Geospatial Analysis & Management of Water Logging Areas in Thane City

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Abstract - **Urban flooding and waterlogging have become recurring challenges in Thane City, particularly in low-lying and densely populated areas such as Talao Pali. This project focuses on the geospatial analysis and engineering management of waterlogging by identifying vulnerable locations, assessing hydrological conditions, and proposing sustainable mitigation techniques. Using rainfall data, runoff calculations, and infiltration analysis, the study evaluates the severity of water accumulation and its impacts on urban life. Among the proposed solutions, the, V-wire injection well system was identified as an effective technique for artificial groundwater recharge and runoff reduction. The system was designed and analyzed based on site-specific parameters including soil permeability, catchment characteristics, and stormwater behavior. Implementation of this method is projected to significantly reduce surface water stagnation, enhance groundwater levels, and improve traffic and public health conditions. This method will not only mitigate waterlogging but also provide significant socio-economic benefits by improving groundwater recharge, enhancing water availability, and reducing infrastructure damage, thus fostering sustainable urban development in the Talao Pali area.**

Key words: **Waterlogging, Thane City, Groundwater Recharge, Geospatial Analysis, V-Wire Injection Well.**

I. INTRODUCTION

Urban flooding has emerged as a critical issue in Indian metropolitan regions, particularly in low-lying and high-density cities like Thane. Waterlogging is a common urban issue caused by excess water from rainfall, poor drainage, or rising groundwater levels. It restricts soil aeration, affects plant growth, damages infrastructure, and disrupts urban life. In Thane City, areas like Talao Pali face severe waterlogging during monsoons due to inadequate drainage systems.

To address this, the project uses geospatial analysis to study the issue and proposes sustainable solutions like V-wire injection wells to reduce waterlogging and improve groundwater recharge. This approach aims to support long-term urban resilience and infrastructure efficiency.

1.1. Study area
Thane City is located in the western coastal region of India, with geographical coordinates ranging from
19.1°N to 19.3°N latitude and 72.9°E to 73.1°E longitude. The topography is a mix of hilly terrain, coastal wetlands, and reclaimed land. The city falls under the tropical monsoon climate, receiving an annual average rainfall of 2500–3000 mm. Urban sprawl and shrinkage of natural water bodies have made the city increasingly susceptible to flash floods and water logging.

1.2. Literature survey
Waterlogging and urban flooding are critical challenges in Thane City, exacerbated by increasing rainfall intensity, inadequate drainage infrastructure, and proximity to water bodies like the Ulhas River estuary and Thane Creek. Geospatial technologies including GIS, remote sensing, and IoT-based sensor networks have been increasingly applied to analyze, monitor, and manage waterlogging in the city.

1.3. Literature Review
The observations highlight how unplanned urban development and encroachment in cities like Dhaka and Khulna have severely disrupted drainage systems, leading to monsoon-related waterlogging and associated socio-environmental issues. High tides and poor drainage contribute to salinity and flooding, with proposed solutions including improving natural drainage, removing obstructions, and redesigning drainage networks. Studies in Chittagong and Urmia demonstrate the use of GIS, AHP, and fuzzy logic to identify groundwater recharge zones, while Malang's eco-drainage with injection wells shows promise in managing runoff. In India, mapping and analyzing waterlogged zones, promoting water reuse, and developing resilient

crops are essential. Additionally, excessive groundwater extraction has led to saline intrusion, necessitating artificial recharge methods. Urban areas like Austin show that urban-induced recharge can support aquifers, contrary to traditional views. Overall, integrating technology, improved planning, and sustainable practices is crucial to tackling waterlogging and groundwater challenges.

II. METHODOLOGY

2.1. Scope of a project:
- ➢ Identifying repetitive water logging areas.
- ➢ Undertake the study of flood prone areas and to assess the impact of water logging.
- ➢ To identify locations for artificial groundwater recharge.
- ➢ Hydrological and Geological studies.
- ➢ To study recharge techniques and methods.
- ➢ Design of Artificial Ground water recharge system.
- ➢ Cost estimation.

