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Evaluation of Automated Portable Vermicomposting Bin

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Abstract: ***The gradual increase in world population and Intensive livestock production, all produce large amounts of organic waste. There is a serious disposal problem all over the world and it is a major cause of environmental pollution. An IoT based portable vermicomposting bin is a modern solution for efficient and convenient composting. This innovative approach utilizes the Internet of Things (IoT) technology to connect the vermicomposting bin to a network and unable real time monitoring and control of various parameters, such as temperature, moisture and pH level. The IoT based vermicomposting bin provide a user friendly and easy to operate level. The IoT based vermicomposting bin provides a user friendly and easy to operate interface making it accessible to a wider range of user, including those who are new to vermicomposting. With automated controls and real time monitoring, the IoT based vermicomposting bin can simplify the composting process and reduce waste, minimizing the environmental impact. It can also help reduce the need for chemical fertilizers, which can be harmful to the environment. The type of worm which is mostly used for vermicomposting is Red Wiggler (Eisenia Fetida). Overall, the IoT based vermicomposting bin is smart and efficient way to recycle organic waste and produce high- quality compost.***

Keywords: IoT, Vermicomposting, Organic Waste, Automated System, Eisenia Fetida

I. INTRODUCTION

Vermicomposting is the process of using worms for decomposition of organic waste into nutrient rich compost. It is an efficient and environmentally friendly way to recycle organic waste and produce high- quality fertilizer. Portable vermicomposting bins are a convenient way to carry out this process in a small space, such as balcony, a small garden or even inside your home. An IoT based vermicomposting bin is a modern and innovative way to monitor and control the vermicomposting process. One area where IoT technology is making a significant impact is in the field of agriculture and sustainability. One such application is the IoT based vermicomposting bin, which is designed to improve the efficiency and effectiveness of the composting process. Vermicomposting is the process of using earthworm to break down organic waste into nutrient rich compost. It is an environmentally friendly way to disposing of organic waste while also creating a valuable resource for agriculture. However, the process can be time- consuming and requires careful monitoring that the compost is of high quality. An IoT based vermicomposting bin is designed to automate the process of composting and make it more efficient. The bin equipped with sensors that monitor temperature, moisture and other environmental condition which are critical for the growth and health of the worms. The sensors are connected to a central control system, which can adjust the condition within the bin as needed to optimize the composting process. The IoT based vermicomposting bin also included a data logging system, which tracks the temperature, moisture and other environmental condition over time.

This data can be used to analyse the composting process and identify area for improvement. The data can also be used to communicate the result of the composting process to stakeholders and other interested parties. Overall, the IoT based vermicompost bin is a powerful toll for improving the efficiency and effectiveness of the composting process. It enables urban area peoples and other agricultural producers to create high quality compost with minimal effort, while also reducing waste and contributing to a more sustainable future.

II. METHODOLOGY

A. Site Specification

1) Location of The Plot

This study was conducted in Gandhi Institute for Technology (Autonomous) – In Vermicomposting Lab (20.2227° N, 85.6739° E). This area was near to the workshop where we have constructed our model frame for our experiments. For proper analysis of data, the total vermicomposting lab is divided into two portion, one side for IoT based bin and another side for manual vermicomposting.

LAYOUT

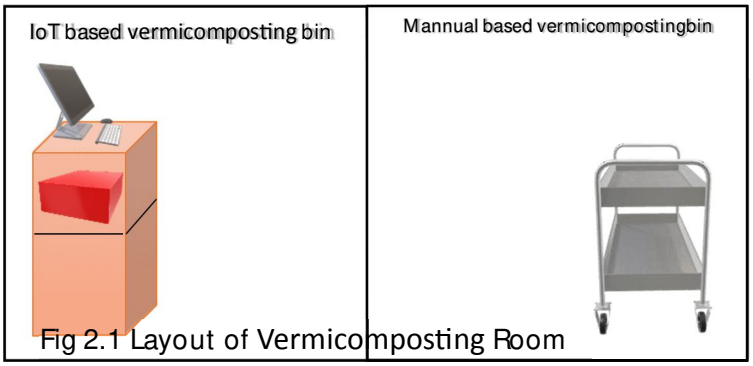

Fig 2.1 Layout of Vermicomposting Room

B. Project Description

This project aims to design and develop an automated portable vermicomposting bin using Raspberry Pi, sensors, LED grow light, an automated irrigation system, temperature sensor andsoil moisture sensor. The overall module should be a mixed combination of agriculture with technology. This automated portable bin will provide convenience and comfort to the user by sensing and controlling the parameter of the bin using a data logging system though which wecan control it effectively.

