

**OPPORTUNITIES FOR ARTIFICIAL INTELLIGENCE IN MUNICIPAL SOLID WASTE MANAGEMENT AT ITAM, UYO****Oparaji, Uzochukwu N.**

Graduate School of Engineering Management, Enugu State University of Science and Technology, Enugu. Nigeria

**ABSTRACT**

This study aimed to identify the challenges of municipal solid waste management in Itam, Uyo and to proffer solutions to addressing them. The study identified inadequate public waste disposal bins in the area study even as the populace referred dumping their waste in public disposal units for it to be collected the responsible waste management agency. The ineffective collection of waste at collection points occasioned indiscriminate dumping of waste. To addressing these challenges, this paper presented a strategy of improving waste management process by utilizing Artificial Intelligent 'AI' to optimizing waste collection routing of garbage trucks for efficient tracking and monitoring of waste management facilities, estimating the waste generation patterns at the waste collection points and for efficient planning and allocation of MSW management resources. Incorporating AI in the municipal solid waste management system enhances its operational guidelines and efficiency.

**Keywords:**

Municipal solid waste (MSW), Artificial Intelligent, Geographic information system (GIS), Smart Waste Bins

**INTRODUCTION**

Management of solid waste has become a major concern and a global environmental issue. This is principally true to urban areas where population is rapidly growing and the amount of waste generated in the same vain increasing like never before. Many nations are being faced with serious issues of waste management. Waste materials being generated everyday by the public is generally regarded as municipal solid wastes. This covers all materials throw away as products of packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries (Afon, 2006) and (Bassey, et al. 2006). According to Bing, et al., (2016), current generation rates of municipal solid waste (MSW) volume is expected to double by 2025. Unfortunately, according to Oluwaseun, *et al.* (2020), only about 38% of the municipal solid wastes 'MSW' generated is effectively managed, through either sanitary landfills, recycling, or energy recovery, while the rest is managed in an unsustainable manner, resulting in environmental challenges. This study aimed to identify challenges and improvement opportunities by incorporating Artificial Intelligence (AI) in Municipal Solid Waste Management in Itam, Uyo.

The indiscriminate disposal of municipal solid waste is becoming a serious challenge in most urban cities like Itam, Uyo of Nigeria. Major commercial activities are located at Itam near Uyo, the capital city of Akwa Ibom State, Nigeria. Prominent amongst them are at the Itam market, Itam Timber market and the Uyo Central Motor Park, Itam. Itam market is one of the biggest market in the State. People come around from neighbouring towns and states to buy and sell at Itam market and usually a daily market. Also, the Itam Timber market is notable for the sales of timber of all types and one of the largest building materials market in the State. Nearby to the Itam Timber Market is the State Transport Company (AKSTC) park, the Uyo Central Motor Park, Itam and the State's Specialist hospital. The State Environmental Protection and Waste Management Agency responsible for waste management in city is not surprisingly located at Item.

The predominant method of waste gathering in the area is by dumping on heaps to be collected by the State Environmental Protection and Waste Management Agency. Public waste bins were not seen during the field study. Heaps of solid waste litters along the streets especially around the Itam Market area, a clear evidence to the inability of the waste management agencies to effectively handle and manage the waste generated by the ever-increasing population. Though, the waste collection agency is doing their best to clear the indiscriminately dumped municipal solid waste off the city, but the rate of generating MSW overwhelming. High commercial activities are considered as a major factor contributing significantly to the generation of large MSW, because

traders do away with food remnants, leaves, plastic, cans, papers, nylon and polyethene, waste from dairy etc. during trading transactions.

The current processes involved in the management of MSW in the study area are all manual, starting from collection, transportation and disposal at dumpsites. Therefore, a strategic management of Municipal Solid Waste is required right from the place of generation to the collection, transportation and proper disposal by adopting a well-structured technology driven waste collection, transportation and disposal techniques.

In reality, improper planning and poor operational strategies are attributed to the poor management of Municipal Solid Waste at Itam. Presently, global attention by Engineers, Environmentalists and Scientists are focusing on devising sustainable and efficient means of managing the ever-increasing municipal solid waste (MSW) to avoid the negative impacts of its poor management on the ecosystem. As an outcome, waste management system driven artificial intelligent 'AI' are being proposed for a more efficient and sustainable waste management methods.

