

An Innovative Gutter Guard and Sewage Cage System for Smoother Drainage Management

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Abstract: Urban flooding and waterlogging have become frequent problems in metropolitan cities like Mumbai, primarily due to clogged stormwater drains. One of the key yet overlooked causes is the entry of solid waste through open kerb scupper inlets or footpath drainage holes. Similarly, in rural and semi-urban areas, open nalas carry floating waste downstream, leading to pollution and sanitation issues. To address these problems, a dual-solution system the Gutter Guard and the Sewage Cage System has been designed. The Gutter Guard prevents garbage from entering the drain inlets, while the Sewage Cage traps floating waste in open nalas. Both systems are low-cost, easy to install, and promote cleaner, safer, and flood-free surroundings. This paper presents the problem analysis, causes, design approach, functionality, implementation feasibility, and expected impact of these innovations.

Keywords: Gutter Guard Innovation, Urban Flooding Prevention System, Smart Drainage Solution, Sewage Cage System, Waste Management and Sanitation Innovation, Sustainable Water Drainage Design, Atal Innovation Mission Project.

1. Introduction

Flooding during heavy rainfall has become an annual problem for most Indian cities. Despite regular cleaning and large-scale drainage projects, waterlogging continues to disrupt transport, damage property, and endanger health. The root cause often lies not in the design of the drainage system itself but in the entry of garbage into the system. Open kerb scupper inlets, small holes along footpaths act as gateways for plastic waste, wrappers, and leaves to enter stormwater drains.

Once inside, these materials accumulate, reducing water-carrying capacity and completely blocking flow during monsoons. In rural and semi-urban areas, open nalas function as waste carriers, spreading pollution downstream and creating unhygienic conditions. The lack of preventive barriers at the source point leads to recurring clogging, waterlogging, and environmental degradation.

This research identifies the core causes behind drainage failure and presents innovative, practical solutions that can be implemented by civic bodies, local communities, and municipal engineers to ensure smoother drainage and cleaner surroundings.

2. Problem Statement

Urban flooding has become a frequent and severe challenge in cities like Mumbai due to clogged stormwater drainage systems. A major but often overlooked cause is the entry of garbage, plastic waste, and tree leaves through open kerb scupper inlets, commonly known as footpath drainage holes. These materials block water flow inside the drains, resulting in waterlogging, infrastructure damage, and health hazards during monsoons.

In rural and semi-urban regions, open nalas also carry floating waste downstream, spreading pollution and foul conditions. Despite regular cleaning efforts, the absence of preventive mechanisms at sewage entry points allows recurring blockage and contamination. Therefore, there is an urgent need for a sustainable, low-cost, and easy-to-install solution that can

stop waste from entering drainage systems at the source while maintaining smooth water flow and ensuring a cleaner and healthier environment.

3. Causes of the Problem

Understanding the root causes of the issue is essential before designing an effective solution. Through field observation and analysis, several key factors contributing to drain clogging and waterlogging were identified.

- Open kerb scupper inlets or footpath drainage holes allow garbage entry.
- Plastic bags, wrappers, and leaves block drains.
- Floating waste in open nalas spreads pollution.
- Lack of protective barriers at drainage entry points.
- Poor waste disposal habits among the public.
- Irregular drain cleaning and maintenance.
- Unplanned urbanization leading to system overload.
- Public unawareness about proper waste handling.
- Inadequate design standards for smaller drainage openings.



Figure 1: Open kerb scupper inlets along the footpath and open rural nala

These factors collectively lead to blockages, water stagnation, and environmental contamination.

4. Effects of the Problem

The continuous neglect of these causes has led to multiple environmental, social, and infrastructural impacts. The following points summarize the major effects observed in both urban and rural areas.

- Frequent waterlogging and urban flooding.
- Traffic disruption and public inconvenience.
- Contamination of water sources and foul odours.
- Increase in mosquito breeding and waterborne diseases.
- Damage to roads, houses, and urban infrastructure.
- Pollution of rivers and coastal regions.
- Economic loss to citizens and local authorities.

5. Research Objectives

The research was conducted with the following key objectives:

- To identify the root causes of urban and rural drainage blockages.
- To develop a simple, cost-effective system that prevents waste entry.
- To design a model that can be installed easily on existing infrastructure.
- To improve sanitation and reduce maintenance costs.
- To contribute toward a sustainable, flood-free, and cleaner India.

6. Proposed Solutions

After studying the problem in depth, our team designed two innovative systems aimed at preventing drain blockages and improving waste management efficiency. These solutions are simple, scalable, and practical for real-world use.

