https://doi.org/10.33472/AFJBS.6.10.2024.930-936

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

SMART WASTE MANAGEMENT REVOLUTIONIZING GARBAGE COLLECTION WITH INTERNET OF THINGS

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Volume 6, Issue 10, 2024

Received: 09 March 2024

Accepted: 10 April 2024

Published: 20 May 2024

doi:10.33472/AFJBS.6.10.2024.930-936

Abstract — Smart Waste Management represents a cutting-edge approach to the optimization of waste collection and disposal through the integration of technology and data-driven solutions. To keep up with rapid urbanization and technological advancement, contemporary communities must have efficient waste management systems in place if they are to maintain a clean and sustainable environment. The potential of Smart Waste Management systems to revolutionize garbage collection via the use of the Internet of Things (IoT) is explored in this research. Using high-tech sensors installed in garbage cans, the proposed solution enables smarter waste management. Using the Internet of Things, these sensors can detect when a bin is full, measure the precise amount of fill, and transmit the data in real-time. Improved resource allocation, reduced operational expenses, and streamlined garbage collection routes are all possible outcomes of this data's analysis. Putting IoT sensors inside garbage cans could help cities improve their waste management in a more data-driven and responsive way. This not only ensures timely and efficient garbage collection but also contributes to a cleaner environment, reduced carbon footprint, and improved overall quality of life for urban residents. The synergy between IoT and waste management opens up new possibilities for creating sustainable and smart cities, setting the stage for a cleaner and greener future.

Index Terms—Global population, Municipal waste generation, Internet of Things, Waste management systems

I. INTRODUCTION

A versatile and scalable observation infrastructure is necessary to meet the ever-changing demands of High Performance Computing (HPC) machine platforms as they undergo significant evolution. With the constant development of new features, improved models, and updated information, intrusion Detection Systems (IDS) and the interference they cause are very dynamic. There has been a lot of research conducted on data from visual images. New and improved information is being made available to allow intrusion detection at the boot level. Results from these studies are beginning to make their way into Intrusion Detection Systems, and they might prove to be much more useful in determining the severity of threats, event trends, and other relevant metrics. Approximately one-third of the world's 2.01 billion metric tons of MSW is not handled in an ecologically sound manner, according to reports. In reality, there is a large disparity between the 0.11 and 4.54 kg of garbage produced per person every day [10]. Waste management is becoming more of a problem as a result of fast urbanization and the ever-increasing worldwide population [11]. Almost every nation deals with the issue of decaying waste on the highways. This reflects poorly on a society that is striving for progress. India produces almost 1.5 million metric tons of solid trash every day [12]. Therefore, effective management of these wastes is crucial. The time has arrived to act decisively and appropriately in order to resolve this issue [13]. To address the problem of the gradual increase of trash over time, a garbage collection management system might be useful. In addition to cutting down on available resources, this system's implementation would have a negative impact on garbage collection costs [14]. Municipal authorities are considering alternatives to the conventional garbage collection system because to the growing impact of abandoned trash on society and the environment. A cost-effective solution for trash management is being sought after by researchers in several nations. The relevant authorities have already put some of the processes into action. The majority of nations still use the tried-and-true method of having trash picked up at regular intervals and then deposited in designated disposal yards (sometimes known as "curbside disposal") [15]. On a daily basis, major Indian cities like Delhi and Mumbai produce almost 10,000 tons of waste. A little over twenty million people call the island of Taiwan, which spans 35,800 km2, home. There are rough mountains that encompass two-thirds of this region. According to [16], the government of Taiwan has chosen to implement new rules that would alter the country's garbage collecting system.

A. *Motivation of the paper*

By deploying cutting-edge sensors within garbage bins, our proposed system aims to bring intelligence to waste monitoring and management. These sensors can discern whether bins are empty or nearing full capacity, measure fill levels accurately, and relay this real-time information through IoT technology. The ensuing data is then subjected to comprehensive analysis, enabling the optimization of garbage collection routes, judicious resource allocation, and a consequential reduction in operational costs.

