Adopting Internet of Things for Community-based Domestic Organic Waste Treatment

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ABSTRACT
Domestic organic waste has been becoming a constant issue in modern society. Waste management is a problem faced by almost all countries in the world. While untreated organic waste potentially creates environmental, health, and social issues, limited research has addressed organic waste treatment at the community scale. The paper aims to propose an Internet of Things (IoT) - based domestic organic waste treatment by enabling more innovative and more effective waste management processes. This paper considers previous literature and theories to design the sensors and actuators installation in waste management systems for real-time monitoring and tracking of waste generation, transportation, and treatment processes. The collected data informs the subsequent waste treatment processes for enhancing operational efficacy and reducing time consumption. This paper contributes to the body of knowledge by proposing an Internet of Thing adoption for a community-wide organic waste management system. IoT in the mechanism is expected to speed up the composting process and allow users to monitor the process remotely.

Keywords: *Composting, IoT, Organic Waste, Smart Composter, Waste Management.*

1. INTRODUCTION

Domestic organic waste has become a constant issue in modern society [1]. Almost every nation faces a waste management problem related to environmental pollution [2, 3]. Since untreated organic waste potentially create environmental pollution by releasing harmful greenhouse gases like methane and carbon dioxide, which contribute to global warming and climate change. The dangers to public health are an additional concern [4, 5]. Organic waste can attract disease-spreading insects and rodents such as flies, mosquitoes, and flies as well as emit foul odours, which can be a nuisance to nearby residents [6, 7]. Organic waste makes up a significant portion of the waste generated by households. When this waste is sent to landfills, it can fill them up quickly, leaving less space for other types of waste [8]. While untreated organic waste is detrimental to the society, the potential benefit of the waste as a source of energy [9, 10], has not been addressed appropriately. Few, if any, research reports the organic waste treatment at the community scale.

Internet of Things (IoT) has the potential to transform small and medium-scale organic waste treatment by enabling smarter and more effective waste management processes [11, 12]. With the Internet of Things, sensors can be installed in waste management systems for real-time monitoring and tracking of waste generation, transportation, and treatment processes [13]. This information can be used to optimise waste treatment processes, enhance operational efficacy, and lower waste management costs [14]. For instance, IoT-enabled waste management systems can monitor the temperature and moisture content of composting piles [15, 16], adjust airflow [17, 18], and water supply [19] accordingly. A sophisticated design of the IoT may provide a more sustainable and efficient solution for the management of organic waste in a community setting.

Adopting the IoT for community-based domestic organic waste management has the potential to transform our approach to this problem [20]. Using IoT technologies, communities can establish a network of intelligent waste management devices [21] that can automatically monitor and manage the disposal of

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organic waste [22]. These devices can monitor waste production, determine when trash cans need to be emptied, and facilitate the composting process. Moreover, the data collected by these devices can be used to optimise waste collection routes and improve overall efficiency. Consequently, a thorough investigation into the adoption of IoT for community-based organic waste management can be a crucial step towards a more sustainable future. Thus, given the growing emphasis on sustainable living.

This paper contributes to the body of knowledge by proposing a community-wide organic waste management system. For automation, Internet of Things capabilities are taken into account.

2. RESEARCH METHOD

This research was conducted to produce a theory synthesis conceptual paper on the adoption of the Internet of Things in organic waste management. According to Jaakkola [23], the primary objective of a theory synthesis conceptual paper is to attain conceptual integration across various theories or literature streams. The potential goals and application of a theoretical synthesis conceptual paper includes summarising and synthesising existing knowledge, identifying the conceptual boundaries of novel phenomena or concepts, and creating a fragmented field by applying a specific theoretical framework. In addition, researchers who write a theory synthesis conceptual paper also have several things that must be considered in determining the research design, the initial stage involves identifying a phenomenon or concept. Following this, relevant literatures that can be argued to address some aspect of the phenomenon or concept are selected as the domain theory/theories. Additionally, a theory for organising the key dimensions of the phenomenon is chosen as the method theory.

3. RESULT AND DISCUSSION

This section explains the conceptual design of the organic waste management system. In Indonesia, every year, organic waste dominates the amount of waste produced in Indonesia. For example, 66.35 percent of 19 tons of waste produced in Indonesia in 2022 is organic waste [24]. Several ways can be used to manage organic waste, including landfilling, composting, recycling, incineration, and source reduction [25-27]. Composting is the best way to handle organic waste [28, 29] and is the most environmentally friendly [30]. Therefore, composting methods are used in this conceptual design using aerobic composters to produce compost that can be used as additional plant nutrients. The concept of the Internet of Things is also applied in this design.