It has the following features:

1) Easy to handle
2) Economical
3) Compact and portable
4) Remotely Operated

C. Diagram of IoT based Vermicomposting Bin System

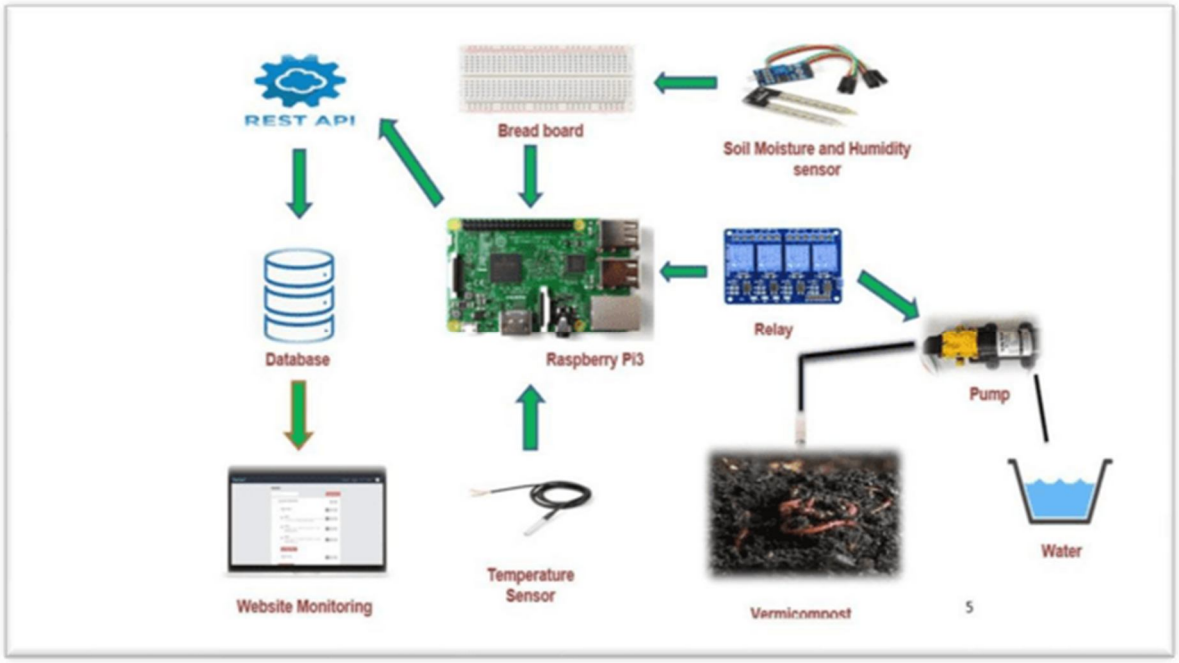

Fig 2.2 Complete working diagram of IoT based vermicomposting system using raspberry pi

The fig 3.1 depicts a symbolical representation of the vermicomposting bin with it's proper working prototype. Sensor, bread board, relay pump all are directly connected to raspberry pi3and whole data base is available in monitor as well whole set up was being controlled through the website monitoring. Where relay works as a switch for operating the water pump, whenever the measured moisture content of the compost is lower in comparison to the desired moisture content for the proper nutrient rich compost.