II. BACKGROUND STUDY

Awoyera, P. O., et al. The study's findings were as follows. The samples made with mineral admixtures met the European Federation of National Associations Representing for Concrete (EFNARC) limitations, according to the findings of the Government Securities Clearing Corporation (GSCC) fresh properties evaluation. Though the V-funnel results were higher than the 12 s limit stipulated by the standard, the control combination nevertheless fulfilled all other criteria. Possible causes of such behavior include mixture segregation and excessive viscosity.

França, E., et al. (3) In Brazil, the number of fatalities reported as Gas chromatography (GC) has been declining. There were significant disparities and divergent temporal patterns among Brazilians from 1996 to 2005 when data were broken out by GC type and developmental level. Over the previous 20 years, Brazil has made progress in upgrading cause-of-death data. Inequalities in mortality coded to GCs have decreased, and less significant GC level 4 was the most common in the nation in 2016.

Kuang, Y., et al. (5) The author want to learn more about the variables that affect citizens' willingness and conduct in relation to University Grants Commission (UGC) in this research, and the author look at the discrepancy between the two as well. A professional survey business randomly surveyed people in Beijing, Shanghai, Guangzhou, and Shenzhen in October 2019. The author used these results to inform these authors study. The main points were outlined below: To begin, the author discovers that in the four Chinese metropolises, there was a discrepancy between the willingness of respondents and their action regarding UGC. In other words, just because people were more open to sorting trash doesn't imply they would. Second, there was a difference between the elements that influence World Trade Center (WTC) and Bank Giro Credit (BGC). The WTC significantly impacted by the respondents' income and level of education. Contrary to what Alhassan et al. found, this research found no statistically significant influence of respondents' wealth on UGC (2018).

Mandpe, A., et al. (7) the current research assessed the feasibility of using General Electric (GE) in conjunction with Fly Ash (FA) to treat organic waste. Out of all the combinations that were evaluated, the compost in vessel 5 was deemed the best.

Pelonero, L., et al. (9) Using a number of IoT sensors, this article proposes an improvement to two main garbage disposal scenarios: door-to-door and dumpsters. From the number of bags outside residences to the amount of space left in dumpsters, these sensors record it all. Garbage collection routes and citizen behaviors better monitored with the usage of the collected data. Municipalities can use the data they acquire to implement initiatives, like incentives, that encourage garbage separation. A number of factors related to citizens' actions tracked using an app, including the status of the bug collection, the earned incentives, and the conferred bags.

Tamaki, S., et al. (11) A pH drop of around 3–4 points was seen in the first week after sowing laboratory waste management (LAB) was used for lactic acid fermentation of synthetic kitchen waste. This prevented solids from dissolving, even when mixed with bacterial sludge from residential wastewater treatment plants. Subsequent anaerobic digestion had a potential ratio of around 0.8 for preservation to biogas generation. In the continuous storage experiment, the most abundant Operational taxonomic unit (OUT) was shown to be closely linked to Lactobacillus.

A. *Problem definition*

Rapid urbanization and increasing waste generation pose significant challenges to traditional waste management systems. Conventional methods lack real-time data and efficiency, leading to suboptimal resource utilization, higher operational costs, and environmental concerns. The need for a smarter and more responsive approach is evident, prompting the exploration of a Smart Waste Management system driven by Internet of Things (IoT) technology. This system aims to address the inefficiencies in current garbage collection processes by introducing advanced sensors in garbage bins to monitor, measure, and manage waste intelligently, ultimately contributing to cleaner and more sustainable cities.

III. MATERIALS AND METHODS

In this study, we propose an innovative approach for accurate garbage content estimation in waste bins, addressing the challenges posed by increasing global population and urbanization.

