority of KCC is located in the Mayur sub-basin, which has seen significant environment changes as a result of recent growth in the area. In addition, extensive and unplanned construction at the loss of lowlands and water bodies began to threaten the Mayur River's natural flow without proper urban planning. Improper solid waste and wastewater from Khulna's residence, industrial, commercial, and healthcare sources gathered in the riverway, finally exceeding its ability for absorption (Khan et al., 2021). As a result, a significant amount of the municipal corporation's wastewater is dumped into the river via around 26 drains without proper water treatment plant.

In 2021, Md. Mahadi Hashan and S.M. Moniruzzaman stated the significant role of river water quality in maintain ecological impact through assessing Mayur river surface water quality. The Mayur River's water quality is consistently "Bad" or "Very Bad" because to unplanned and unrefined garbage disposal, improper sewerage management system, fertilizer usage, and KCC drains. Residents who live near the river and utilize the water on a regular basis are at serious risk of contamination. The examination of water samples obtained by the Department of Environment from the Mayur River in April 2022 reveals that the quality of the water differs significantly from the required level of water purification which is given below.

Table 1. Water Pollution Parameter of Mayur River

Year	**Dissolved Oxygen (DO) (mg/L)**	**Biochemical Oxygen Demand (BOD) (mg/L)**	**Total Dissolved Solids (TDS) (mg/L)**
Standard	5	6	300 (upto 1,000, the water is considered unsuitable for human consumption.)
2013	0.5–2.9	75–86	5,000–6,000
2016	0.5–2.9	N/A	N/A
2022	0.2-0.6	78-86	6060

The table shows that the quality of water in Mayur River is degrading day by day and absolutely not standard for proper use. Gauranga Nandi, a 25-year researcher on the Khulna region's rivers and ecology, claims that KCC waste gathers in the Mayur, Bhairab, and Rupsha rivers, degrading the aquatic ecosystems. The WQI (water Quality Indicators) assessments imply unacceptable degradation, requiring immediate action to enhance the Mayur river's water quality.

Riverfront development

The BNBC provides complex processes for safe and ecologically friendly construction activities on all sorts of structures, especially those near rivers. While the BNBC does not have a separate section designated solely to riverfront development, some of its rules are relevant to such projects: setback specifications, environmental and ecological aspects, accessibility, public use type and control. This includes establishing pedestrian as well as transit space, landscape, and recreational space, as well as connected to the urban surroundings. The research, Waterfront Development for Sustainable Urban Planning by Istiaque and Ahsan (2018), focuses on riverfront revitalization in Khulna. It emphasizes the need of considering environmental, and socioeconomic factors while building such initiatives. It demonstrates that any waterfront in Khulna plays a significant role and should be maintained as much as possible.

Paneria, Mehta, and Bhatt (2017) highlighted the waterfront development of the Sabarmati Riverfront, which transforms cities into cultural and heritage hubs. One development along the river

has an influence on environmental betterment, socioeconomic uplifting, and revitalization of cities, all of which will regenerate Ahmedabad. The establishment of a riverfront greenway, preventing improper riverbank usage, and maximizing the benefits of the riverfront via recreational use. The 2003 Prime Minister's National Award for Excellence in Urban Planning and Design was given to a project aimed at making Ahmedabad's riverside a public resource. The project will improve the sidewalks heading up to the river, establish 11.5 km of pedestrian, construct new landscaped areas, and develop public amenities like as cultural institutions, galleries, athletic venues, trade shows grounds, and market squares.