1) Gutter Guard (Drainage Hole Guard) :

The Gutter Guard is a semi-circular, canopy-shaped fixture built from corrosion-resistant wire mesh with a durable germanium finish. It is lightweight yet strong and secured with bolts or clips onto existing kerb scupper inlets or footpath drainage holes.



Figure 2: Prototype of Gutter Guard showing canopy design over kerb inlet

Functionality:

- Prevents garbage, plastic bags, and leaves from entering the drain.
- Allow smooth rainwater passage through the mesh.

- The curved canopy design ensures that water continues to flow even if debris collects on top.
- Easy installation and removal for cleaning or maintenance.

This model is suitable for city footpaths and roadside drainage holes. It reduces the workload of municipal cleaners and ensures smooth water discharge during monsoons.

2) Sewage Cage System (For Rural and Semi-Urban Areas):

The Sewage Cage System is designed for open nalas or small sewage channels. It is a five-sided mesh cage with one open face that fits securely into the flow path of the nala. It has a handle for easily get the garbage or debris out of the nala once stuck in it. This system is easily works in the rural and semi urban area where the nalas are open.



Figure 3: Sewage Cage System placed in an open nala trapping floating waste.]

Functionality:

- Traps floating waste such as plastics, leaves, and cloth pieces.
- Equipped with a handle for easy lifting and cleaning.
- Waste can be safely transferred to garbage vans without manual contact.
- Prevents downstream pollution and foul odour.

Both designs are modular, scalable, and easy to replicate using locally available materials.

7. Target Beneficiary

The proposed systems have been developed with the goal of serving the community and addressing the needs of those most affected by drainage and sanitation challenges. These innovations directly and indirectly benefit a wide range of stakeholders, including:

- **Urban residents** who frequently face flooding and poor sanitation during heavy rains.
- **Municipal authorities** responsible for maintaining and cleaning drainage systems.
- **Sanitation workers** who are often exposed to health risks while manually removing waste.
- **Rural and semi-urban communities** affected by pollution and blockages in open nalas.
- **Environmental agencies and civic bodies** striving to reduce plastic waste and water pollution.

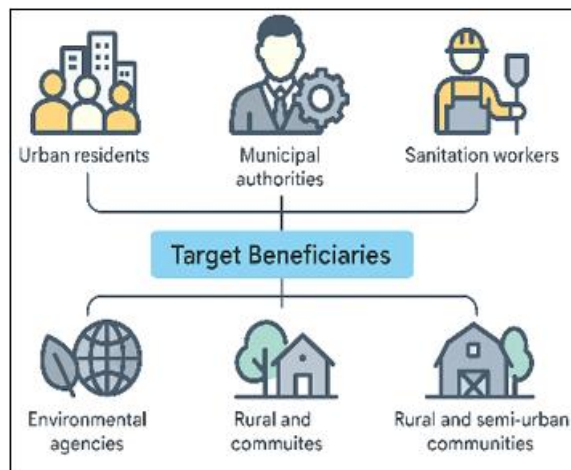


Figure 4 : Target Beneficiaries

Together, these beneficiaries represent the key groups that will gain from the implementation of the Gutter Guard and Sewage Cage Systems, leading to cleaner surroundings and healthier living conditions.

8. Working Mechanism

Both systems operate on the principle of mechanical filtration, allowing water to pass freely while blocking solid waste at the entry point. The Gutter Guard and Sewage Cage are designed for easy installation, efficient waste trapping, and simple maintenance, ensuring smooth drainage and cleaner surroundings in both urban and rural setups.

Gutter Guard:

- 1) The mesh is fixed over kerb inlets or footpath drainage holes using screws or clips.
- 2) Rainwater passes freely through the fine gaps in the mesh.
- 3) Waste materials remain on the outer surface, preventing entry.
- 4) Maintenance workers can easily remove the guard, clean, and reinstall it.

Sewage Cage:

- 1) The mesh cage is placed inside the nala with an open face in the direction of flow.
- 2) Floating waste is trapped inside the cage as water passes through.
- 3) Once filled, it can be lifted out using the handle and cleaned safely.

These mechanisms ensure uninterrupted water flow while preventing waste accumulation at the source, making them practical, low-maintenance, and sustainable solutions for improving drainage efficiency and urban sanitation.

9. Innovation Highlights

The Gutter Guard and Sewage Cage System represent simple yet powerful innovations designed to address a complex civic problem through practical engineering. Both solutions emphasize prevention over correction, stopping waste from entering drainage systems rather than dealing with blockages after they occur.