One of the ways of achieving the smart city concept is the application of AI solution for MSW management problems as the current manual waste administration frameworks cannot effectively manage the huge loads of waste that are generated each day. It is against this backdrop that this paper presents a strategy of improving waste management process by utilizing Artificial Intelligent 'AI' to optimize waste collection routing of garbage trucks for efficient tracking and monitoring of waste management facilities, estimating of waste generation patterns at the waste collection points and for efficient planning and allocation of MSW management resources at the study area.

### OBJECTIVES

The main objectives of this work are to identify challenges of municipal solid waste management in Itam, Uyo and to proffer solutions to addressing them. Also, to develop a structured process of managing municipal solid waste by incorporating Artificial Intelligence 'AI' based models to achieving a systematic and sustainable waste management processes from waste collection to disposal at the dump sites.

### METHODOLOGY

This study was conducted using qualitative design. Questionnaire was designed using 5-Likert scale and was intended to capture the aim and objectives of the study. Likewise, data were also collected from interviews of officials of The State Environmental Protection and Waste Management Agency and the State Ministry of Environment officials.

The study was grouped into four categories of investigation areas as follows: (1) Preferred method of Management of Solid Waste by the residence in the study area. (2) Reasons for poor Solid Waste Management. (3) Systematic Process of waste management and (4) Technology applications to improve waste management. Currently, Artificial Intelligence 'AI' is providing innovative technology to solving both social and engineering problems confronting mankind. Methods of Artificial Intelligent AI applications in managing different steps of Municipal Solid Waste Management are highlighted as, Smart Waste Bins approach, GIS approach and AI algorithm.

**GIS approach:** Geographic information system (GPS) consists of a set of computerized tools and procedures that can be used to effectively store, retrieve, overlay, correlate, manipulate, analyze, query, display (both graphically and numerically) and disseminate land related information. Therefore, effective MSW management decisions such as, optimal selection location of waste collection points (waste bins location), evaluation of population density, topography, drainage, soil properties, groundwater and surface water could be made with information provided by 'GIS' technology.

**Smart Waste Bins approach:** Intelligent waste bins in which wireless fill-level sensors are embedded inside the trash bin detects how full the bin is and then send this data to a cloud-based monitoring and analytics platform to the nearest sensor referenced base station or at the base control center.

**AI algorithm:** On the basis of the analysis of data from the intelligent waste bins by AI techniques, optimal waste collection and transportation sequence are scheduled based on waste bins that are filled. Then, waste collection service trucks can then optimize their routes and frequency. The most optimized routes that prioritizes filled waste bins are scheduled for the pickup trucks. Not only that it reduces cost of the waste collection round trips but also providing accurate records of the quantity of waste collected per trip.

Artificial Neural Network (ANN) model was suggested in this study. ANN is one of the machine learning algorithms that is part of AI. ANN is inspired by the human brain's anatomy. ANNs are the most widely used

# iJETRM

## International Journal of Engineering Technology Research & Management

[www.ijetrm.com](http://www.ijetrm.com)

AI technologies because they are much easier to implement. ANN is used to capture the non-linear relationship between the input and output factors and has proven successful for making predictions and taking decisions. In the same vein, ANN algorithm can successfully forecast and manage the waste collection routes and waste transportation based on information or data generated from smart waste bins. The proposed applications of AI algorithm and with expert geographical information system ‘GIS’ based route planning and transportation model for waste collection and transportation will improve municipal solid waste management in Itam, Uyo. Fig.1 below show the proposed smart waste management architecture. In this scenario, the Computerized Control Center AI Algorithm generated a waste collection routing schedule that starts from filled Smart Waste Bin No. 2, 7, 8, 11 and then to disposal at the dump site. The Flowchart of proposed (AI) Smart Waste management system is shown in Fig. 2 below.