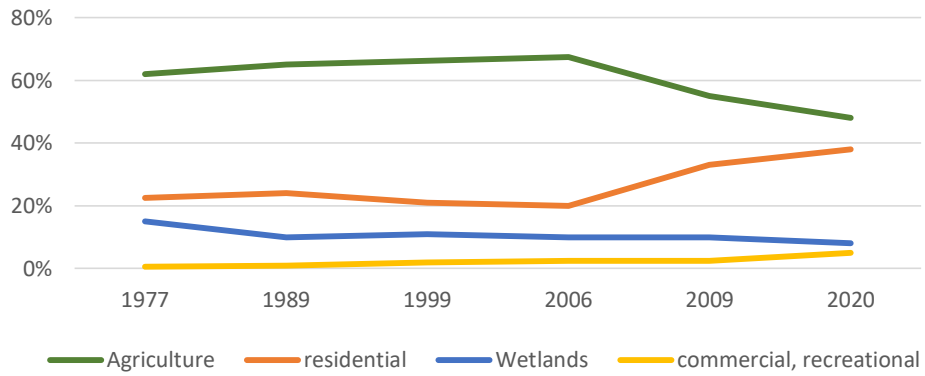
METHODOLOGY

The four steps of research methods are outlined for this process. The empirical approach is utilized to accumulate information around the chosen case study, the 'Mayur River', and recognize its degrading condition of river front and water quality. Second, using the field survey, the researchers visited specific areas in the 'Mayur River' to study its land use before taking live images, illustration, and conducting interviews with a selected group of individuals who live near the river. In addition to interviews, a questionnaire was issued to get feedback on the river's current issues and potential solutions. The paper's analytical technique involves analyzing background studies and survey findings. Finally, the research uses the logical approach to propose strategies for revitalizing dying rivers by studying related case studies.

LAND USE TYPE AND THEIR PORTION OF OCCUPANCY

Over the past three decades, the Mayur sub-basin has undergone significant land use transformations, categorized into five primary classes: residential, commercial, recreational, agriculture, and other (undefined) areas.

Chart 1: Land use shifting of Mayur riverbank



Agriculture which used to be the most common land use type has shifted significantly downwards. At the same time there has been increased development of residential and commercial buildings due to increase in urbanization and population. Commercial zones have also expanded, particularly in urban centers, contributing to economic development and altering the sub-basin's land use dynamics. As for the recreational land use, one of the significant developments is the Linear Park along the Mayur River.

According to the graphs there were only 22.5% of total area were residential land use which become 38% in 2022. Thus, in 1977 the low-density settlements were the most numerous, they occupied about 65,5% of the total area of settlements, whereas the high-density settlements occupied only about 3% of the total area of settlements. In the year 2009, the category of medium density had emerged as the most extensive, accounting for about 58 percent of the overall settlement area (Akber, Datta, & Khan, 2017). The rate of increase in medium density was the highest of all the settlement types in the periods 1977–1989 and 1999–2020. However, the growth rate for low-density settlements reduced during this period from +0.02 percent per year to -0.35 percent per year and this seems to have continued.

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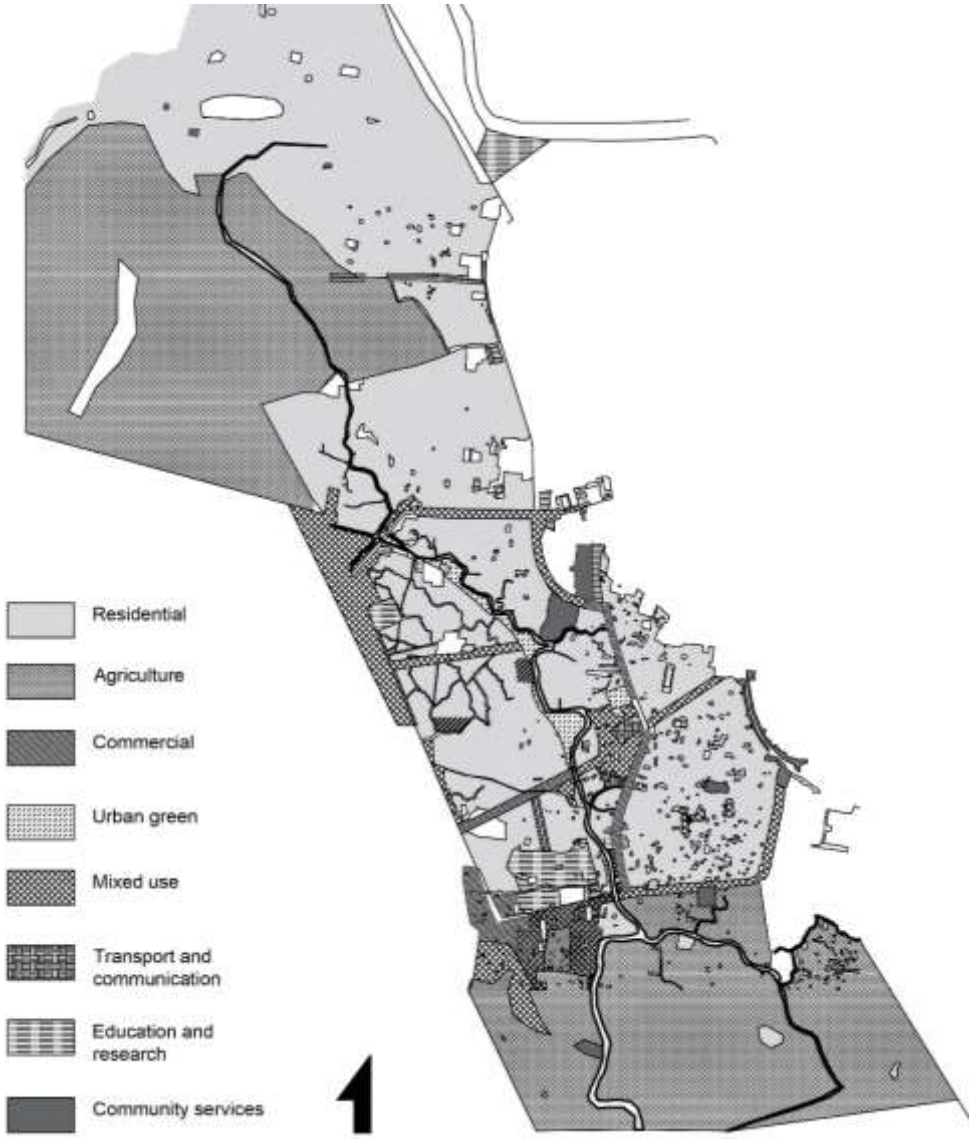