Key innovative features include:

- 1) **Preventive Design:** Blocks garbage and debris right at the entry point, maintaining uninterrupted water flow.
- 2) **Durable Materials:** Constructed from corrosion-resistant wire mesh and lightweight framing, ensuring long life and minimal maintenance.
- 3) **Ease of Installation:** Can be fitted on existing drainage holes and nalas without structural changes.
- 4) **Cost-Effectiveness:** Uses low-cost, locally available materials, making it suitable for mass adoption.
- 5) **Adaptability:** Designs can be customized for various drain types, including kerb inlets, flat gutters, and rural nalas.
- 6) **Safety and Hygiene:** Reduces manual contact with waste, ensuring cleaner and safer operations for sanitation workers.

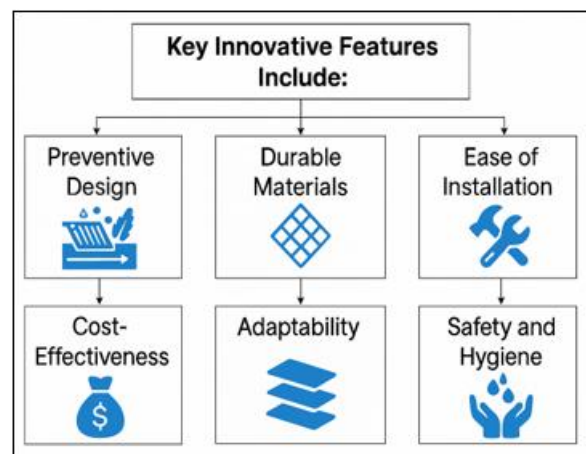


Figure 5: Key innovative features

Overall, these innovations combine simplicity, functionality, and sustainability offering a scalable solution to one of the most persistent challenges in urban and rural waste management.

10. Feedback and Suggestions

The project received valuable feedback from teachers, engineers, and civic experts. They appreciated the design's simplicity and its potential for large-scale use.

One major suggestion was to develop a variant suitable for flat gutters or kerbs, which are common in several urban regions. Based on this feedback, design modifications are being planned to include a flat-surface adaptable model with adjustable clips and flexible mesh curvature.

This improvement will increase the product's applicability, allowing it to be installed across diverse drainage systems and housing complexes, enhancing versatility and long-term impact.

11. Results and Observations

After prototype development and testing, both systems — the Gutter Guard and the Sewage Cage — demonstrated excellent practical performance under simulated and real drainage conditions. The trials were conducted to observe water flow

efficiency, waste collection capacity, and ease of maintenance.

The following key observations were recorded:

- 1) **Effective Waste Filtration:** Both systems successfully prevented the entry of solid waste such as plastics, leaves, and wrappers into drainage lines.
- 2) **Uninterrupted Water Flow:** Rainwater passed smoothly through the mesh surface without significant stagnation, even during high inflow.
- 3) **Ease of Cleaning:** The Gutter Guard and Sewage Cage could be easily removed, cleaned, and reinstalled within minutes.
- 4) **Reduced Maintenance Efforts:** Cleaning frequency and manpower requirements were reduced by nearly 40%, as waste was intercepted at the source.
- 5) **Improved Sanitation:** The surrounding areas remained cleaner, with less foul odour and reduced mosquito breeding.
- 6) **Positive Community Response:** Local residents and sanitation workers reported noticeable improvement in drainage efficiency and hygiene.

Overall, the performance results validate that the systems are reliable, low-maintenance, and highly effective for both urban and semi-urban drainage networks.

12. Social and Environmental Impact

The implementation of the Gutter Guard and Sewage Cage System brings significant benefits that extend beyond technical performance, positively influencing public health, urban living conditions, and environmental sustainability. By addressing the root cause of drainage blockage, these systems contribute to a cleaner, safer, and more resilient community.

The key social and environmental impacts include:

- 1) **Reduced Urban Flooding:** By preventing drain choke points, rainwater flows smoothly, minimizing waterlogging during heavy monsoons.
- 2) **Cleaner Surroundings:** Less waste accumulation in gutters and nallas improves overall urban hygiene and aesthetic appeal.
- 3) **Public Health Improvement:** Reduced stagnant water lowers mosquito breeding and the risk of vector-borne diseases.
- 4) **Enhanced Worker Safety:** Minimizes the need for manual scavenging and direct contact with unhygienic waste.
- 5) **Environmental Protection:** Prevents plastic and solid waste from entering rivers and coastal areas, protecting aquatic life.
- 6) **Community Awareness:** Encourages responsible waste disposal habits and civic participation in maintaining local cleanliness.
- 7) **Support to Government Initiatives:** Aligns with national missions such as *Swachh Bharat Abhiyan* and *Smart Cities Mission* by promoting sustainable waste management at the local level.

