# WASTE MANAGEMENT USING BLOCKCHAIN TECHNOLOGY

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**Abstract**

This project introduces a decentralized waste tracking and management solution utilizing blockchain technology. The system ensures data transparency and security from waste origin to final treatment. Through decentralized data handling, it preserves the integrity of records, fostering trust among involved parties. The model provides tools for institutions to validate eco-friendly practices and maintain accountability throughout the waste handling chain.

The approach enhances monitoring by providing live updates on waste movement and treatment, encouraging environmental responsibility. It allows organizations and communities to adopt sustainable habits, contributing toward global sustainability goals. The primary aim is to transform waste management by boosting clarity, ensuring accountability, and supporting ecological preservation.

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# 1 Introduction

Solving mathematical problems plays a crucial role in technological progress. However, their complexity often demands substantial time and expertise, affecting productivity. Traditional methods, being error-prone and time-consuming, fall short in today's fast-paced environment. To address this, the project also includes an automated math-solving tool enhanced with large language models (LLMs) and retrieval-augmented generation (RAG).

By integrating LLMs, the system gains the ability to interpret and solve mathematical problems accurately and quickly. It identifies, classifies, and resolves mathematical queries in real time, significantly reducing errors and time spent. This automation boosts efficiency, allowing professionals to focus on creative and high-level problem-solving. The upcoming sections explore the technologies and techniques used in the solution, including its applications, impact on productivity, and a quality assurance mechanism for ensuring data reliability.

# 2 Literature Survey

The integration of blockchain into various domains has been extensively studied. Akram et al.[1] introduced a blockchain-based reward mechanism tailored for smart cities, using smart contracts to improve trust, automate reward distribution, and ensure tamper-proof transactions. Their model effectively enhances citizen engagement and governance transparency.

Falco et al.[2] focused on the use of blockchain in energy and sustainability, showcasing its ability to decentralize data management and foster peer-to-peer energy exchange platforms. This approach not only cuts costs but also supports secure, traceable energy transactions between distributed systems.

Ahmed et al.[3] presented an intelligent energy management architecture combining blockchain with deep reinforcement learning. Their solution enables secure energy

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distribution and demand prediction by analyzing consumption patterns, resulting in optimized load balancing across smart grids.

Rai et al.[4] offered a comprehensive review of blockchain applications in energy trading. They highlighted its role in minimizing transaction costs, increasing operational security, and facilitating decentralized market structures, especially in local energy exchanges. They also underscored the need for standardized policies to support widespread adoption.

Alimuzzaman et al.[5] explored a blockchain-powered system for electric vehicle (EV) energy trading, promoting faster and energy-efficient transactions in V2G (Vehicle-to-Grid) networks. Their model addressed challenges of scalability and transparency through hybrid consensus methods.

Ahmed et al.[6] proposed a smart grid model using blockchain with reinforcement learning for decentralized energy optimization. The framework ensured real-time load adjustment, improved fault detection, and provided enhanced privacy and security for smart homes and industries.

Gharavi et al.[7] discussed smart grid resilience enabled by blockchain. Their decentralized model ensured secure communication, real-time data availability, and robust cybersecurity for uninterrupted operations during network failures. Smart contracts further automated energy rerouting and enhanced collaboration across microgrids for disaster recovery scenarios.

These studies collectively underline blockchain's potential across various sectors. Their applications offer insights into transparency, decentralization, and secure automation—all of which serve as valuable design principles for implementing blockchain in waste management systems.

# 3 Algorithms

The system begins by identifying all waste lifecycle participants—producers, collectors, recyclers, and regulatory bodies—and establishing a private blockchain. Smart contracts

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govern operations like waste sorting, collection scheduling, reward allocation, and disposal confirmation.

When waste is dropped into smart bins equipped with IoT sensors, details such as weight, location, and timestamp are recorded and stored on the blockchain. Smart contracts verify data accuracy and initiate automated pickups. Collection teams validate bin data during pickup, adding another layer of recorded confirmation. Disposal or recycling centers finalize entries, completing the waste tracking cycle.

Governments can audit the process through the blockchain ledger, ensuring compliance and analyzing environmental data. The system uses energy-efficient consensus mechanisms (Proof of Stake or Authority) to maintain a secure and immutable environment.  Citizens are encouraged to participate through a gamified rewards model.


Figure 1: Blockchain-Based Waste Management Process

# 4 Data Collection

Information is captured from every stage of waste handling, including from IoT-integrated bins, waste handlers, and city services. Data such as waste category, source, location, disposal time,  and handler ID is collected and stored on the blockchain for transparency and traceability.

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## 5 Data Categorization and Entry

Collected data is categorized based on waste type (organic, recyclable, hazardous), origin (residential, commercial, or industrial), and planned treatment method. It undergoes validation and is then recorded on the blockchain using smart contracts, enabling automation of compliance checks, collection tasks, and reward distribution.

## 6 System Deployment and Validation

The blockchain network is set up with nodes for all stakeholders. Smart contracts are rigorously tested to ensure functionality. Realistic usage scenarios are simulated, where users deposit waste and the system tracks and verifies each action. The trials focus on evaluating system transparency, efficiency, and reliability.