2.2. Objective of a project:
- Improvement in infiltration and reduction in runoff.
- Improvement in groundwater levels and yields.
- Reduction in Waterlogging.
- Improvement in traffic flow.
- Long-term management and maintenance of the water logging mitigation systems.

2.3. Problem Statement:
- Identification, analysis and providing engineering solutions for few repetitive water logging areas in Thane city.

Figure No. 2.1 Contour Map

2.4. Causes and Effects of Water logging area:
- Due to lake overflow, water reaches the road.
- The drainage system is insufficient to drain roadside water.

- The drainage system and roads are at the same level.
- Urban development occurs without proper consideration of drainage patterns and water flow.
- Drainage systems are not maintained regularly.
- Some drainage systems are above road level, causing water to overflow from them.
- Drains get clogged due to solid waste accumulation.

2.5. Effects:
- Road damage occurs due to the reduced bearing capacity of waterlogged soil.
- Waterlogging causes significant reductions in traffic speed and volume.
- The risk of accidents increases.
- Increased risk of disease outbreaks.
- Causes inconvenience to local residents.

2.6. Identifying methods for Artificial ground water recharge:
1. Injection Wells – Water is directly injected into deep aquifers through drilled wells.
2. Recharge Shafts – Vertical shafts filled with gravel allow rapid infiltration to deeper layers.
3. Recharge Pits – Shallow pits filled with sand or gravel enable surface water to percolate underground.
4. Stormwater Management – Controls urban runoff to enhance groundwater recharge in paved areas.
5. Aquifer Storage – Stores surplus water in aquifers during wet seasons for use in dry periods.

2.7. Injection well:
- Reason of Selection - Areas with confined aquifers or in urban areas where land for surface recharge is limited.
- Example- Injection wells used in urban groundwater recharge programs, or industrial wastewater injection.
- Working Principal of Injection well:
- o Rainwater collection: Rainwater, dirt, and debris flow through down take pipes into the filter.
- o Filtration: The filter element flushes out dirt and debris automatically using cohesive and

centrifugal force.
- o Water storage: Clean water is diverted into the sump or recharging well through the clean water outlet.
- o Water injection: The water is injected into the deeper layers of the semi-impervious soil strata through the V-wire Screens.
- o Water percolation: The water percolates into the deeper layer of the earth strata.

2.8. Construction Procedure Of V-wire Injection Well.

❖ Construction Procedure of Storage well (Secondary Filtration Module).

1. Drill the Bore Well
   - o Choose the location based on water studies.
   - o Drill to reach the aquifer; diameter larger than regular wells.
2. Excavate Around the Bore
   - o Dig a pit (1.5–2 m wide, 2–3 m deep) around the bore for placing rings.
   - o Ensure proper safety during excavation.
3. Install Precast Concrete Rings
   - o Lower and stack rings in the pit to form the well casing.
   - o Align and seal each ring properly.
4. Build the Injection Chamber
   - o Continue stacking rings up to or just above ground level.
   - o This chamber will hold filtered water before it seeps down.
5. Fix V-Wire Screen
   - o Place the V-wire screen at the bottom of the bore.
   - o Acts as a filter to block fine particles; gravel can be added around it.
6. Add Air Vent
   - o Install a vent pipe to release trapped air/gases.
7. Install Perforated Lid
   - o Place a lid with holes on top to allow water in and keep debris out.
8. Place Extra Ring (Optional)
   - o Add another ring above the lid for protection in traffic zones.
9. Build Filter Bed on Top
   - o Add layers (top to bottom): Pebbles → Gravel → Coarse Sand → Fine Sand.
   - o Filters water before it enters the injection well.
10. Backfill & Finish Surface
    - o Fill around the well with gravel/sand for support.
    - o Shape the surface to direct water into the filter bed.