Figure 1 Land use map of Mayuri riverside Surroundings

THE MAYUR RIVER'S POLLUTION AND ITS MAIN CAUSES

Mayur River, a critical waterway river in Khulna, Bangladesh, is one of the most polluted rivers in the world. This water body is often polluted by untreated or partially treated domestic sewage, industrial discharges and agricultural runoff. The populations that live in the territories adjacent to the Mayur River as well as the areas that are developed for commerce let out large quantities of pollutants into the river.

According to research, businesses that are located near the Mayur River, particularly those in the commercial zones of Gollamari Bazar, release a significant number of pollutants into the atmosphere. Without the necessary treatment, sewage from homes, markets, and small businesses is dumped straight into the river. Because they flow into the river, the tributaries from other parts of the nation also contribute to the pollution. Other uses of the Mayur River's water include irrigation, fishing, and residential consumption, all of which contribute to pollution. Both point and non-point sources contribute to river pollution, and in order to improve the river's health and safeguard the welfare of the people, an immediate solution and appropriate management are required (Kishnani, 2018).

Determining the Mayur River of Khulna's Point and Non-Point Sources of Pollution Point Sources (70% of Total Pollution)- According to the CPCB (2008), point sources are structured sources of pollution with a quantifiable pollutant load. These sources include sewage pumping stations, surface drains that transport industrial or municipal garbage, etc.

Residential Pollution (55%)- It is showed that the main source of pollution in the Mayur River, accounting for 55% of its total pollution, has been domestic activity. The residents of the residential

neighborhoods, slums, and business districts along the river, about 80% of the city's polluted water, mixed with household waste, falls into the river through 22 drains.

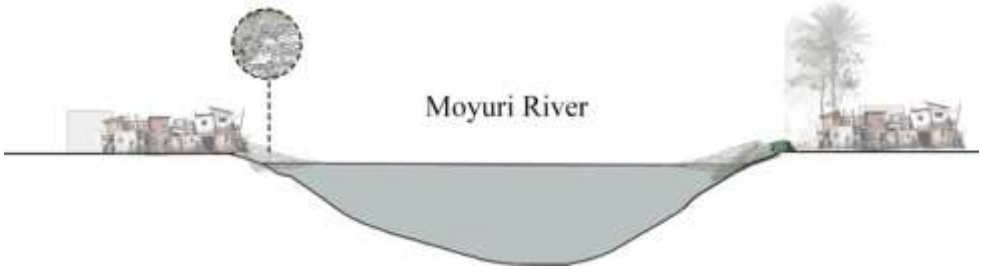

Figure 2 Existing condition of Mayur riverside along with Dargah para

Commercial pollution (15%)- Along the Mayur River, commercial activity is less common than residential use. There are a few markets and small businesses along the river that boost the local economy but also negatively impact the environment due to inadequate waste management practices. Dead fish, animal carcasses, and other organic waste also wind up in the river, especially in commercial districts like Gollamari Bazar. When these items decompose, pollutants and harmful microorganisms are released, lowering the water's quality.

Figure 3 Existing condition of Mayur riverside along with Gollamari Bazar

Non-Point Sources (30% of Total Pollution)- Non-point sources of pollution are dispersed, disorganized, and diffused sources where it is difficult to quantify the pollution load. Both human activity and natural processes throughout the watershed area contribute to these sources. Approximately 30% of the Mayur River's overall pollution comes from non-point sources.

