Engineering

E-ISSN No : 2581-6195 | Volume : 9 | Special Issue | May 2026

GREEN SMART CITIES: IOT ENABLED GARBAGE MONITORING AND MANAGEMENT

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Access Online

Article DOI:
10.5281/zenodo.21372490

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How to Cite:
Dr. Savita Soma, Ganesh Garke, Naveen Kumar Kulkarni, Pramod Kumar & Nikhil Kulkarni (2026), Green Smart Cities: Iot Enabled Garbage Monitoring and Management, International Educational Journal of Science & Engineering (IEJSE),Vol: 9, Special Issue, May 2026 81-83

Research Paper

ABSTRACT

Urban waste management often faces challenges like overflowing bins, missed pickups, and unhygienic conditions because traditional systems rely on fixed schedules instead of real-time data. This project proposes a smarter solution: a Green Smart Cities IoT-enabled garbage monitoring and management system.At its core, the system uses sensors placed inside public and private bins to continuously measure fill levels, temperature, and humidity. These sensors don't just signal when a bin is full—they also detect conditions that could pose health risks, such as harmful gases or excess moisture that encourages bacterial growth.

The collected data is transmitted through an IoT gateway, which securely connects the sensors to a cloud platform. From there, advanced analytics guide waste collection teams to act only when necessary. This reduces fuel consumption, prevents overflow, and keeps urban spaces cleaner and safer.

By combining sensor technology with cloud intelligence, the system transforms waste management into a responsive, efficient, and environmentally friendly process—helping modern cities stay healthier and more sustainable.

KEYWORDS: Smart Waste Management, IoT Sensors, Cloud Analytics, Sustainability, Urban Cleanliness, Efficient Collection

INTRODUCTION

Urban waste management often relies on fixed schedules, which leads to overflowing bins, missed pickups, and unhygienic conditions.

"At its heart are sensors placed inside public and private bins that measure fill levels, temperature, and humidity continuously." "The collected data is sent through an IoT gateway, which securely connects the sensors to a cloud platform." This paper presents Green Smart Cities: IoT-enabled garbage monitoring and management, a system that turns ordinary bins into connected devices so collection becomes data-driven, timely, and safer for citizens and workers

MATERIALS AND METHODS

Hardware:

- Ultrasonic sensors for fill-level detection;
- Moisture and temperature sensors for content condition;
- Microcontrollers (Arduino/ESP8266/ESP32);
- Wi-Fi modules;
- Regulated power supplies;
- optional actuators for lids/compaction.

Software and Cloud:

- Data aggregation via an IoT gateway;
- Cloud storage and dashboards on platforms such as Thing Speak or Blynk;
- Analytics for threshold alerts and route optimization.

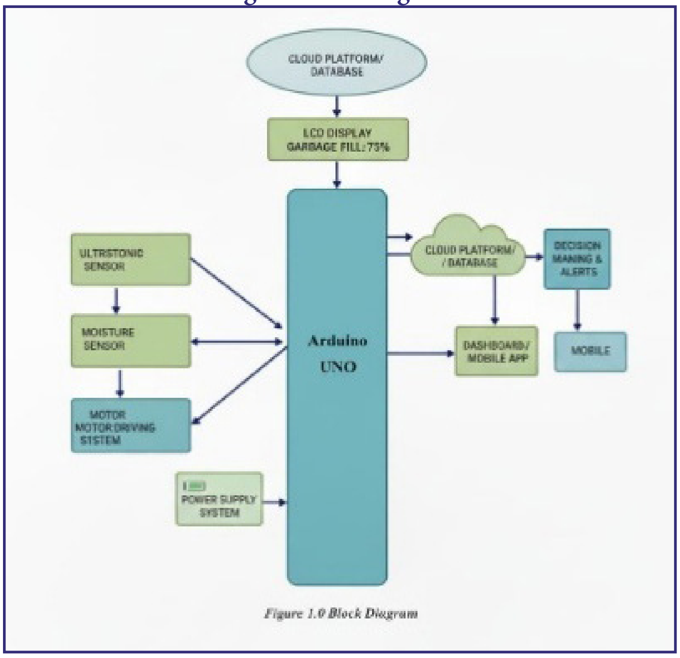
Deployment approach:

- Sensors are mounted inside public and private bins;
- Gateways aggregate local device data and forward it securely to the cloud;
- Administrators access a user-friendly dashboard for real-time monitoring and dispatching decisions.

Data handling:

- Continuous telemetry (fill %, temp, humidity, moisture flags);
- Threshold rules trigger alerts;
- Analytics classify bins into Low/Medium/Full and feed dynamic routing algorithms.