Figure No. 2.2 Precast modular ring

❖ Construction Procedure for Silt Trap (Primary Filtration Module).

- Excavation:
  - o Dig a pit near the injection well (1.5–2 meters deep).
  - o Ensure the base is level and walls are stable.
- Installing Precast Rings:
  - o Place concrete rings from bottom to near ground level.
  - o Align and seal joints properly for stability.
- Laying Filter Media:
  - o Add layers at the bottom inside the rings:
    - ▪ 20 cm gravel (40–60 mm)
    - ▪ 10 cm coarse sand (2–4 mm)
- V-Wire Screen Placement:
  - o Place a strong horizontal V-wire screen on top of the rings.
  - o It filters water and supports light loads.
- Connecting to Injection Well:
  - o Use a sloped PVC or RCC pipe (1–2% slope).
  - o Draws cleaner water from below the screen into the injection well.
- Connecting to Collection Trap:
  - o Link surface water collector to the silt trap via an inlet pipe.
  - o Ensure pipe is sloped and securely installed for smooth flow.

Figure No. 2.3 V-Wire Screen

III. DATA COLLECTION AND CALCULATION
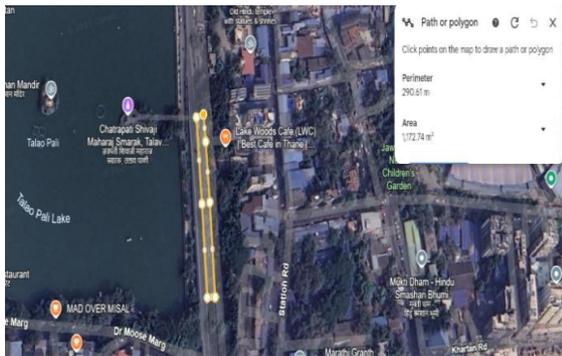
3.1. Catchment Area Taloa Pali

Figure 3.1 Catchment Area

Catchment Area: - 1,172 sq. m

3.2. Rainfall Data and surface runoff Volume:

Table No. 3.1 Avg rain and runoff volume

Month / Year	Avg rain (mm)	RUNOFF (cu.m)
2012	263.28	277.88
2013	301.93	318.67
2014	219.60	231.78
2015	116.17	122.61
2016	880.67	929.51
2017	220.46	232.68
2018	270.47	285.47
2019	99.84	105.37
2020	316.09	333.62
2021	207.01	218.49
2022	314.99	332.46
2023	291.98	308.17

• Rainfall is concentrated from June to September. In the dry season, low soil moisture and light rainfall allow easy absorption, reducing waterlogging. In the rainy season, saturated soil and intense, short-duration rains hinder absorption, increasing the risk of waterlogging.

• Determination of Runoff

Surface runoff = C×I×A

Q = peak runoff rate (cubic meters per second or liters per second).

C = runoff coefficient (depends on surface type).

C = 0.9 (indicating a highly impervious surface).

I = rainfall intensity (mm/hr or m/s, depending on the units used).

A = catchment area (m²).

• Peak Surface Runoff Volume

= 929.51 m^3 per month … (from Table No. 3.1)

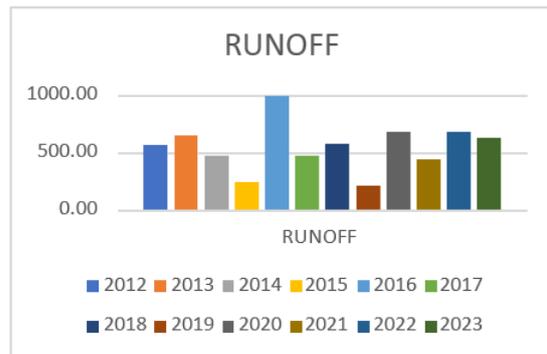= 929.51×10^3 lit per month

Figure 3.2 Waterlogged area

Figure 3.3 Peak Rainfall Graph

Maximum Runoff = 929.51×10^3 lit per month (year 2016)

3.3. Soil Type: -

• Deep black soils are found along the Vaitarna and Ulhas River plains.

