

Design of Rain Water Collection and Treatment in Urban Areas

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Abstract

Rapid urbanization and population growth have led to increased pressure on conventional water resources, resulting in water scarcity in many cities. This study presents the design and evaluation of a rooftop rainwater collection and treatment system for urban applications. A typical institutional building with a catchment area of 500 m² and an average annual rainfall of 800 mm was considered.

The estimated annual rainwater harvesting potential is approximately 340 m³. A storage tank of 70 m³ capacity was designed along with a multi-stage treatment system consisting of first flush diversion, filtration, and disinfection. The treated water was found suitable for non-potable uses such as flushing, gardening, and cleaning. The results demonstrate that rainwater harvesting systems can significantly reduce dependency on municipal water supply and groundwater resources. The study concludes that rooftop rainwater harvesting is a sustainable, economical, and efficient solution for urban water management.

KEYWORDS: Rainwater Harvesting, Urban Water Management, Rooftop Collection, Water Treatment, Sustainability

INTRODUCTION

Urban areas are increasingly facing water scarcity due to rapid population growth, industrialization, and excessive exploitation of groundwater resources. Conventional water supply systems are often unable to meet rising demand, leading to irregular supply and dependence on alternative sources such as tanker water.

Rainwater harvesting has emerged as an effective and sustainable solution to address these challenges. It involves the collection, storage, and treatment of rainwater for reuse. In urban environments, rooftops provide ideal catchment surfaces due to their impervious nature and ease of access.

In addition to conserving water, rainwater harvesting reduces surface runoff, thereby mitigating urban flooding. When combined with proper treatment techniques, harvested rainwater can be safely used for various non-potable applications. This study aims to design a rainwater collection and treatment system suitable for urban buildings and evaluate its feasibility and performance.

LITERATURE REVIEW

Previous studies have highlighted the importance of rainwater harvesting in sustainable urban water

management. According to the Central Ground Water Board (CGWB), rooftop rainwater harvesting can meet up to 30–40% of urban water demand.

Research indicates that the efficiency of rainwater harvesting systems depends on factors such as rainfall intensity, catchment area, runoff coefficient, and storage capacity. BIS Code IS 15797:2008 provides guidelines for system design and implementation.

Various treatment methods such as filtration, activated carbon adsorption, and disinfection have been proven effective in improving rainwater quality. However, many studies focus on theoretical analysis, and there is a need for practical design-based studies, which this paper addresses.

METHODOLOGY

Study Area

A typical urban institutional building with a rooftop area of 500 m² was selected. The region receives an average annual rainfall of approximately 800 mm, primarily during the monsoon season.

System Components

The proposed rainwater harvesting system includes:

- Catchment surface (RCC rooftop)
- Conveyance system (gutters and downpipes)
- First flush device
- Filtration unit (sand, gravel, activated carbon)
- Storage tank
- Disinfection unit

Rainwater Yield Estimation

The annual rainwater yield was calculated using standard runoff equations considering rainfall, catchment area, and runoff coefficient.

Estimated

yield:

≈ 340 m³/year

Storage and Treatment Design

A storage tank of 70 m³ capacity was designed to store rainwater during peak rainfall periods. The treatment system consists of:

- First flush diversion to remove initial contaminants
- Filtration unit for removal of suspended particles
- Disinfection (chlorination/UV) for microbial safety

RESULT AND DISCUSSION

Rainwater Availability

The study confirms that sufficient rainfall is available to support rainwater harvesting. The estimated yield of 340 m³ represents a significant supplementary water source.

Storage Efficiency

The selected storage capacity ensures optimal utilization of harvested water while maintaining cost efficiency. Excess water is safely discharged through overflow systems.

Water Quality Improvement

The multi-stage treatment system effectively improves water quality:

- First flush removes debris and pollutants
- Filtration reduces turbidity
- Disinfection eliminates microorganisms

The treated water meets standards for non-potable use.

Impact on Urban Water Management

The system contributes to:

- Reduction in groundwater extraction
- Decreased load on municipal supply
- Mitigation of urban flooding
- Promotion of sustainable practices

Economic and Environmental Benefits

- Low operational cost
- Reduced water bills
- Energy savings
- Environment-friendly solution

Limitations

- Dependence on rainfall variability
- Requirement of regular maintenance
- Limited to non-potable applications without advanced treatment

CONCLUSION

This study demonstrates that rooftop rainwater harvesting is a viable solution for urban water scarcity. A building with a 500 m² rooftop can harvest approximately 340 m³ of water annually. The designed system, including storage and treatment units, ensures efficient utilization of rainwater for non-potable purposes. The implementation of such systems can significantly reduce dependency on conventional water sources and contribute to sustainable urban development. Future work may focus on advanced treatment techniques for potable use and integration with smart monitoring systems.

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