Agricultural Runoff (10%)- Fertilizers, pesticides, and herbicides are introduced into the Mayur River by agricultural runoff from neighboring farmlands. Rainfall causes nutrient contamination and the possibility of eutrophication because surplus water from stormwater and irrigation transfers chemicals, nutrients (such as phosphorus and nitrogen), and suspended particles into the river. Roughly 10% of the Mayur River's overall pollution is caused by agricultural runoff.

Recreational pollution (3%)- However, because the park side section is encircled by green space, the linear park is comparatively less polluting the Mayur river. Utilizing this green area as a buffer zone allows the river to be less polluted than any other zones.

Figure 4 Existing condition of Mayur riverside along with Linear Park

Dumping of Solid Waste and Carcasses (12%)- A major non-point source of pollution, illegal dumping of solid waste, including construction debris, market waste, and residential garbage, accounts for around 12% of all contamination.

Water Use in-stream (5%)- About 5% of the pollution in the Mayur River comes from direct in-stream usage like bathing, laundry, and livestock wading. Soap, oils, detergents, and human waste are all introduced into the river by these activities. Particularly in informal communities, open defecation near riverbanks adds to water contamination, endangering the public's health.

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FINDINGS AND ANALYSIS

Sabarmati Riverfront Development Project
Location-Ahmedabad, Ongoing, India
Year-2002

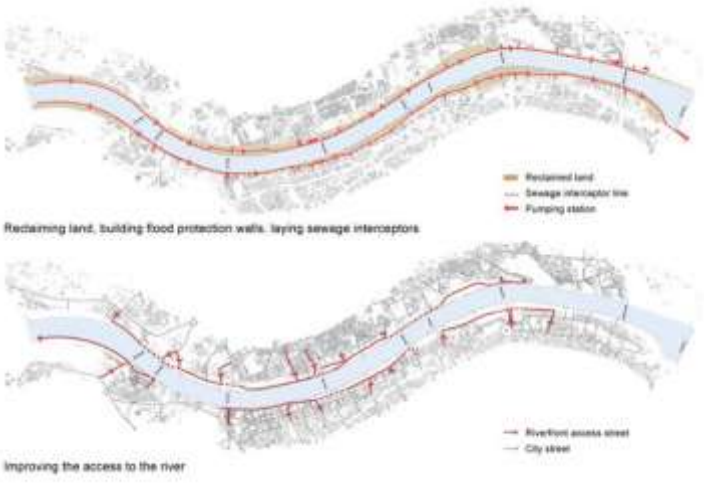

Fig 5 Improving the access to the river (Drawing © HCPDPM)

The Sabarmati Riverfront Development Project is an environmental improvement, social uplift and urban rejuvenation project that will renew Ahmedabad. Since Sabarmati is a seasonal river, water is channeled into the river from Narmada canal, which intersects the river upstream from Ahmedabad and is retained in the river using the Vasna Barrage which is located downstream. To prevent untreated sewage from flowing into the river, two sewage interceptor lines with new pumping stations have been constructed along both the reclaimed banks. These lines carry untreated sewage to the augmented sewage treatment plants south of Vasna Barrage (Paneria et al., 2017).

Key Features of the Sabarmati Riverfront Development Project:

Wastewater Treatment Infrastructure:

- One of the major activities that were considered in the project were the provision of Sewage Treatment Plants (STPs).). All these STPs were commissioned have receive the city's existing untreated sewage which was discharging into the river.
- The project introduced an efficient network of intercepting sewers along the river's banks to collect and treat wastewater before it could be discharged into the river.
- The STPs used modern technologies such as membrane bioreactors (MBR) and activated sludge processes to achieve high treatment standards, improving the water quality significantly.
  Sabarmati Riverfront Development Corporation Limited (SRFDCL) reports highlight the installation of 12 sewage treatment plants and extensive sewer networks as part of the revitalization project.

Fig 6 Improved Sewage System (Paneria et al., 2017))

Solid Waste Management:

- The riverfront development also embraced strategies in the elimination of solid wastes that would end up in the river. Special focus was therefore made to address waste disposal through reclaiming the garbage and debris that was lying along the river banks and other nearby areas.
- Collection centers were provided at the river frontage, and measures were taken to stop illegal discharge, which is a problem in many riverine cities.

  Ahmedabad Municipal Corporation outlines how solid waste management was integrated into the riverfront project, improving both cleanliness and public engagement with the space.