A. *Garbage bin sensor*

Using a waste bin sensor is one approach to monitor the state and contents of a trash can. Trash cans often have these sensors built in, and they leverage IoT technology to provide real-time data on several parameters. Many features are shared, including weight, fill level, temperature, and sometimes even environmental elements. The sensors use a variety of technologies, including as weight sensors, infrared, and ultrasonic, to accurately detect and record data. A central system, often hosted in the cloud, receives the collected data wirelessly, allowing for remote monitoring and analysis. The use of garbage bin sensors is crucial for improved waste management. These sensors give authorities precise and current information about the condition of garbage bins, which improves decision-making and helps with collection scheduling, operational cost reduction, and environmental sustainability in general. One further use for weight sensors is to monitor variations in weight; this will let you know when the bin can no longer support any more weight.

B. *IoT (Internet of Things)*

A "thing" is any inanimate device that can perform an action (such as turning on or off a light, opening or closing a door, adjusting the rotation speed of a motor, etc.) and is equipped with sensors that gather data to be sent across a network. Refrigerators, streetlights, buildings, cars, factories, and rehab tools are all included in this broad category of things. In certain cases, sensors don't even need to be physically attached to the items themselves; rather, they only need to keep tabs on the stuff going on around them.

Gateways Information can go freely between items and the cloud through gateways. A gateway connects devices to the cloud service, filters information before sending it there to decrease the amount of data that has to be processed and stored, and relays orders from the cloud to the devices. Actuators on objects then carry out commands. Cloud gateway helps edge gateways and cloud IoT backends communicate securely and efficiently by enabling encrypted data flow and compression. It also ensures compatibility with several protocols and modifies its communications with field gateways so that they work with the specific gateways' protocols. Streaming data processor controls data flow efficiently from sources to a data lake. No information can ever be accidentally deleted or damaged. Data Lake IoT data is collected and stored in its unprocessed form in a data lake. Both "batches" and "streams" are frequently used delivery strategies for massive data. Before data is transported to a massive data warehouse for analysis, it is kept in a data lake. Big data warehouse Before data is moved from a data lake to a big data warehouse, it is filtered and preprocessed so that it can yield actionable insights. Big data warehouses hold only data that has been cleaned, processed, and matched, in contrast to data lakes which gather raw sensor data. The data warehouse stores information about the things and sensors (such as the location of the sensors) in addition to the instructions control applications deliver to the objects. Data analytics Information scientists can mine the massive data repository for useful patterns and insights. Big data analysis (and visualization in schemes, diagrams, and info graphics) shows things like how well devices are functioning, where improvements can be made, and how an Internet of Things (IoT) system can be made more reliable and customer-centric.

C. *ESP8266*

The ESP8266 is a Wi-Fi capable microcontroller made by the Chinese company Espressif. In August 2014, with the release of the ESP-01, the chip first caught the attention of manufacturers in the West. For microcontrollers, this little board means easy TCP/IP connections utilizing Hayes-style instructions and Wi-Fi networking. Unfortunately, the chip and the instructions it could process were not well documented in English at the time. Many hackers were interested in the module, chip, and software on it, and they even translated the Chinese documentation, all because of the cheap pricing and the fact that there were very few external components on the module, which signals that it can someday be extremely affordable in volume.

D. *Gas Sensor*

A sensor for detecting is known as a gas sensor. Gas, is a highly combustible fuel utilized for a variety of domestic and commercial applications. However, gas sensor can accumulate in the air and present a significant fire hazard if there is a leak in the gas line or appliance. In order to determine whether there is gas sensor in the air, a semiconductor or electrochemical sensor is commonly used in an r gas sensor. In the presence of gas sensor, the sensor undergoes a reaction that modifies its electrical conductivity or other characteristics. The sensor then uses this variation as the basis for an alarm or other notification. Homes, companies, and other establishments that utilize gas sensor as a fuel often install gas sensors that detect the presence of this gas. They can function alone or as part of a larger system, such as a gas detector or an alarm.

