DEVELOPMENT OF E-WALLET BASED PLASTIC WASTE MANAGEMENT SYSTEM FOR NIGERIAN ENVIRONMENT: A CASE STUDY OF THE SOUTH – EAST

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Abstract:

E-wallet based plastic waste management system will not only reduces the environmental impact of plastic waste but also encourages responsible consumption and financial earnings for the users as you dispose. Despite growing awareness of the problem, efforts to mitigate plastic pollution have been hampered by a lack of effective waste management infrastructure and inadequate policy frameworks. The objectives of the research work include, conducting a comprehensive analysis of plastic waste generation patterns, disposal methods, and existing recycling infrastructure in various residential and commercial areas, identifying gaps and opportunities for improvement, design and construct IoT- enabled smart bins for efficient collection, sorting, and processing of plastic waste. This study adopted a mixed-methods approach, structured methodology and embedded system prototyping methodology. Some of the tools used are arduino 2.x, NetBeans, FlutLab.io, Jama Software, and KiCAD. Some of the raw materials used are Arduino Nano Microtroller, Dependent Resistor (LDR), BC337 NPN Bipolar Junction Transistor. At the end of the research, we will be able to produce two hundred (200) functional E-wallet based plastic waste management system that will be installed at the major cities of south east region of Nigeria.

Key Words: innovative recycling technologies, Arduino nano Technology, plastic waste management system and plastic waste crisis

I. Introduction

The Eco cycle approach to plastic waste management represents a promising paradigm shift towards sustainability. By integrating principles of circular economy, innovative recycling technologies, and community engagement, Eco cycle offers a holistic solution to the growing plastic waste crisis (Geyer *et al*, 2017). This model will not only reduces the environmental impact of plastic waste but also encourages responsible consumption, production patterns and financial earnings for the users as you dispose. As global awareness of plastic pollution rises, adopting and scaling up such sustainable practices is essential for achieving a cleaner, healthier planet. Ultimately, the success of the Eco cycle approach depends on collective action from governments, industries, and individuals, reinforcing that sustainable plastic waste management is not just a possibility but a necessary commitment for the future.

The proposed research seeks to address this gap by exploring the design and implementation of a novel system that sensitize plastic recycling using Internet of Things IoT, microcontroller, and Artificial intelligence/Machine learning peripherals like the ESP32-CAM module. By offering users a stipend for recycling plastic waste, the system aims to reduce the amount of plastic entering the environment and promote a circular economy approach to waste management.

II. Problem Statement

According to Kaza, 2018, the world is grappling with an alarming plastic waste crisis that poses a severe threat to the environment and human health. Plastic production has skyrocketed in recent decades, with an estimated 359 million tons of plastic produced globally in 2018 alone (Moss, 2021). Alarmingly, a significant portion of this plastic ends up as waste, polluting terrestrial and marine ecosystems.

The widespread use of plastics in various industries, coupled with inefficient waste management practices, has led to the accumulation of plastic debris in oceans, rivers, and terrestrial environments Plastics Europe (2021), Plastic waste poses a myriad of threats to the environment. Marine life often mistake plastic debris for food, leading to ingestion and entanglement, which can result in injury, suffocation, and death, UN Environment Programme (2018). Moreover, plastics do not biodegrade but break down into smaller particles known as micro plastics, which can persist in the environment for hundreds of years and accumulate in food chains, ultimately posing risks to human health.

Despite growing awareness of the problem, efforts to mitigate plastic pollution have been hampered by a lack of effective waste management infrastructure, limited recycling rates, and inadequate policy frameworks. There is a clear need for innovative solutions that address the root causes of plastic pollution and promote sustainable waste management practices.

III. Objectives of the Research

ii. To conduct a comprehensive analysis of plastic waste generation patterns, disposal methods, and existing recycling infrastructure in various residential and commercial areas, identifying gaps and opportunities for improvement.

iii. To design and develop an integrated hardware system consisting of IoT-enabled smart bins, microcontrollers, and sensor modules for efficient collection, sorting, and processing of plastic waste.

iv. To implement advanced AI/ML algorithms and computer vision techniques for accurate identification, classification, and categorization of different types of plastic waste, optimizing the sorting and recycling processes.

v. To develop a user-friendly mobile application that allows users to track their plastic waste recycling activities, earn monetary incentives or rewards based on the quantity and quality of recycled materials.

vi. To incorporate gamification elements and social sharing features within the mobile application to encourage user engagement, foster a sense of community, and promote behavioral changes towards responsible plastic waste management.