• Infiltration rate ranges from 2 to 10 cm/hr, due to high clay content and organic matter, which enhance water absorption.

IV. DESIGN CALCULATIONS OF V-WIRE INJECTION WELL

4.1. Design of Primary Filtration Module (Silt Trap):

• Structure

O Made of precast modular rings (Ø1000 mm x 300 mm height x 50 mm thick).

o Total height from ground level: 2700 mm.

o Freeboard (top safety buffer): 525 mm.

• Water Inlet/Outlet:

o Connected using 150 mm diameter PVC pipes.

• Filter Media at Bottom:

o Gravel layer (200 mm, 40–100 mm size).

- o Coarse sand layer (100 mm, clean sand).
- o Total filter depth: 300 mm, to trap fine particles.

- • Effective Water Storage Depth:
- o After deducting space for filter, freeboard, and top lid = 2.025 m.

- • Storage Capacity:
- o Volume = $\pi \times (0.5 \text{ m})^2 \times 2.025$ m ≈ 1.59 m³
- o Holds approx. 1590 litres before discharge.

4.2. Design of Secondary Filtration Module (Storage Well):

- • Structure:
- o Precast rings: Ø2000 mm × 300 mm height × 50 mm thick
- o Total depth: 4.5 m
- o Perforated lid (Ø2000 mm) prevents debris entry
- o 150 mm PVC pipe for water flow from silt trap
- o V-wire screen (Ø150 mm × 600 mm) filters water into bore well

- • Filter Media (Bottom Layers):
- o 200 mm gravel (coarse)
- o 50 mm charcoal (purifies)
- o 50 mm coarse sand (fine filtration)
- o Total filter depth: 300 mm

- • Capacity:
- o Volume = $\pi \times (1 \text{ m})^2 \times 4.5$ m ≈ 14.14 m³
- o Approx. 14,137 litres of water storage before bore well entry

4.3. Infiltration Analysis of Silt Trap and Storage Well System

- o Peak Runoff: 929,510 L/month
- o Infiltration Rate (conservative): 2000 L/hr
- o Total Storage Capacity:
- o Silt Trap: 1,590 L
- o Storage Well: 14,137 L
- o Total: 15,727 L

- o Time to Discharge Once

$$= \frac{15{,}727\ liters}{2000\ \frac{liters}{hour}} = 8 \text{ hours}$$

- o Cycles Needed per Month:

$$= \frac{929{,}510}{15{,}727} = 65 \text{ cycles}$$

- o Total Time Needed:

= 65 cycles × 8 hours = 520 hours ≈ 22 days

- o Conclusion:

The system can handle monthly runoff in ~22 days, leaving 8–9 days buffer for maintenance or peak rains.

Approximate Cost Estimation:

4.4. Approximate Cost Estimation:

1. Perforated Concrete Lid (2 Nos.)
- • Unit Rate: ₹2,000/- per piece
- • Total Cost: ₹2,000 × 2 = ₹4,000/-
2. Precast Modular RCC Rings:
- O For Silt Trap (Diameter: 1000 mm)
- • Quantity: 10 Nos.
- • Unit Rate: ₹800/- per ring
- • Total Cost: ₹800 × 10 = ₹8,000/-
- o For Storage Well (Diameter: 2000 mm)
- • Quantity: 19 Nos.
- • Unit Rate: ₹1,500/- per ring
- • Total Cost: ₹1,500 × 19 = ₹28,500/-
3. V-wire Screen (Size: 150 mm × 600 mm)
- • Quantity: 2 Nos.
- • Unit Rate: ₹22,000/- per screen
- • Total Cost: ₹22,000 × 2 = ₹44,000/-
4. PVC Pipe (Diameter: 150 mm)
- • Quantity: 30m
- • Unit Rate: ₹350/- per m
- • Total Cost: ₹350 × 30 = ₹10,500/-
5. Borewell Drilling (Diameter: 250 mm, Depth: 25m)
- • Lump Sum Cost: ₹1,50,000/-
6. Labour Charges (Approximate)
- • Total Cost: ₹20,000/-

