

DEVELOPMENT OF VERMICOMPOSTING MONITORING

SYSTEM IoT AND ARDUINO MODULE

Abstract—Vermicomposting is a low-cost technology that naturally converts organic wastes into organic fertilizers, commonly called vermicompost, through the combined action of earthworms and mesophilic microorganisms. Vital parameters, such as moisture, temperature and CO₂ level must be considered in the vermicompost production to achieve optimum yield. The system which monitors these vital parameters and determines the readiness of vermicompost is developed. The system uses Arduino Nano microcontroller, sensors, and an android phone for monitoring.

INTRODUCTION

Vermicomposting is a sustainable method of recycling nutrients and energy from organic materials like food waste and paper products. It uses earthworms and microorganisms to break down, accumulate, detoxify, and convert waste materials into a product that can be used for agricultural purposes.

Eudrilus worms, particularly *Eudrilus eugeniae*, play a vital role in vermicomposting by efficiently decomposing organic matter, rapidly processing large quantities of waste, and exhibiting a high reproductive rate. These worms foster a symbiotic relationship with microorganisms in their digestive tracts, leading to enhanced microbial activity that breaks down complex compounds into nutrient-rich vermicompost. Their prolific breeding contributes to increased composting efficiency, while the resulting vermicompost improves soil structure, aeration, water retention, and nutrient availability. *Eudrilus* worms' adaptability to various conditions and low maintenance requirements make them well-suited for both indoor and outdoor vermicomposting systems, offering an eco-friendly and effective way to convert organic waste into valuable soil amendments.

Two of the vital parameters that needs consideration in a vermicomposting system are moisture and temperature. The worm bedding must be able to hold enough moisture because they breathe through their skin. A moisture level less than 50% is fatal to worms. Also, maintaining temperature within the worms' tolerance is important to both vermicomposting and vermiculture processes. According to Macabuhay, moisture level must be maintained at around 60-80% in Philippine setting so that microbial activity is high and food matter is easy to feed up. Studies show that *Eudrilus eugeniae* have preferences for high temperature, with maximum biomass production occurring from 25°C – 30° C, while growth rates were very low at 15°C .

The system consist of Arduino nano microcontroller which constantly sense pH value, temperature and CO₂ level in compost through temperature sensor (DS18B20), pH gel electrode sensor, CO₂ sensor (MHZ19E). Then these values are uploaded in an IoT system

Vermicomposting is the process of turning agricultural waste into compost with the help of worms and microorganisms. It is an efficient process that is also energy-saving, cost-effective, and highly controlled. One such IoT-based vermicomposting system uses an Arduino Nano board, pH sensor, CO₂ sensor, and temperature sensor.

Vermicompost is the method of using earthworms to transform organic waste into nutrient rich compost. Soil earthworms play an important role in agriculture, it decomposes dead organic litter by consuming them and release as castings. The earthworms accelerate decomposition of plant litter and organic matter and improve soil fertility by releasing mineral elements in the forms that are easily uptake by plants (Curry, 1987). Vermicompost contains most nutrients in plant available form such as nitrates, phosphates, exchangeable calcium and soluble potassium (Edwards, 1998; Orozco, 1996). The behavioural activity of earthworms that is feeding, burrowing and casting, modify the physical, chemical and biological properties of organic matter and soil for plant growth and nutrient acquisition. Due to large surface area, vermicompost offers several micro sites for nutrient retention and exchange and microbial activity (Shi-wei and Fu-Zhen, 1991). Vermicompost is usually rich in microbial populations and diversity particularly fungi, bacteria and actinomycetes (Edwards, 1998; Tomati et al., 1987). The compost prepared by earthworm contain several types of enzymes, hormones, vitamins, antibiotics and many essential nutrients needed for plant growth and also play important role in improving soil structure and water holding capacity, thereby improving crop productivity and quality. Vermicompost is characterized by high porosity, aeration, drainage, water holding capacity and microbial activity (Edwards and Burrows, 1988; Atiyeh et al., 1999, 2000).

As a whole, due to their different production processes, vermicompost might exhibit different physical, chemical and chemical features, which influenced plant growth and overall morphology in diverse ways. Thus, application of vermicompost as organic manure in soil built-up organic carbon, improve nutrient status, enhance cation exchange capacity, microbial activities, microbial biomass carbon and enzymatic activities.