IV. Research Questions

i. How can comprehensive analysis be conducted for the waste management system in the South-
ii. region of Nigeria?

iii. ii. What are the requirement analysis on the design and development of the waste management system hardware?
iv. Iii. What are the requirement analysis on the design and development of the waste management system application?
v. iv. How can the residents of the south – south region of Nigeria be aware this monetary incentives waste management system?

V. Literature Review

Numerous studies and research efforts have been conducted in the areas of plastic waste management, recycling technologies, and the application of emerging technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and Machine Learning (ML). This section provides an overview of relevant literature that informs and supports the development of the ECOCYCLE project.

Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: challenges and opportunities. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526), 2115-2126. This study highlights the challenges faced by traditional plastic recycling methods and emphasizes the need for improved collection, sorting, and processing technologies to enhance the efficiency and sustainability of plastic recycling systems.

Hannan, M. A., Arebey, M., Basri, R. A., Begum, R. A., & Al Mamun, M. A. (2020). Intelligent waste management system using IoT with Thingspeak: A case study at Malaysian University. IEEE Access, 8, 71855-71865. This research explores the potential of IoT-enabled smart bins and real-time monitoring systems for efficient waste collection and transportation, demonstrating their practical implementation and benefits.

Nie, S., Luo, Y., Wang, G., & Sun, K. (2021). Deep learning for waste classification in the Internet of Things. Future Generation Computer Systems, 124, 361-369. This study demonstrates the application of computer vision and deep learning algorithms for accurate identification and classification of plastic waste, improving sorting and recycling processes

Sharma, N., Mirchandani, V., Young, J., & Chandani, V. (2021). Applying machine learning in solid waste management: A systematic literature review. Environmental Research, 197, 111004. This systematic review provides a comprehensive analysis of the application of machine learning techniques in various aspects of solid waste management, including plastic waste, highlighting their potential and limitations.

Timlett, R. E., & Williams, I. D. (2008). Public participation and recycling performance in England: A review of unitary authorities. Resources, Conservation and Recycling, 52(5), 775-784. This study examines the effectiveness of incentive-based programs, such as monetary rewards or rebates, in increasing recycling rates and promoting sustainable practices among the public.

Geyer *et al*, 2017 highlighted the challenges faced by traditional plastic recycling methods and emphasizes the need for improved collection, sorting, and processing technologies to enhance the efficiency and sustainability of plastic recycling systems.

Plastics Europe (2021) explored the potential of IoT-enabled smart bins and real-time monitoring systems for efficient waste collection and transportation, demonstrating their practical implementation and benefits.

Moss, E. (2021) demonstrated the application of computer vision and deep learning algorithms for accurate identification and classification of plastic waste, improving sorting and recycling processes.

VI. Research Methodology

This study will adopt a mixed-methods approach, combining structured methodology and embedded system prototyping methodology to achieve the development of E-wallet based plastic waste management system for Nigerian environment focused on the South – South region.

VII. The System Design

Figure 1 is the Block diagram of E-wallet based plastic waste management system that comprises of the DC power supply, three sensors (level sensor, LM 358 and PIR sensor), LCD display the control unit with Arduino nano Technology, the ULN 2003 driver, GSM module, the waste management application managed by the waste management authority, relays and DC motor. Figure 2 is the circuit diagram in Proteus VSM professional, this shows the simulation of the overall system. Figure 3 is the control panel of E-wallet based plastic waste management system while figure 4 is the prototype of E-wallet based plastic waste management system.