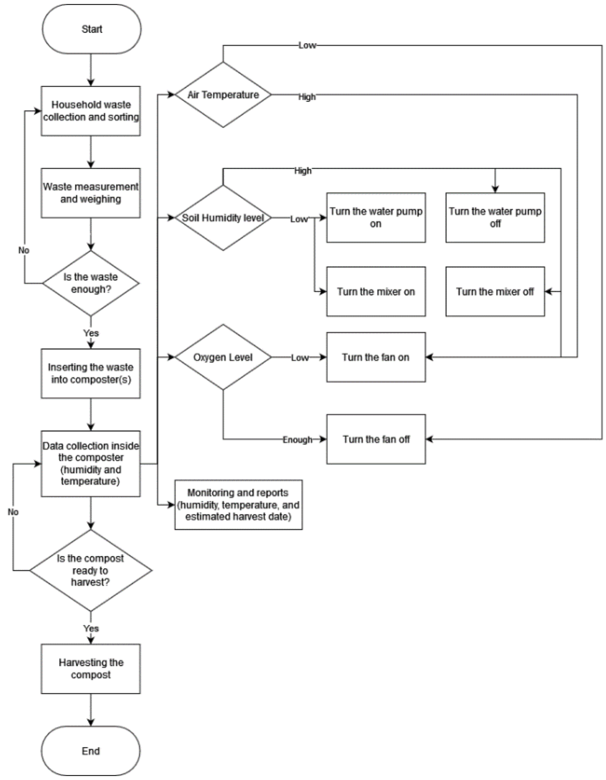

Figure 1 System diagram.

According to El Haggar [31], there are four main factors in the process of composting, which are oxygen levels (aeration), humidity, temperature, and nutrients (ratio of nitrogen and carbon). The monitoring of these factors often requires direct contact with workers, which increase the risk of disease. By adopting the Internet of Things, these factors can be monitored and controlled remotely so that the risk of disease can be reduced [32-34]. Additionally, adopting the Internet of Things in waste management systems reduced operational and maintenance costs [32, 35-37]. Also, the process is more reliable, efficient, and effective [32, 36-45]. The diagram of the organic waste management system designed in this paper can be seen in Figure 1.

The system starts with collecting household waste, which is then sorted. Organic waste will be brought and collected and then weighed to meet the needs of the composter. If sufficient, the organic waste will be put into the composter, and the composting process will begin. The composter consists of an ESP32 microcontroller, a DHT22 temperature and humidity sensor, a DS18B20A waterproof temperature probe, a soil humidity sensor, a water pump, a fan, and a mixer. During the composting process, the conditions in the compost will be monitored and automated to meet the main factors that affect the composting process, as mentioned earlier. In more detail, fans are used for maintaining oxygen level (aeration) so that aerobic fermentation can be maintained. A soil humidity sensor, water pump, and mixer are used to maintain humidity. It must be between 40% to 60%. If it is less than 40%, the activity of bacteria will decrease and become dormant. If it is more than 60%, it will inhibit the decomposition process, and an unpleasant odour will come out from methane gas that comes out due to anaerobic decompositionIn addition, it is critical to maintain the system's environment temperature to remain between 32 to 60 degrees Celsius. Since over-limit temperature will inhibit the activity of microorganisms or even kill them, the temperature of organic waste is also monitored using the DS18B20A temperature probe because the composting process produces heat from microbial activities that consume organic waste [31], so that if the heat does not arise from organic waste, it can be concluded that the composting process has been completed and the organic waste has become fully composted. Once a decision is made that the compost is ready to harvest, the bottom door of the composter will open, and the finished compost will be pushed into the compost bin for use. In addition to automation, this system also monitors and reports to personnel via the Internet so that they can find out the condition of the composter without having to check directly. A flowchart of how the system communicates over the Internet can be seen in Figure 3, and an illustration of the composter report can be seen in Figure 4.