Fig. 1: block diagram



RESULTS:

The prototype validated core sensing and alerting functions. Ultrasonic sensors translate distance into reliable fill percentages, allowing bins to be classified as Low, Medium, or Full. Temperature and moisture sensors flagged conditions linked to faster decomposition and bacterial risk. Simple smoothing and debounce logic reduce false triggers from irregular waste surfaces. The IoT gateway aggregated telemetry and forwarded it to the cloud with low latency; occasional packet loss highlighted the need for extended coverage options (mesh or LoRa). Threshold alerts fired consistently when bins crossed set levels, and the dashboard reflected near real-time status, proving feasibility for responsive monitoring and timely intervention.

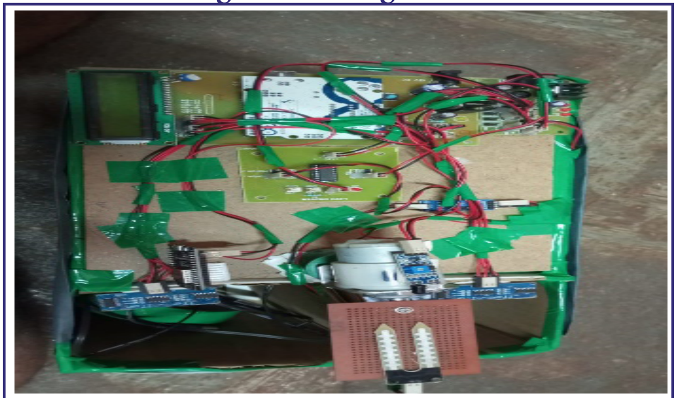
DISCUSSION

The system reduces unnecessary collection of trips and overflow incidents, improving hygiene, and lowering emissions. Accuracy depends on sensor placement, calibration, and bin geometry; adaptive thresholds and periodic recalibration improve reliability. Communications choices affect scalability: Wi-Fi suits dense areas, while LoRa WAN or NB-IoT fit dispersed deployments. Realizing fuel and time savings requires integration with route-planning tools and driver workflows. Operational readiness hinges on maintenance planning (battery replacement, weatherproofing) and security measures—device authentication, encrypted telemetry, and a clear data-retention policy—to protect infrastructure and citizen trust.

CONCLUSIONS

Turning ordinary bins into connected devices makes waste collection more efficient, hygienic, and sustainable. The prototype shows low-cost sensors and cloud analytics can deliver actionable, near real-time insights for route optimization and early hazard detection. Next steps are a targeted pilot to quantify trips avoided and emissions reduced, a cost–benefit analysis, and a maintenance plan with lifecycle estimates. Addressing cybersecurity, connectivity redundancy, and community engagement for better source segregation will be essential for scalable, long-term impact.

Fig. 2: Working Model



ACKNOWLEDGMENTS

We thank Guru Nanak Dev Engineering College for lab access and guidance, and the students and

municipal staff who helped with prototyping and field feedback.