Fig 7 Improved Condition of Bazaar and Markets (Paneria et al., 2017)

Pollution Control Measures:

- Construction of a barrage on the upper stretch of the river supported regulation of water discharge, and the water level was kept constant so that water post-treatment was blended with clean water in the right proportions as to quality.
- Supervisory control systems were put in place to check the status of water as regards to the provision of adequate treated wastewater.

  According to reports from the *Ahmedabad Urban Development Authority* (AUDA), the barrage and water monitoring systems helped control pollution levels.

Public and Green Spaces:

- Supervisory control systems were put in place to check the status of water as regards to the provision of adequate treated wastewater.
- Riverfront and greenbelt were incorporated with the layout of the green spaces to perform functions such as removing pollutants and controlling soil erosion.

  The Sabarmati Riverfront Development Plan by the *Ahmedabad Urban Development Authority* (AUDA) outlines the integration of green spaces along the river, focusing on environmental and social sustainability.

Fig 8 Improved Urban Forestry (Paneria et al., 2017)

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RESULT AND DISCUSSIONS

The assessment of the present condition of the Mayur River shows the urgent requirement of sustainable waste management strategies for different land use areas of this river. The findings of this study show that unsustainable waste disposal is the leading cause of the river pollution with a major influence being felt in water and soil qualities. Concentrations of heavy metals and BOD, biological oxygen demand also increased significantly, especially around the industrial and populated residential areas. Studies revealed that the major concentration of wastes was observed in low income populated areas and in the informal business areas close to the riverine areas.

The interviews with the stakeholders and the community, as well as the results of the surveys carried out, revealed the absence of consciousness and facilities for the correct disposal of waste. Though residents in high density areas show willingness to adopt sustainable practices, lack of proper recycling facilities and lack of awareness campaigns were main challenges identified. Similarly, agricultural areas close to the river were also identified to discharge organic wastes, which if well utilised, could be used for composting for the farming activities.

The design interventions that have been proposed for consideration are intended to incorporate solutions that are specific to land use, in order to enhance the efficiency of waste management. The following table outlines guidelines for interventions based on the land use zones around the Mayur River:

RECOMMENDATIONS

Residential Zone

- According to BNBC 2020 General Guidelines for River Setbacks- **Secondary Rivers (Smaller rivers, tributaries):**Minimum setback: **10–15 meters** from the edge of the riverbank.This setback must be ensured along Mayur river.
- Establishing **zoned waste collection points** within residential clusters.
- Adopting phytoremediation in the residential areas of the Mayur River, utilizing plant roots to naturally filter and absorb pollutants from sewage water, can provide an eco-friendly, low-cost, and low-maintenance solution while purifying water for agricultural use and enhancing environmental protection.

Commercial Zone

- Implement designated waste collection points for markets and commercial hubs.
- Raw Products markets such as Fish ,meat,vegetables should not be at close proximity along river side, a buffer belt must be introduced.
- If the raw product market is close to river side proper zoning of waste dumping and storage must be included in the market plan design.
- Provision of collection centers at the river frontage, and measures to stop illegal discharge.
- Ensure compliance with local **Environmental Impact Assessments (EIA)** for waste disposal.

Recreational Zone

- Placing recycling bins beside pathways and imposing fines for littering to ensure little waste is thrown on the ground.
- Grey water from facilities should be treated before being reused or subsequently discharged (Rini et al., 2020).

Agricultural Zone

- Creating a vegetative strip on the rest portion of lands alongside the river, to filter sediments and nutrients.
- Installation of sediment traps and irrigation channels that prevent agrochemical runoff into the river.

Other (Undefined) Areas

- There is a need for constant supervision of the informal settlements and undefined zones in the country to check on the activity of people involved in illegal dumping.

Such interventions do not only solve the existing problems of waste management but also help to rehabilitate the Mayur River. Due to the fact that the framework is focused on specific needs of each land use zone, the implementation of the measures is fair and efficient, which stimulates the community participation and sustainable development.

CONCLUSION

The need of effective waste control in mayor river is emphasized by this study. The results show that the rapid urbanization and poor waste management have severely polluted many rivers, including the Mayur River in Khulna City, Bangladesh. Once a source of life, the river is now heavily contaminated by untreated sewage, industrial waste, agricultural runoff, and illegal dumping from commercial and residential zone. This pollution has degraded its water quality, harmed ecosystems, increased flood risks, and posed health threats to nearby communities. In order to successfully reduce the adverse environmental effects, vendors, market regulators, and the significance of putting sustainable waste management techniques into practice must be understood and valued by regular users. To successfully handle these issues, a thorough waste management plan that incorporates infrastructure development, policy change, and cooperation between governmental and stakeholder organizations is needed.

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