D. Material And Methods

Design and development

1) Hardware Module

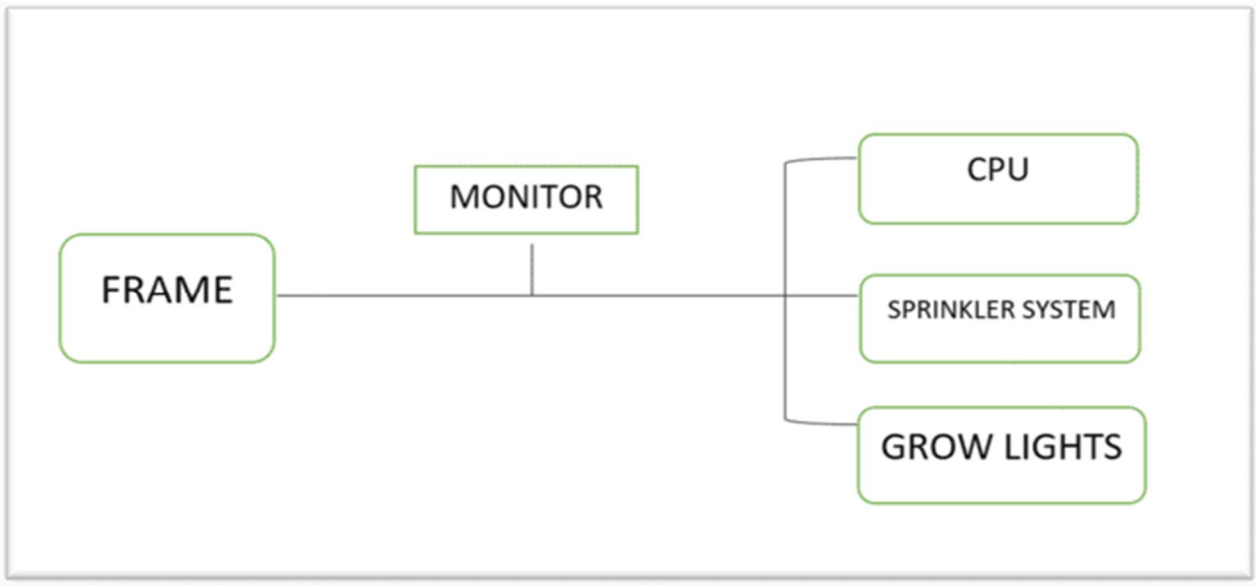

Fig 2.3 Block Diagram of the prototype

2) Fiber Frame

We have designed a frame for completion of the whole process, which is length= 0.63m, width= 0.52m, height= 1.64m as shown is fig. Whole frame is of 5 layers, which is made up ofsquare bar and fibre. First the top layer is design for the basement to the monitor and its CPU. Then rest four layer was designed for the installation of LED lights from top to its bottom. TheLED lights are placed inside the chamber so it provides the right amount of light in each specific bin which helps the worm produce more energy as well also enhances the total carbondioxide produced by the worms.

Fig 2.4 Phase wise model preparation

3) Red Light As Grow Light

Red light is starting to be recognized as an essential component of vermicomposting, bringingthem to maximum efficiency. Despite lacking sight organs earthworms possess the ability to perceive light, which may not be news to us. Their skin possesses cells that are sensitive to light, enabling them to seek refuge in their bedding when exposed to light. This is especially important during daylight hours when sunlight can be lethal to them. Their reaction is a natural survival mechanism, causing them to immediately submerge themselves upon exposure to lightwhen the lid is removed. Whereas red light does not affect earth worms as much as white or other colored light because they can't detect it. To avoid startling them and causing them to conceal themselves observe their feeding or reproduction habits using a red light.

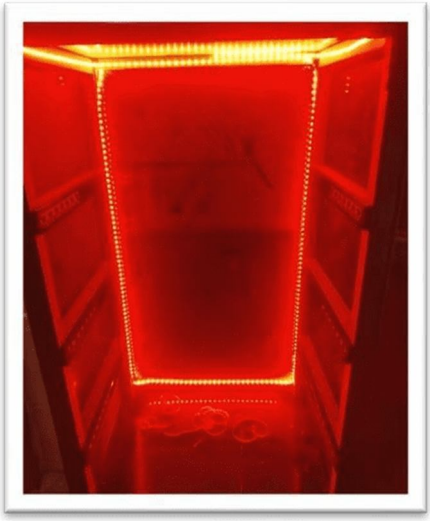

Fig 2.5 Red light as growth light for vermiworms

Table 2.1 Details of the amounts of worm produced in the wild, and under different kind of light colors in the lab worm bins.