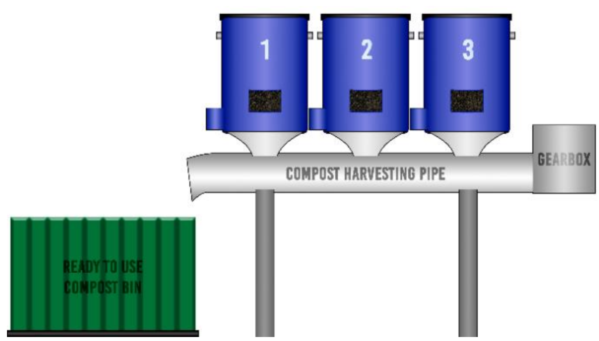

Figure 2 System illustration.

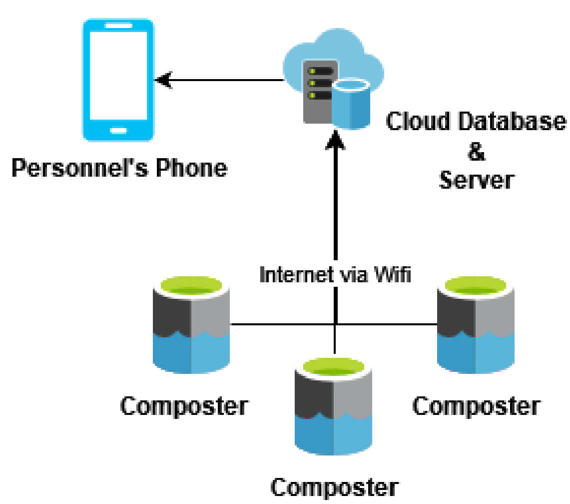

Figure 3 Internet of Things flowchart.

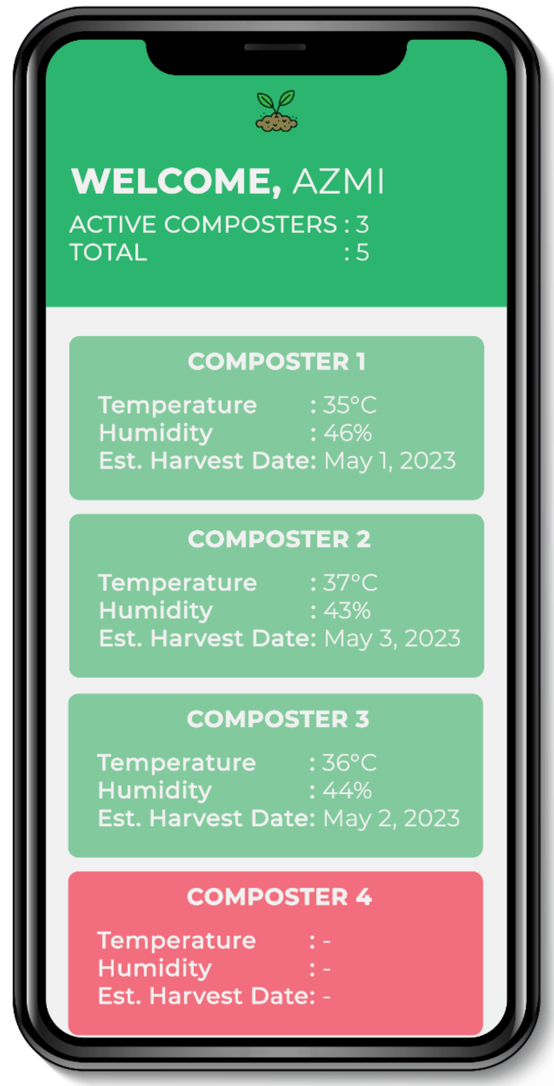

Figure 4 Composter report illustration.

4. CONCLUSION

The adoption of the Internet of Things in community-based domestic organic waste management is expected to be a renewal in how to process organic waste, especially at the community level. Data collection and automation will likely increase the composting process's speed and the compost quality obtained by previous studies. Monitoring and reporting composter data via the Internet also makes it possible to find out the condition of the composter without having to check the composter directly.

Apart from many advantages, the concept presented in this paper also has disadvantages, namely requiring an Internet connection so that the composter must be placed in a place covered by a WiFi network. Future research is expected to apply other Internet of Things protocols, especially those that can be connected from a distance, such as LoRa, GSM, or Sigfox.

AUTHORS' CONTRIBUTIONS

Muhamad Nur Azmi Wahyudi made the conceptual design. Also wrote the research method, result and discussion, and conclusion.

Cucuk Wawan Budiyanto wrote the abstract and introduction. Also refined the manuscript draft.

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