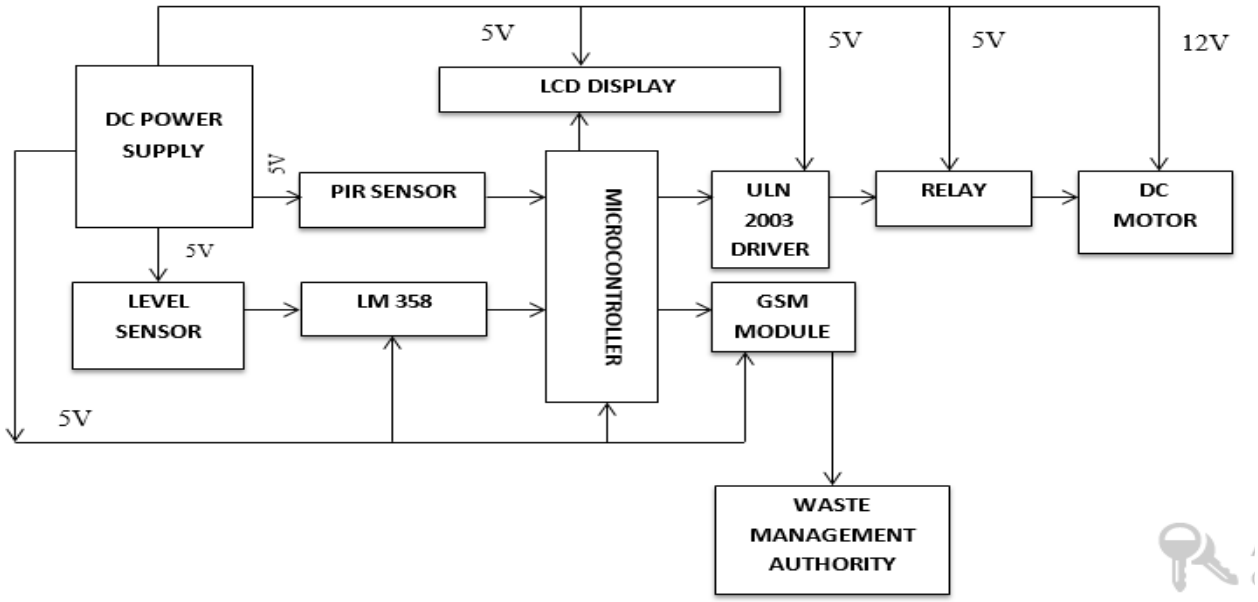

Figure 1: Block diagram of **E-wallet based plastic waste management system**

Figure 2: circuit diagram of **E-wallet based plastic waste management system**

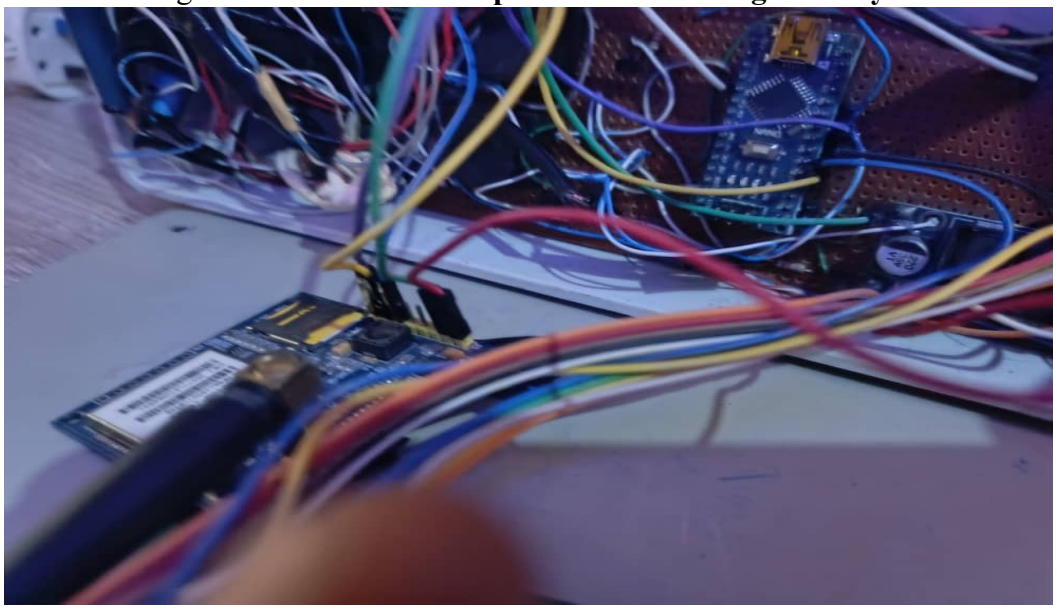

Figure 3: control panel of **E-wallet based plastic waste management system**

Figure 4: front view of **E-wallet based plastic waste management system** (prototype)

VIII Results

At the end of the research, we were able to produce a prototype of plastic waste management system, with disposal methods and existing recycling infrastructure that can be deployed in various residential and commercial areas in south-east region of Nigeria. We were able to integrate hardware system consisting of IoT-enabled smart bins, Arduino nano Technology and sensor modules for efficient collection, sorting, and processing of plastic waste with user-friendly mobile application that allows users to track their plastic waste recycling activities, earn monetary incentives or rewards based on the quantity and quality of recycled materials.

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