Condition of Production by colors	Amount of cast produced (Ton)	Production relative to control in this experiment	Production relative to natural production in the wild
The wild (natural) (Madge, 1969; Lavelle et al., 1998,etc)	200	0.18	1
Control (Dark)	1127.8	1	5.64
White Light	761.3	0.68	3.81
Green Light	1486.5	1.32	7.43
Blue Light	1670	1.48	8.35
Red Light	1872	1.66	9.36

4) Sprinkler System

The provision of right amount of water to the vermicomposting bin plays a crucial role while considering all better composting factors. It designed in such a way that it will work automatically without any manual effort. The module detects the compost humidity by means of the neutron probe. If the compost is dry or the measured moisture content is less than desirable level then the sensor will direct the pump to switch on. This allows water from the tank to lift up with the help of a 12v electric pump and get deposited at the bottom portion of the bin with a small water tank and lift up through a 2 m diameter pipe. The pump will get off once the moisture content is reached to its required level. The working of these switches in thepump is handled by programming only and it's controlled by a webpage.

Fig 3.6 Brass water sprinkling nozzle with 12 V electric pump

5) Compost Health Indicator

It is very important to check the condition of the organic waste used for vermicomposting in the beginning of the composting bin preparation. This will allow the worms to compost the waste easily and improve vermicomposting quality as well. To measure the health, we need to know the moisture, humidity, pH and the light availability in the vermicompost.

Method of using the sensor: Select any of the features among moisture or pH and insert the probe inside the compost at a certain depth. Then it shows the reading in meter; according to that we may take any necessary action for better growth if needed.

MOISTURE: Moisture is an important factor to consider when managing a vermicompost bin. Too much moisture can lead to anaerobic condition, bad odours, and the growth of harmful bacteria, while too little moisture can slow down the composting process and make it difficult for worms to move through the material. Ideally, the moisture level in a vermicompost bin should be around 60-80%. Monitoring and maintaining the moisture level in a vermicompost bin is crucial for creating a healthy and productive environment for the worms and the composting process.

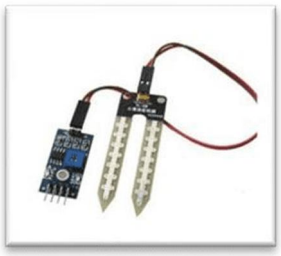

Fig 2.7 Soil Moisture Sensor

Fig 2.8 Hygrometer

pH: pH is another important factor to consider when managing a vermicomposting bin. The optimal pH range for vermicomposting is typically between 6.0 and 8.0. If the pH level is too low(acidic), it harms the worms and slow down the composting process. If the pH level is too high(alkaline), it can also negatively affect the worm and microbial activity in the bin. pH levels in a vermicomposting bin can fluctuate over time, especially as different material is added. Regularly maintaining the pH level and making adjustment as needed can help create ahealthy and productive environment for the worms and the composting process.

LIGHT: Providing adequate lighting for our vermicomposting bin can help worms thrive and increase their efficiency in breaking down organic waste. However, it is important to note thatworm prefer to work in darkness so we don't need to provide bright or direct light. A simple low- level light source such as a red light with minimum wavelength can be sufficient to help the worm move towards the surface of the bin and consume the organic matter.

6) Raspberry PI

A Raspberry pi can be used for vermicomposting in various ways. Vermicomposting is the process of using worms to decompose organic waste into nutrient- rich soil. Here are a few examples of how we can used Raspberry in vermicomposting:

a) Environmental monitoring: A Raspberry pi can be used to monitor the environment condition inside a vermicomposting bin, such as temperature, humidity and pH levels. This information can help us ensuring that the condition is optimal for the worms to thrive and break down the organic waste.

b) Automated Feeding: With a Raspberry Pi, we can set up an automated feeding system for worms. We can use sensors to detect when the worms have finished consuming theprevious batch food and automatically dispense the next batch food.

c) Data Logging and Analysis: A Raspberry Pi can be used to collect data on thevermicomposting process, such as amount of organic waste added, the rate of decomposition and the quality of resulting soil. This data can be analysed to identify patterns and optimize the process of maximum efficiency.

Overall, using a Raspberry Pi in vermicomposting can help us create a more efficient andeffective system for converting organic waste into nutrient- rich soil.