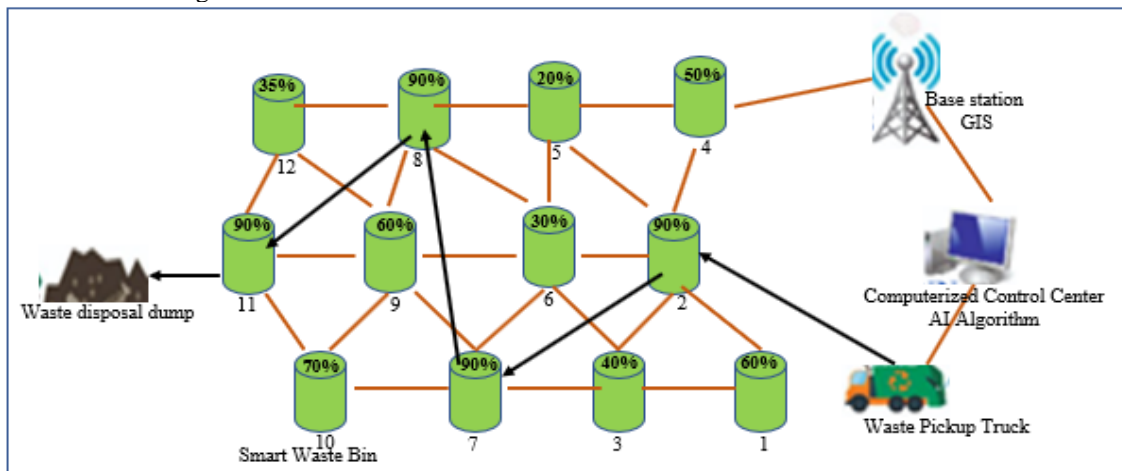


Fig. 1: Proposed smart waste management architecture

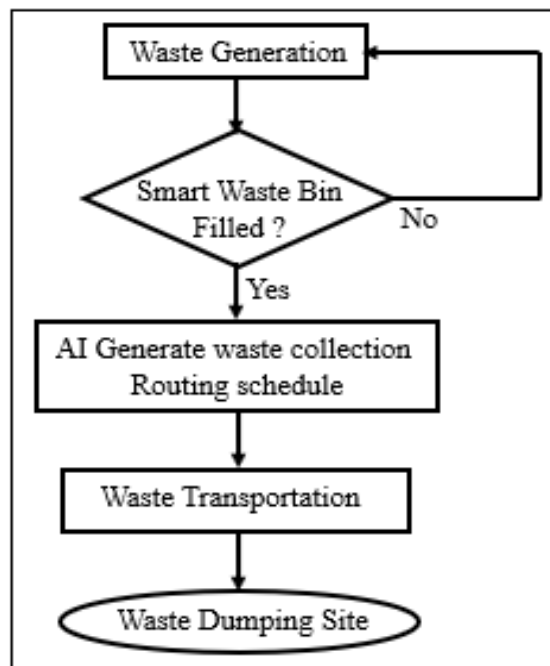


Fig. 2: Flowchart of proposed (AI) Smart Waste management system

### RESULTS AND DISCUSSION

Specifically, the observed challenges of municipal solid waste management in the study area are the ugly sight of numerous clusters of hip of MSW with negative health concerns. Similarly, there are challenges of inefficient capacity utilization of available waste management resources as a result of uncoordinated waste management methodology and planning. The result of questionnaire analysis revealed that **79.7%** of respondents strongly preferred dumping of waste in public disposal units for it to be collected by the responsible agency, while **33.5%** preferred employing private waste management companies to come and collect it. This implies that dumping waste in public disposal units for it to be collected by the responsible agency constitutes the most accepted method by the populace in managing their solid waste in the study area.

On the reasons for poor municipal solid waste management, **78.4%** of respondents Strongly Agreed that there are delays in collection or incomplete collection of waste at public disposal collection points. **76.6%** Strongly Agreed there are lack of public awareness on the hazards of poor waste management which is causing indiscriminate waste dumping. **82.3%** Strongly Agreed there are inadequate or non-existence of public waste disposal bins in the area study. **77.4%** Strongly Agreed that waste management authorities are not coping with the rate of waste generation in the area study, while **81.8%** Strongly Agreed that enforcement of environmental Laws are weak.