E. *Temperature Sensor*

Besides its obvious industrial applications, temperature sensors find widespread usage in a variety of other contexts, such as medical devices, home automation systems, and weather monitoring systems. If industrial IoT applications can use temperature and humidity sensors to provide real-time data on environmental conditions, it crucial for keeping industrial processes safe and effective. Businesses can improve their operations, eliminate waste, and enhance productivity by monitoring and adjusting temperature levels.

F. *Ultrasonic Module HC-SR04*

To determine its distance from the object, the ultrasonic sensor employs SONAR and RADAR principles. Ultrasound uses sound waves with a pitch higher than what humans are capable of hearing. The human ear is capable of picking up a whistling sound at a frequency of 20–20,000 hertz. But since ultrasonic frequencies are more than 20,000 Hz, people cannot hear them. The HC-SR04 is an ultrasonic distance sensor that is built around a pair of transducers. The purpose of the transmitter is to convert electrical impulses into pulses of 40 kilohertz ultrasonic sound. The receiver picks up on the sent pulses. It generates an output pulse whose width used to determine the received pulse's traveled distance.

G. *WIFI UART*

One popular wireless communication protocol used in industrial IoT applications is Wi-Fi UART, which stands for Universal Asynchronous Receiver/Transmitter. A microcontroller and a wireless network are two examples of devices that can use it to transmit and receive data wirelessly. The Universal Asynchronous Receiver-Transmitter (UART) is a popular serial communication protocol that is used by many embedded devices. It allows for the sharing of data transmission and reception among several devices, including sensors and microcontrollers. Connecting several devices to a network in an industrial IoT environment is made simple and dependable with the WIreless FIdelity (Wi-Fi) UART. This allows them to wirelessly exchange data and communicate with one another. This is especially useful in outdoor monitoring systems or large-scale industrial sites where actual cables would be impractical or impossible to use. Connecting and relocating devices is made possible by wireless data transmission and receiving, eliminating the need for rewiring or reconfiguring.

IV. RESULTS AND DISCUSSION

The results of our implemented garbage content estimation system, integrating IoT and sensors, underscore its effectiveness in revolutionizing waste management practices.

Table 1: Information of participants

House ID	Family size	Family type	Child /infant	Age group	City
1	2	Couple	0	50-55	Coimbatore
2	4	Couple	2	7-50	Coimbatore
3	2	Couple	0	28-29	Coimbatore
4	2	Single	0	22-23	Coimbatore
5	3	Couple	1	27-29	Coimbatore

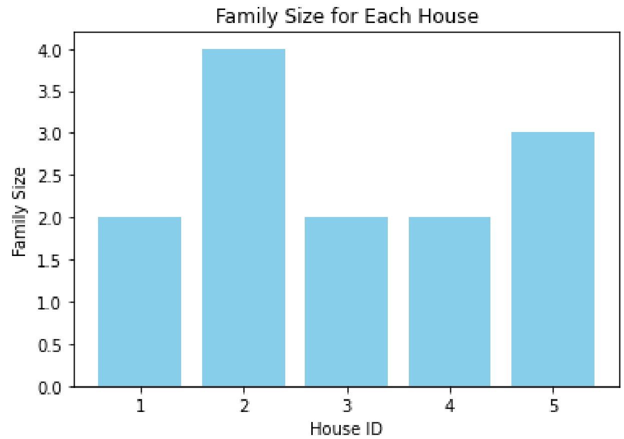

Fig.1 : Family size for each house

Table 1 and figure 1 demonstrate that the number of persons in each household ranges from two to four. In addition to homes with children or newborns, there are also households with couples and singles. For example, House 2 can accommodate a couple with two children ranging in age from seven to fifty. On the other hand, House 4 is occupied by a single person, who is between the ages of 22 and 23. The members of the family vary in age from 27 to 29, albeit there is a significant age gap. In sum, this dataset captures the age distribution, family composition, and size of various Coimbatore households, among other demographic details.

Table 2: Garbage annotation frequency found in house 1 to 5.