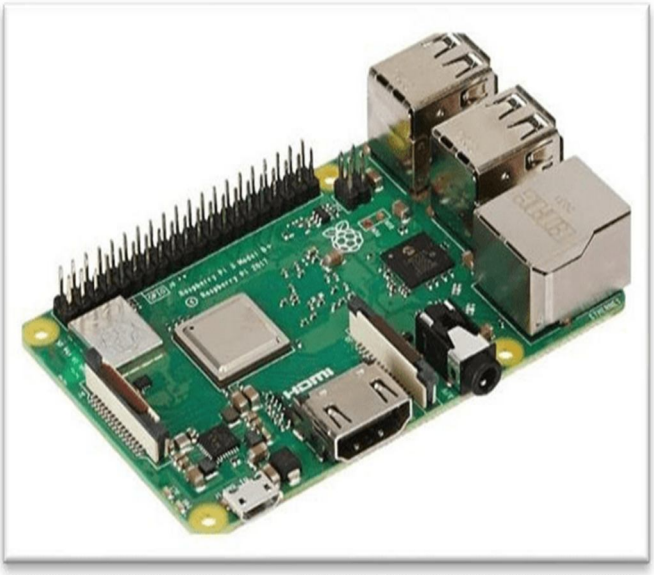

Fig 3.9 Raspberry Pi 3

7) Raspberry Pie System

In our system we have used Raspberry pi 3 to operate our vermicomposting bin.SENSORS USED IN THE SYSTEM ARE:

a) Raspberry pi3
b) 32GB SD card
c) SD card adaptor
d) Metal aluminium case with double fan
e) 5V and 3A power supply (micro- USB)
f) Temperature sensor model kit with water proof electronic building blocks
g) Capacitive soil moisture sensor
h) Connecting wire
i) 16*2 LCD display
j) 12V and 5A SMPS power supply
k) Jumper wire
l) 6 channel Relay 5V module
m) Electric pump 12V
n) Shrink tube

All these sensors are used to build in the whole structure to convert an ordinary structure to an IoT based vermicomposting bin.

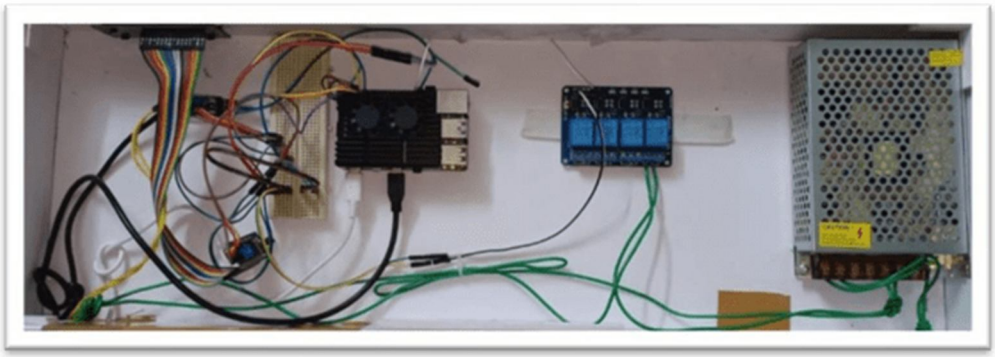

Fig 3.10 Sensors

8) Mobile Application

For digital representation of the growth and composting period, we have used an IoT platform that control Temperature and water intake period via the Internet through an android smart phone. The interface can be useful tool for managing and monitoring vermicomposting system remotely. The dashboard will provide an overview of the current status of the vermicomposting bin, including temperature, humidity and water requirementto the bin. This can help us ensure that the condition is optimal for worms to thrive and break down the organic waste. This application can collect the data on the vermicompostingprocess, which can be analysed to identify patterns and optimize the process for maximumefficiency. The application can send notification to your screen when the bed temp is hightand you need to switch on the exhaust fan to cool down the environmental condition insidethe bin. This gives us through data on which we can analyse the process with right temp and pH for better vermicomposting. This application can make it easier to manage and monitor our vermicomposting system from anywhere using our mobile device. It can help us optimize the vermicomposting process and produce high- quality compost for plants.