Total Approximate Estimated Cost: ₹2,56,000/-
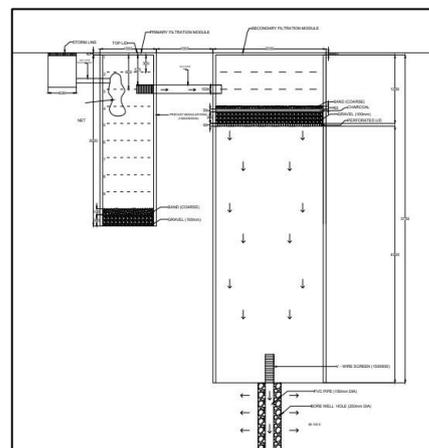
4.5. Auto CAD Detailed Drawing
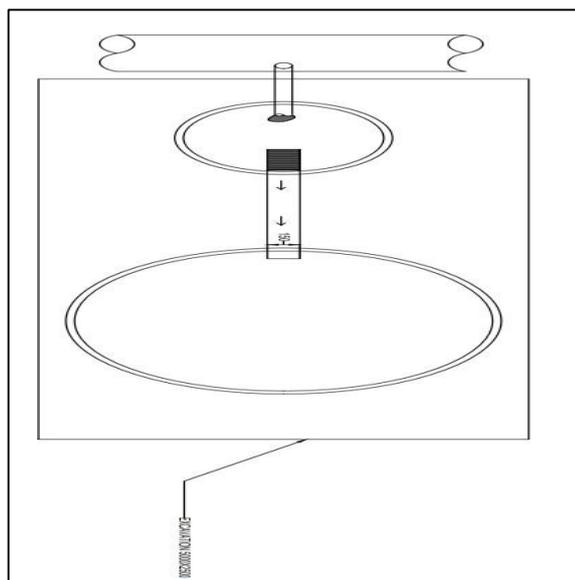

Figure 4.1 Section View of Filtration Module

Figure 4.2 Top View of Filtration Modul

5. RESULT & CONCLUSION

5.5. Result

- Filtration Achievement

  The V-wire injection system filtered 929,510 liters of stormwater in about 22 days, based on a conservative infiltration rate of 2,000 liters/hour. The remaining 8–9 days each month provide a buffer for maintenance, weather variations, and system downtime.

- Fulfilment of Project Objectives

o Better Infiltration, Less Runoff: The system helps rainwater soak into the ground, cutting down surface runoff.

o Boosted Groundwater: High-volume recharge supports rising groundwater levels.

o Less Waterlogging: Excess water is absorbed, easing flooding in the Talao Pali area.

o Improved Traffic Flow: Faster drainage reduces road flooding, making travel smoother and more convenient.

- Socio-Environmental Impact (Simplified)

o Better Flood Control: Helps manage urban flooding and eases pressure on drainage systems.

o Improved Public Health: Less waterlogging means fewer waterborne diseases and safer roads.

o Scalable Solution: A low-cost model that can be applied to other flood-prone areas.

5.6. Conclusion

The project effectively addressed urban waterlogging in Thane's Talao Pali area through a site-specific. The core of the project was focused on providing an engineering solution that is both sustainable and site-specific. After a comparative evaluation of artificial recharge methods, the V-wire injection well system was selected for its suitability in confined urban settings with limited land availability and high runoff rates. The implemented V-wire injection well system significantly improved stormwater management and urban resilience, offering a replicable model for similar urban challenges.

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