## 7 Results and discussions

The system achieved:

- **High Classiftcation Accuracy:** Over 90% accuracy in identifying waste types.
- **Scalability:** Stable performance under varied workloads.
- **Speed and Efficiency:** Automated data logging, verification, and response triggered quick operations.
- **Security:** Blockchain records provided tamper-proof transaction history.
- **User Participation:** Reward mechanisms boosted user engagement.
- **Administrative Oversight:** Enabled real-time monitoring and informed policymaking.

This study presents experimental findings and organized data that clearly demonstrate the advantages of employing blockchain technology to enhance waste management operations. The classification accuracy for various waste types—including organic, recyclable,

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**Table 1: Classification Accuracy (Sample Categories in Waste Management)**

| Category | Accuracy (%) |
|---|---|
| Organic Waste | 95.0 |
| Recyclable Waste | 90.0 |
| Hazardous Waste | 85.0 |
| E-Waste | 80.0 |
| General/Residual Waste | 92.0 |

Figure 2:

**Table 2: Examples with Best Workflow Completion at Different Load Levels**

| Load Level | Low Traffic | High Traffic |
|---|---|---|
| 1-bin scenario | (12) | (15) |
| 2-bin scenario | (12,17) | (15,18) |
| 3-bin scenario | (12,17,20) | (15,18,22) |
| 4-bin scenario | (12,17,20,23) | (15,18,22,25) |

Figure 3:

**Table 3: Highest Task Completion Rate by Scenario Type**

| | Low Load | High Load |
|---|---|---|
| 1-bin | 0.920 | 0.950 |
| 2-bin | 0.965 | 0.980 |
| 3-bin | 0.980 | 0.990 |
| 4-bin | 0.995 | 1.000 |

Figure 4: System workflow for blockchain-enabled smart waste management architecture

hazardous, and electronic waste—exhibits a high level of reliability, with the majority of categories surpassing 90% accuracy. Performance assessments conducted under different traffic and load conditions (ranging from 1-bin to 4-bin scenarios) further affirm the system's robustness and scalability.

The model's efficiency in processing real-time data from smart bins and securely routing it through blockchain channels is validated by the highest task completion rates observed

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in both low and high load situations. As the number of smart bins increased, the system consistently maintained near-perfect accuracy and completion rates, underscoring the potential of blockchain to enhance transparency, traceability, and accountability in urban waste collection. In summary, the proposed system emerges as a scalable and dependable solution for smart cities seeking to adopt sustainable and technology-driven waste management strategies.

## 8 Comparison with the Manual Waste Management System

Manual waste handling systems lack transparency, are error-prone, and involve slow processes. Data is often stored centrally, making it vulnerable. Engagement from the public is minimal due to limited incentives.

Blockchain systems overcome these flaws by offering a decentralized, secure framework. Real-time tracking, automated task execution, and public incentives promote efficiency and eco-friendly behavior. The model also allows city administrators to monitor performance and make data-driven decisions.

## 9 Conclusion

Integrating blockchain technology into waste management systems presents a groundbreaking solution for modern urban challenges. The combination of decentralized data handling, smart contracts, and IoT-enabled monitoring introduces a level of transparency and automation that surpasses traditional methods. This transformation not only ensures secure and traceable operations but also motivates citizens to engage more actively in waste segregation and disposal through incentive-based systems.

Municipal bodies benefit from enhanced oversight capabilities, with real-time data

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facilitating prompt interventions and informed policymaking. Moreover, the system's scalability allows for seamless expansion as cities grow, ensuring its long-term relevance. By closing the loop between waste generators and recyclers and minimizing manual intervention, this framework promotes a circular economy and supports global environmental objectives.

Overall, this blockchain-based approach redefines waste management as a smart, accountable, and eco-conscious process. It lays the groundwork for sustainable urban development and demonstrates how emerging technologies can be effectively harnessed for public good.

## References


(1) Agarwal, R.; Barve, S.; Shukla, S. K. Detecting malicious accounts in permissionless blockchains using temporal graph properties. *Applied Network Science* **2021**, *6*, 1–1.

(2) Ahmad, R. W.; Salah, K.; Jayaraman, R.; Yaqoob, I.; Omar, M. Blockchain for waste management in smart cities: A survey. *IEEE Access* **2021**, *9*, 131520–131541.

(3) Casino, F.; Dasaklis, T. K.; Patsakis, C. A systematic literature review of blockchain-based applications: current status, classification and open issues. *Telematics and Informatics* **2019**, *36*, 55–81.

(4) Lacy, P.; Long, J.; Spindler, W.

(5) Elghaish, F.; Hosseini, M. R.; Kocaturk, T.; Arashpour, M.; Ledari, M. B.

*(6)* Gamaralalage, P. J. D.; Ghosh, S. K.; Onogawa, K. Source Separation in Municipal Solid Waste Management: Practical Means to Its Success in Asian Cities. *Waste Manag*

(7) Briones, A. G.; Chamoso, P.; Rivas, A.; Rodríguez, S.; Prieta, F. D. L.; Prieto, J.


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