E. Coding

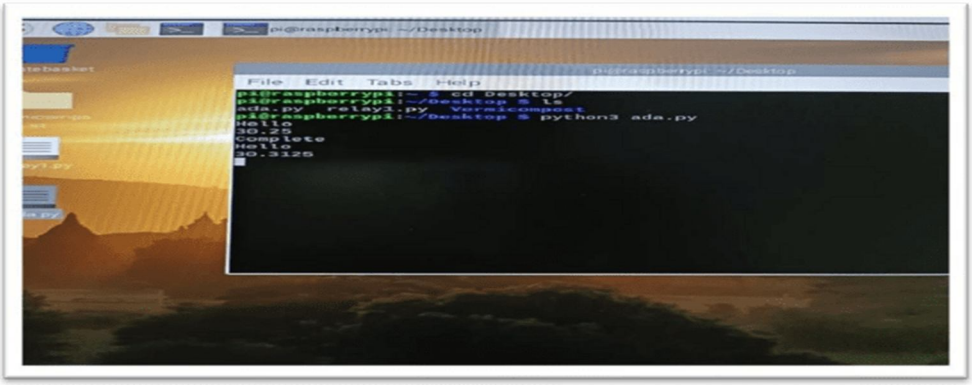

fig. 3.16 Coding for temperature sensor

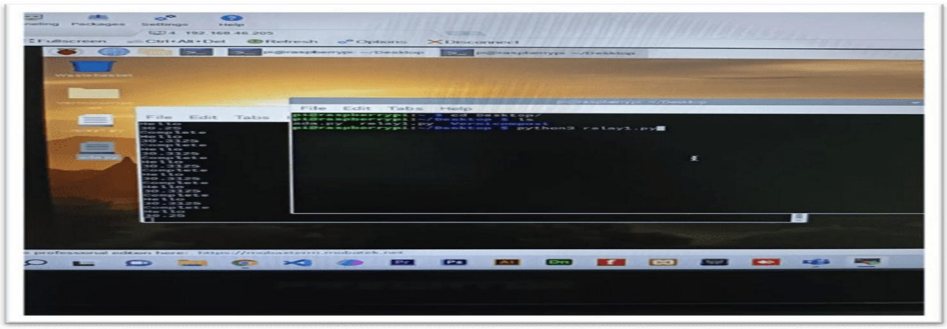

Fig 3.17 Coding for operating the pump

These coding are done to run the file which is developed by using python programming, with the help of proper syntax we use to run the file and get the fruitful output to know theproper temperature and to operate the pump to sprinkle water to maintain proper moisture content in the bin for better compost.

F. Cost Analysis

Table 2.2 Total cost Estimation of Vermicomposting Bin

SL NO	MATERIALS	PRICE
1	Bin	750/-
2	Square Bar	2,050/-
3	Hardware	1,605/-
4	Telescopic Channel	1,290/-
5	Fibre Sheet	3,400/-
6	Cow dunk+ Earthworm	955/-
7	Wheel	400/-
8	Sensors and Electronics	12,500/-
9	LED Light	1,250/-
10	Exhaust Fan	270/-
11	Gasket Strap	80/-
12	Pipe + Bucket	170/-
13	Carpenter	1,500/-
14	Flex+ NPK Test	800/-
15	Travel	3,500/-
	TOTAL	30,520/-

This is the total estimation that cost us during manufacturing of the IoT based vermicompostingbin.

III. RESULT AND DISCUSSION

A. Observation Of Bin 01: (63-65) Day Under Controlled Environment

This experiment was on kitchen waste, like vegetable waste, fruits peel etc. We observe the pH, moisture content and temperature through temperature sensor and hygrometer.

Table 4.1 Observation of IoT based vermicomposting bin

DAYS	TEMPERATURE	MOISTURE CONTENT (%)	pH
1	23.06	45%	6.91
3	24.08	44.45%	6.98
6	23.05	44.13%	7.00
9	23	43.81%	7.21
11	23.25	43.75%	7.27
15	23.45	43.71%	7.33
18	24	42.41%	7.36
22	23.25	42.78%	7.38
25	23.85	42.45%	7.39
29	23.08	42.32%	7.41
33	24	41.66%	7.45
36	24.25	41.32%	7.51
40	24.48	41.27%	7.52
44	23.85	40.87%	7.55
48	25	40.47%	7.56
50	25.45	40.32%	7.58
54	25.02	40.25%	7.60
56	25.85	40.14%	7.63
60	26	40.13%	7.66
63	26.45	40.07%	7.69
65	26.85	40.01%	7.71

The whole vermicomposting process is completed in 65 days under controlled environment. The moisture content and the pH value as well as the temperature of the bin gives us fruitful result. The pH values of the compost are within the standard limit thoughtit is neither acidic nor alkaline. By monitoring the real time temperature, we generate the reports on the proper temperature of the worm bin which provides valuable insights into the health and productivity of the compost. After whole completion of the process the nutrient rich compost is ready to use. So, the NKP value is (nitrogen-0.17%, potassium-0.48 % and phosphorus-0.52%).