Questionnaire analysis on the methodology and process of solid waste management indicated **95.8%** of respondents Strongly Agreed that waste is not collected speedily when due or just-in-time. **79.2%** respondents of the waste agency personnel 'Strongly Agreed' that waste collection trucks are not pre-programed daily per waste generation information to specific collection points for optimal coverage. Therefore, monitoring waste collection trucks utilization is a huge challenge. **87.5%** of respondents Strongly Agreed that there are no proper records of daily records of waste collection tonnage as a measure of performance and efficiency. **95.8%** Strongly Agreed that there is no methodological sorting of waste before disposal. Therefore, the current MSW management methodology and process needs improvement to meet the present environmental realities in the city. Fig.3 show the process of MSW collection.

On the knowledge of technology applications like artificial intelligence in solid waste management. The result showed very low awareness of how technology could be applied to deal with the observed numerous challenges confronting municipal solid waste management at Itam. **87.5%** of respondents Strongly Agreed not to have heard of Artificial Intelligence (AI) and its applications in municipal solid waste management.

However, areas AI could improve waste management process are identified as follows:

- Real-time monitoring and predicting of waste generation and optimizing waste collection.
- Real-time monitoring of waste disposal bins and other waste facilities.
- Improved efficiency of the waste collection system through GIS based waste collection route planning, which will also monitor performance of waste operators through tracking of waste collection and transportation vehicles.
- Providing operational guidelines for efficient municipal solid waste management system.



**Fig. 3: The MSW collection process in the area.**

#### ACKNOWLEDGEMENT

I thank the officials of The State Environmental Protection and Waste Management Agency and the State Ministry of Environment officials for responding to the questionnaire. I would like to thank, Professor T. O.

Chime, of the Faculty of Engineering, Enugu State University of Science and Technology, Enugu. Nigeria. for his continued guidance and diligent support over the course of this study.

#### CONCLUSION

The following are key conclusions from the findings of this work: The quantity and the rate of MSW generation at the area of study are rapidly increasing as the commercial activities are also increasing. The study also revealed that the waste management methodology and process adopted at the area of study is mainly on the random traditional vehicle routing of waste collection which is not efficient. For waste management agencies to effectively manage the ever-increasing municipal solid waste, there should be a system that can effectively supervise the collection and disposal of waste. The system should be capable of tracking the waste generation rate and the waste collecting trucks and provide real-time monitoring, thereby increasing work efficiency.

AI model proposed in this paper will ensure that waste is collected as soon as smart waste bins reaches the maximum fill level. Consequently, the system will be more efficient and accurate information to track will be available. Currently, most waste trucks and other waste disposal equipment are operated on random schedules and there is no available information for optimal waste route collection scheduling, resulting to inefficient man-hour and capacity utilization, which is not cost effective.

There is no doubt that AI technologies suggested in this work is not fully comprehensive but has demonstrated the potential and opportunities of AI technologies to tackle municipal solid waste management and environmental challenges. However, the focus on improvement in municipal solid waste management should not only be technology driven but also people oriented. The citizens should do their best to follow waste management procedures and government on their part endeavor to enforce necessary sanitation guidelines.

#### REFERENCES

- [1] Afon, A.O. (2006). *Estimating the quantity of solid waste generation in Oyo, Oyo State, Nigeria*. Journal of Institute Town Planners
- [2] Bassey, B. E; Benka, M. O, Aluyi, H.S. A, (2006). Characterization and management of solid medical wastes in the Federal Capital Territory, Abuja, Nigeria. African Health Sciences of Health,
- [3] Bing, X.; Bloemhof-Ruwaard, J.; Ramos, T.R.P.; Barbosa-Povoa, A.P.; Wong, C.Y.; Van Der Vorst, J.G. (2016) Research challenges in municipal solid waste logistics management. Available online: <https://doi.org/10.1016/j.wasman.2015.11.025>
- [4] Deepika, M, Sangeetha, S, Vanitha, M, Baskaran, M (2021). Smart Waste Management Using AI Available online: <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>
- [5] Oluwaseun Nubi, Stephen Morse and Richard J. Murphy (2022). Electricity Generation from Municipal Solid Waste in Nigeria: A Prospective LCA Study. Available online (accessed on 4 Nov. 2022)
- [6] United Nations Population Projections (2022) Uyo, Nigeria Metro Area Population Macro Trends Available online: <https://worldpopulationreview.com/world-cities/uyo-population>
- [7] United Nations Department of Economic and Social Affairs (2018). 68% of the world population projected to live in urban areas by 2050. Available online: <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>