CID	C Name	House 1	House 2	House 3	House 4	House 5
1	**Kitchen waste**	81	39	106	27	153
2	**Meal garbage**	68	62	127	17	137
3	**Paper/softbox**	371	204	180	60	52
4	**Fabric**	22	17	23	9	79
5	**plastic**	6	7	17	2	11
6	**Dust**	51	13	4	3	7
7	**Plant**	21	11	15	1	3
8	**All other**	78	26	82	22	19
	Total	699	381	557	145	466

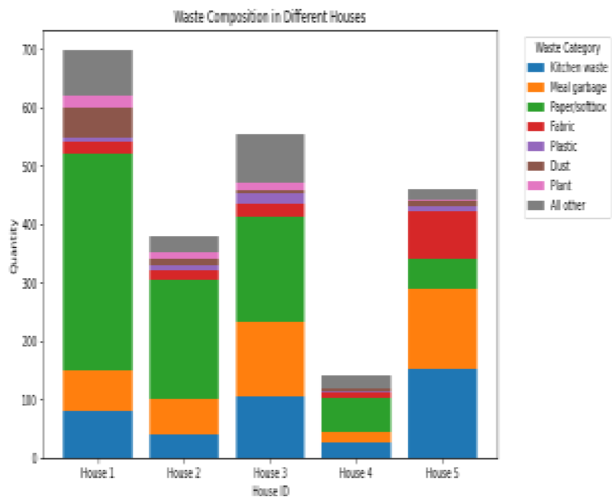

Fig.2 : Waste comparison in different houses

Table 2 and figure 2 provide a detailed breakdown of the many types of trash from each residence (residence 1 to House 5), including food scraps, paper/softbox, fabric, plastic, dust, plants, and everything else. The amounts of various waste types differ from home to house. Consider House 3, which accounts for 371 units of paper/softbox trash, and House 1, which accounts for 81 units of kitchen garbage. Down the bottom row, you can see the sum of all the garbage that each household produces. It is possible to analyze the distribution of various forms of garbage among homes in depth using this data, which provides insights on the patterns of waste management in the given areas.

V. CONCLUSION

In conclusion, the incorporation of IoT-driven Smart Waste Management systems signifies a revolutionary step towards more efficient and environmentally friendly city life. One innovative approach to the problems caused by increasing waste creation in fast-growing cities is the use of high-tech sensors that are integrated into trash cans. In order to enhance future predictions, data on trash level broken down by region is gathered. Every day, the trash trucks are lent out by the Waste Management Department of the Municipal Authority, but they don't know exactly how many vehicles are needed for garbage collection. Since our system handles the garbage levels in real time, we can tackle this issue by forecasting the number of trucks needed for that day. This research provides information on five houses in Coimbatore, each characterized by House ID, Family size, Family type, number of children/infants, age group, and city. The families exhibit diversity in terms of size, with variations from couples to a single-person household, and include a range of age groups. Notably, House 2 stands out with a family size of four, comprising a couple with two children aged 7-50. This vision is driven by advancements in waste management that are enabled by the Internet of Things (IoT). In the future, we can make our system more eco-friendly by reducing the power cost on energy. Predicting the amount of bins and their sizes in a given region allows for efficient bin distribution. In order to dispose of trash in a more environmentally conscious way, waste segregation might also be considered for the future.