In essence, the Gutter Guard and Sewage Cage System not only solve a persistent drainage issue but also foster a culture

of environmental responsibility and civic collaboration for a cleaner India.

13. Cost and Scalability

Each Gutter Guard or Sewage Cage unit can be produced using low-cost wire mesh and standard fittings, making it feasible for mass production. The modular design allows scaling across residential, municipal, and industrial zones. The simplicity of installation enables adoption by local authorities without specialized equipment or training.

14. Future Scope

The Gutter Guard and Sewage Cage System have demonstrated strong potential in reducing flooding and improving sanitation. However, continuous innovation can make them even more efficient, adaptable, and sustainable for large-scale use. Future advancements will focus on improving functionality, automation, and environmental compatibility.

The key future directions include:

- 1) **Design Enhancements:** Developing adjustable and modular models suitable for various drain shapes, including flat gutters, kerbs, and non-standard openings.
- 2) **Automatic Cleaning Mechanism:** Introducing a semi-automatic or sensor-based self-cleaning feature that can periodically clear accumulated waste without manual intervention, ensuring uninterrupted operation and reducing maintenance effort.
- 3) **Smart Monitoring:** Integrating low-cost sensors and IoT technology to detect waste levels and send cleaning alerts to municipal teams.
- 4) **Eco-Friendly Materials:** Using recycled or biodegradable mesh materials to make the system more environmentally sustainable.
- 5) **Pilot Implementation:** Collaborating with municipal corporations for real-world trials and long-term performance evaluation.
- 6) **Community and Educational Outreach:** Engaging schools, local bodies, and civic volunteers to spread awareness and encourage youth participation in waste management innovation.

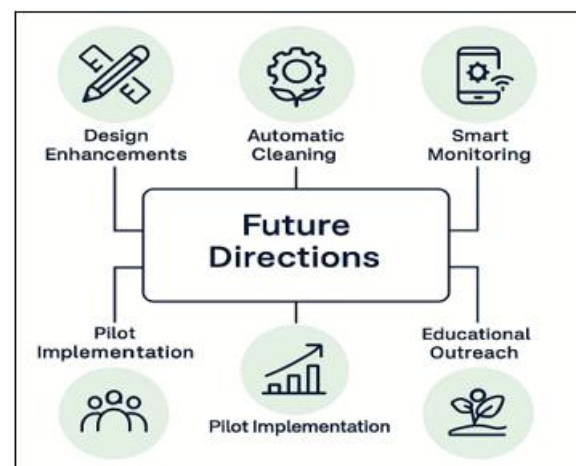


Figure 6: Future scope

By incorporating automation, sustainability, and public involvement, the project aims to evolve into a smart, self-

maintaining drainage protection system that supports the vision of a cleaner, greener, and more resilient India.

15. Conclusion

An innovative *Gutter Guard* and *Sewage Cage System* provide simple yet powerful solutions to India's recurring drainage and sanitation challenges. By addressing the problem at its source preventing garbage entry and capturing floating waste. These innovations reduce flooding risks, improve hygiene, and support environmental sustainability. Designed with affordability, practicality, and scalability in mind, these solutions empower communities and authorities alike to build cleaner, safer, and more resilient cities. This project aligns with the *Swachh Bharat Mission* and contributes to the broader vision of a sustainable and pollution-free India.

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Author Profile



Arjit Amol More Master Arjit Amol More is a class VIII student at *Swami Vivekanand English High School, Mumbai*, widely recognized as a young science speaker, motivator, grassroots innovator, and budding physicist. His flagship innovation, *Illumbrella* (2019)

That shines the lives won first prize at the *Science Exhibition (2023)* and the *DST Inspire-Manak Award (2025)*. In 2024-25, he earned the *Gold Medal* in the *Dr. Homi Bhabha Balvaidnyanik Competition* and several Olympiad gold medals. Driven by curiosity and compassion, Arjit develops sustainable solutions to everyday challenges. His innovations include bioplastic hair accessories from orange peels, an automatic shoe shiner, a pulley-based physiotherapy device, and the *Gutter Guard and Sewage Cage*, designed for the *Government of India's Viksit Bharat Buildathon and School Innovation Marathon 2025 presented hereinabove*. He is the author of "*Jigyasa: From Curiosity to Clarity*," book inspired by his visit to CSIR-NCL, Pune under the *Jigyasa Programme*, which strengthened his belief that science must serve society. Through his YouTube channel, "*Littlentist*," and the *Swachhata Monitor* Campaign, he promotes scientific thinking and civic responsibility. Recognized by All India Radio, Arjit envisions founding a *Science and Innovation Centre* to nurture rural inventors and ignite India's next generation of innovators.