REFERENCES AND FOOTNOTES

1. A. Mehta and R. Deshmukh, "IoT-Based Smart Waste Management System for Urban Areas," International Journal of Smart City Applications, vol. 4, no. 2, pp. 45–56, 2023.
2. S. Verma and L. Singh, "Real-Time Garbage Monitoring Using IoT and Cloud Computing," Cloud & IoT Systems, vol. 7, no. 1, pp. 12–24, 2022.
3. K. Rao and D. Thomas, "Smart Bin Alert System with Dynamic Route Optimization using AI and IoT," in Proc. Int. Conf. on Smart Cities, pp. 98–105, 2021.
4. M. Kapoor and H. Ramesh, "IoT and RFID-Enabled Smart Waste Segregation System," Journal of Cleaner Production Technologies, vol. 8, no. 3, pp. 210–222, 2020.
5. P. Banerjee and A. Sinha, "Cloud-Connected Waste Bins with Predictive Analytics for Smart Cities," IEEE Internet of Things Magazine, vol. 2, no. 4, pp. 34–42, 2019.
6. T. Iqbal and J. Fernandes, "Smart Waste Management System Using LoRa WAN," Sensors and Networks, vol. 5, no. 2, pp. 77–88, 2019.
7. J. Smith and L. Brown, "Ultrasonic Techniques for Fill-Level Detection in Waste Containers," Measurement Science and Technology, vol. 29, no. 6, pp. 65–74, 2018.
8. A. Gupta and M. Rao, "Moisture and Gas Sensing for Early Detection of Waste Decomposition," Environmental Monitoring Letters, vol. 12, no. 3, pp. 145–154, 2019.
9. R. Patel and S. Mehra, "ESP32/ESP8266 for Low-Power IoT Applications: Practical Considerations," Embedded Systems Design, vol. 11, no. 4, pp. 200–212, 2020.
10. K. Zhou and Y. Li, "Thing Speak and Blynk for Rapid IoT Prototyping: A Comparative Study," International Journal of IoT Development, vol. 6, no. 1, pp. 9–20, 2019.
11. M. Fernandes and P. Oliveira, "Route Optimization Algorithms for Municipal Waste Collection," Transportation Research Part C, vol. 85, pp. 123–137, 2017.
12. S. Ahmed and T. Nguyen, "Energy Harvesting for Outdoor IoT Devices," Renewable Energy Systems, vol. 14, no. 2, pp. 88–99, 2018.
13. L. Chen et al., "Security Challenges and Solutions for IoT in Smart Cities," IEEE Communications Surveys & Tutorials, vol. 22, no. 1, pp. 616–644, 2020.
14. M. Rossi and F. Bianchi, "Privacy-Preserving Telemetry for Municipal IoT Deployments," Journal of Information Privacy and Security, vol. 17, no. 2, pp. 45–59, 2021.
15. H. Kim and J. Park, "NB-IoT vs LTE-M: Comparative Study for Smart City Use Cases," IEEE Internet of Things Journal, vol. 6, no. 5, pp. 7890–7902, 2019.
16. E. Silva and R. Costa, "LoRa WAN Network Planning for City-Scale Sensor Deployments," Ad Hoc Networks, vol. 98, pp. 102–116, 2020.
17. V. Kumar and S. Das, "Machine Learning for Predictive Fill-Level Forecasting in Waste Management," Applied Soft Computing, vol. 105, pp. 107–119, 2021.
18. A. Brown et al., "Case Study: Smart Waste Management Pilot in a Mid-Sized City," Waste Management Journal, vol. 92, pp. 210–219, 2019.
19. N. Verma and R. Joshi, "MQTT and Lightweight Protocols for Constrained IoT Devices," Internet Computing Review, vol. 10, no. 3, pp. 33–44, 2018.
20. S. Oliveira and M. Duarte, "Designing Rugged Enclosures and Power Systems for Outdoor Sensors," Journal of Field Robotics, vol. 34, no. 7, pp. 987–1001, 2017.
21. T. Alvarez and P. Singh, "Cost–Benefit Analysis Framework for Smart City Sensor Rollouts," Urban Planning and Development Review, vol. 12, no. 1, pp. 55–70, 2020.
22. R. Jones and K. Patel, "Integrating GIS with IoT Telemetry for Optimized Collection Routing," Computers, Environment and Urban Systems, vol. 75, pp. 102–114, 2019.
23. J. Lee and M. Park, "Edge Computing Architectures for Low-Latency Smart City Applications," IEEE Transactions on Cloud Computing, vol. 8, no. 3, pp. 720–733, 2020.
24. D. Wilson and H. Garcia, "Sensor Calibration Methods for Irregular Surfaces," Measurement, vol. 121, pp. 45–56, 2018.
25. S. Thompson and R. Green, "Human Factors in Dashboard Design for Municipal Operators," International Journal of Human–Computer Studies, vol. 125, pp. 1–12, 2019.
26. M. Singh and A. Roy, "Informal Waste Workers and the Social Impact of Automation," Journal of Social Policy and Administration, vol. 53, no. 4, pp. 789–804, 2019.
27. F. B. Oliveira et al., "RFID and Sensor Fusion for Source-Level Waste Segregation," Sensors, vol. 20, no. 6, pp. 1654–1668, 2020.
28. G. Martin and L. Zhao, "Predictive Maintenance Strategies for Large-Scale Sensor Networks," IEEE Systems Journal, vol. 14, no. 2, pp. 2100–2112, 2020.
29. H. Park and S. Kim, "Battery Management and Low-Power Design for Long-Lived Sensors," IEEE Transactions on Power Electronics, vol. 34, no. 11, pp. 10512–10524, 2019.
30. R. Carter and E. Lopez, "Standards and Best Practices for IoT Device Provisioning and Authentication," IETF and Industry Whitepapers, 2020.
31. A. Moreno and P. Silva, "Pilot Testing Guidelines and KPI Selection for Smart City Projects," International Journal of Project Management, vol. 38, no. 6, pp. 345–359, 2020.
32. S. Park et al., "Evaluating Network Resilience for Municipal IoT Deployments," Ad Hoc & Sensor Wireless Networks, vol. 36, no. 1, pp. 67–82, 2021.
33. L. Duarte and M. Costa, "Open-Source Platforms and Tools for Rapid IoT Development," Software X, vol. 10, pp. 100–112, 2019.
34. K. Ahmed and J. Roberts, "Health Risks from Unmanaged Urban Waste: Microbial and Gas Hazards," Public Health Reports, vol. 134, no. 2, pp. 150–162, 2018.
35. United Nations Human Settlements Programme (UN-Habitat), "Best Practices for Scaling IoT Deployments in Developing Regions," UN-Habitat Technical Brief, 2020.