B. Application Interface

To digitally display the parameter of vermicomposting bin we have use Adafruit IoT application. The interface has been used to monitor the parameter and regulate it remotelyif necessary.

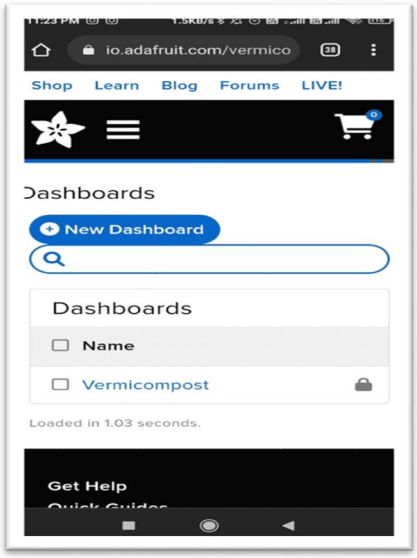

Fig 3.1 Project Interface

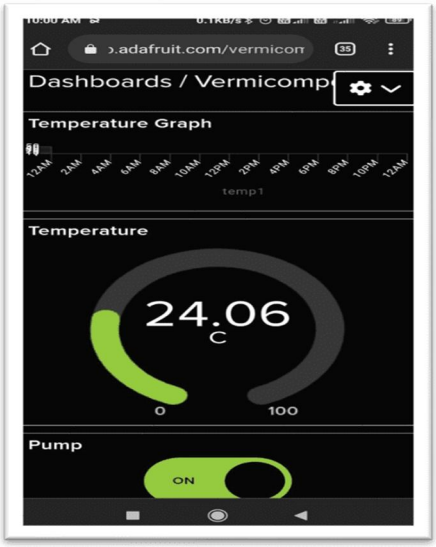

Fig 3.2 Regulation of vermicompostingbin on Application

The above figures depict the use of Adafruit application for regulation of model. The project was named as Automated vermicomposting using portable bin, with temperature control and water pump switch as input data shown in fig 4.2. The compost moisture content is represented in terms of percentage which works when the neutron probe is inserted to the soil.

C. Prototype Set-Up

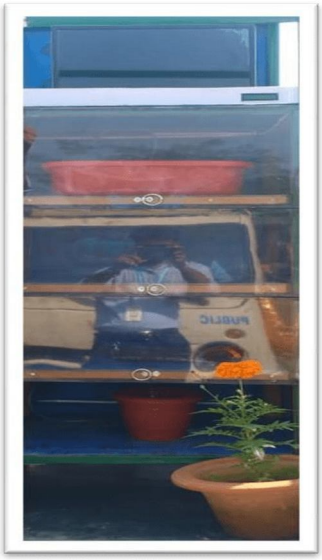

Fig 3.3 Integrated Prototype

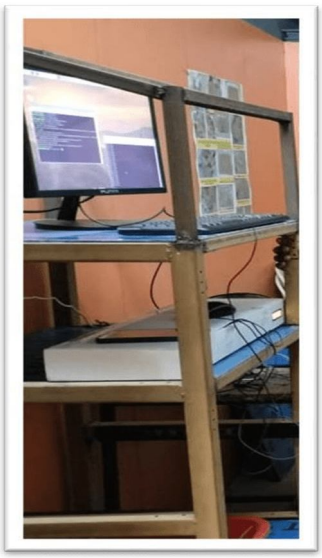

Fig 3.4 Working Model

IV. CONCLUSION

IoT based portable vermicomposting bins offer several benefits for small scale vermicomposting operations. The use of IoT technology allows for remote monitoring and control of critical environment conditions, which can improve the efficiency and effectivenessof the composting process.

Additionally, the portability of the bin allows for greater flexibility in location and usage, this making it an ideal solution for urban or small space environment. However, there are also potential threats to consider including cybersecurity risk, technical complexity etc. But with proper measures, such as cyber security protocols, regular maintenance, and proper waste handling can help mitigate these treats and ensure safe and effective operation.