REFERENCES

1. Awoyera, P. O., Kirgiz, M. S., Viloria, A., & Ovallos-Gazabon, D. (2020). Estimating strength properties of geopolymer self-compacting concrete using machine learning techniques. Journal of Materials Research and Technology, 9(4), 9016–9028. doi:10.1016/j.jmrt.2020.06.008
2. Domenech, J., & Marcos, R. (2021). Pathways of human exposure to microplastics, and estimation of the total burden. Current Opinion in Food Science, 39, 144–151. doi:10.1016/j.cofs.2021.01.004
3. França, E., Ishitani, L. H., Teixeira, R., Duncan, B. B., Marinho, F., & Naghavi, M. (2020). Changes in the quality of cause-of-death statistics in Brazil: garbage codes among registered deaths in 1996–2016. Population Health Metrics, 18(S1). doi:10.1186/s12963-020-00221-4
4. Jiang, J., Wang, Y., Yu, D., Yao, X., Han, J., Cheng, R., … Zhu, G. (2021). Garbage enzymes effectively regulated the succession of enzymatic activities and the bacterial community during sewage sludge composting. Bioresource Technology, 327, 124792. doi:10.1016/j.biortech.2021.124792
5. Kuang, Y., & Lin, B. (2021). Public participation and city sustainability: Evidence from Urban Garbage Classification in China. Sustainable Cities and Society, 67, 102741. doi:10.1016/j.scs.2021.102741
6. Lou, C. X., Shuai, J., Luo, L., & Li, H. (2020). Optimal transportation planning of

classified domestic garbage based on map distance. Journal of Environmental Management, 254, 109781. doi:10.1016/j.jenvman.2019.109781

7. Mandpe, A., Yadav, N., Paliya, S., Tyagi, L., Ram Yadav, B., Singh, L., … Kumar, R. (2020). Exploring the synergic effect of fly ash and garbage enzymes on biotransformation of organic wastes in in-vessel composting system. Bioresource Technology, 124557. doi:10.1016/j.biortech.2020.124557
8. Moreau, G., Lutz, L., & Amendt, J. (2019). Honey, Can You Take Out the Garbage Can? Modeling Weather Data for Cadavers Found Within Containers. Pure and Applied Geophysics. doi:10.1007/s00024-019-02105-7
9. Pelonero, L., Fornaia, A., & Tramontana, E. (2020). From Smart City to Smart Citizen: Rewarding Waste Recycle by Designing a Data-Centric IoT based Garbage Collection Service. 2020 IEEE International Conference on Smart Computing (SMARTCOMP). doi:10.1109/smartcomp50058.2020.00081
10. Peng, H., Shen, N., Ying, H., & Wang, Q. (2021). Factor analysis and policy simulation of domestic waste classification behavior based on a multiagent study—Taking Shanghai's garbage classification as an example. Environmental Impact Assessment Review, 89, 106598. doi:10.1016/j.eiar.2021.106598
11. Tamaki, S., Hidaka, T., & Nishimura, F. (2021). Effects of using lactic acid bacteria in the storage and subsequent anaerobic co-digestion of crushed kitchen garbage. Bioresource Technology Reports, 13, 100640. doi:10.1016/j.biteb.2021.100640
12. Wei, X., Cao, P., Wang, G., & Han, J. (2020). Microbial inoculant and garbage enzyme reduced cadmium (Cd) uptake in Salvia miltiorrhiza (Bge.) under Cd stress. Ecotoxicology and Environmental Safety, 192, 110311. doi:10.1016/j.ecoenv.2020.110311
13. Yang, J., Zeng, Z., Wang, K., Zou, H., & Xie, L. (2021). GarbageNet: A Unified Learning Framework for Robust Garbage Classification. IEEE Transactions on Artificial Intelligence, 2(4), 372–380. https://doi.org/10.1109/tai.2021.3081055
14. Zambrano-Monserrate, M. A., & Ruano, M. A. (2020). Estimating the damage cost of plastic waste in Galapagos Islands: A contingent valuation approach. Marine Policy, 117, 103933. doi:10.1016/j.marpol.2020.103933
15. Ellen MacArthur Foundation. The New Plastics Economy: Rethinking the Future of Plastics and Catalysing Action. Accessed: Nov. 5, 2022. [Online]. Available: https://ellenmacarthurfoundation.org/the-newplastics- economy-rethinking-the-future-of-plastics-and-catalysing
16. N. Nnamoko, J. Barrowclough, and J. Procter, ''Solid waste image classification using deep convolutional neural network,'' *Infrastructures*, vol. 7, no. 4, p. 47, Mar. 2022.