Overall, IoT based portable vermicomposting bins have the potential to revolutionize the way small- scale vermicomposting is done, making it more efficient, effective and accessible to a wide range of users. However, careful consideration and management of the potential threats and challenges is essential to ensure their safe and effective use. This prototype takes to the new era where people are able to connect with the bin via a mobile application.

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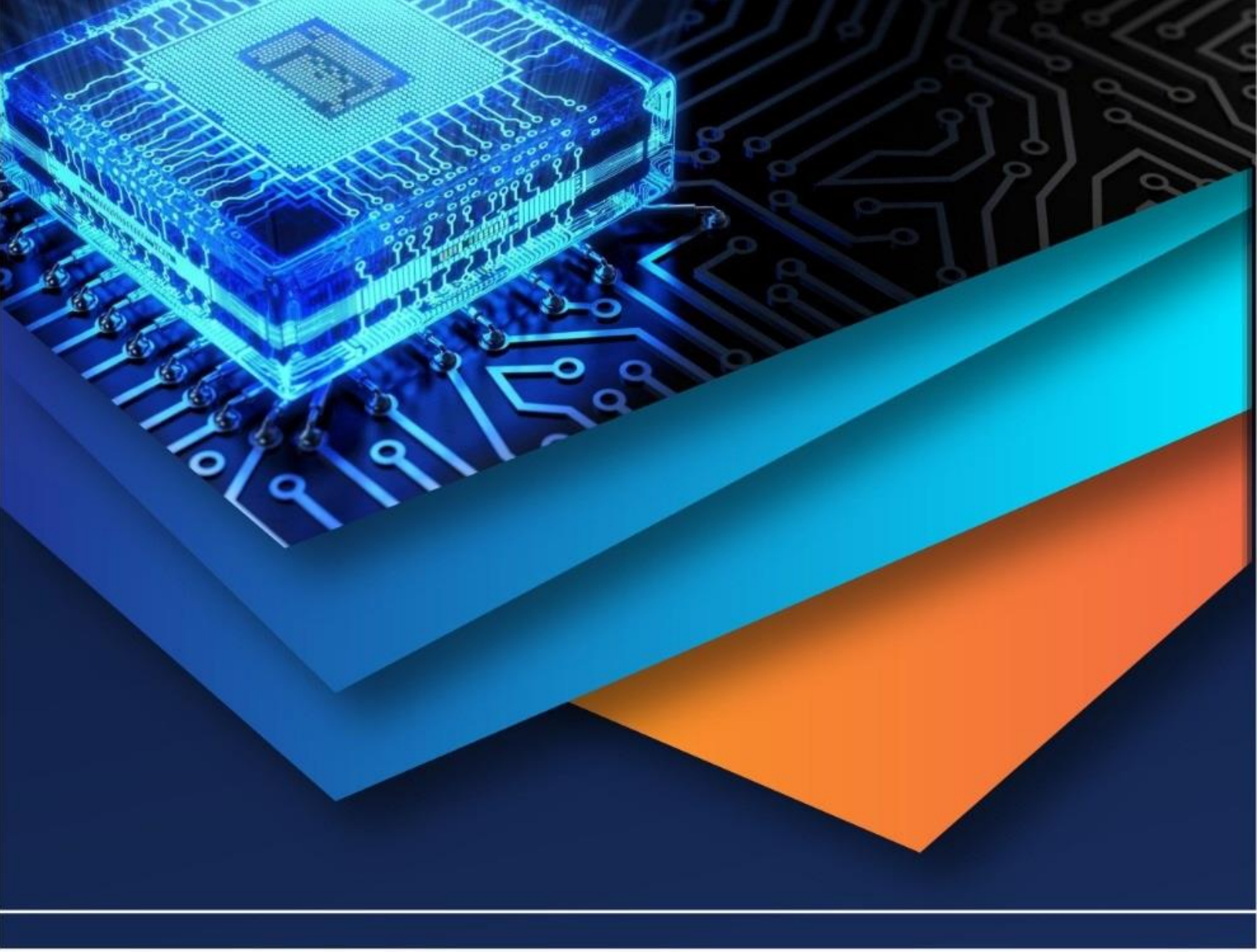

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