This research explores the integration of Internet of Things (IoT) technologies into vermicomposting, aiming to enhance the efficiency and management of the composting process. The system utilizes Arduino Nano microcontrollers, pH sensors, CO₂ sensors, and temperature sensors to monitor key environmental parameters.

Real-time data collected from the composting environment is transmitted wirelessly to a central server for analysis and visualization.

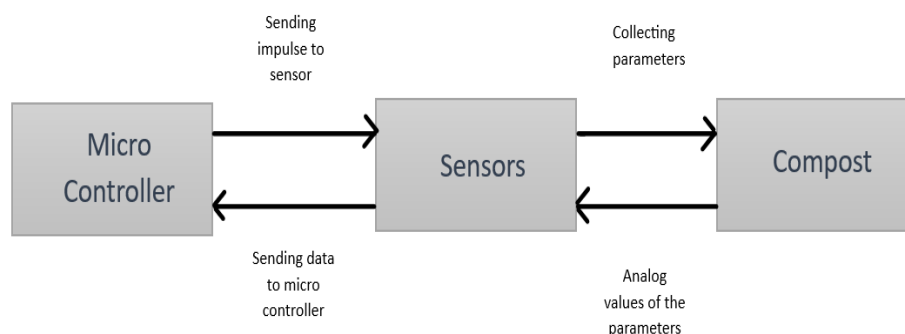
CONTROLLING

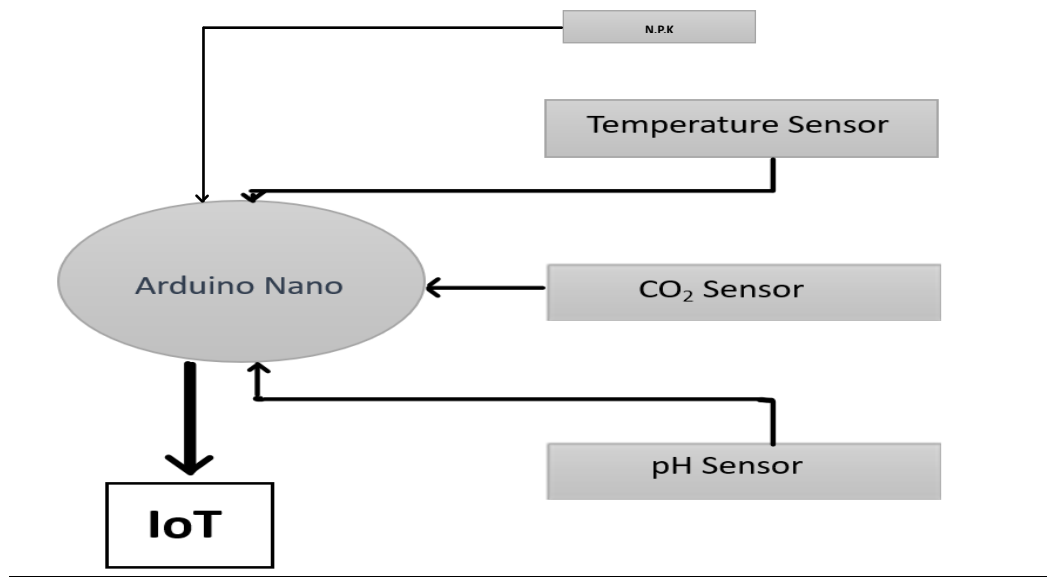
In this paper, we are collecting the physical parameter of the Vermicompost. We are trying to improve the production of vermin composting with maintaining its physical condition, so that it can help in production without degrading the soil fertility. With the help of Arduino Nano we design the system. With input devices, ultrasonic sensor, temperature, CO2 and pH sensor to collect data from manure

The Arduino Nano microcontroller acts as the central processing unit, orchestrating data acquisition from the connected sensors. A pH sensor ensures optimal acidity levels, a CO2 sensor monitors composting activity, and a temperature sensor gauges the thermal conditions crucial for the proliferation of composting organisms. The IoT architecture enables remote monitoring and control, facilitating timely interventions and adjustments.

The findings of this study demonstrate the potential of the IoT-based vermicompost system in optimizing composting processes, ensuring a conducive environment for earthworms, and ultimately promoting sustainable waste management practices. The integration of various sensors enhances the system's adaptability to different composting scenarios.

Flow Control

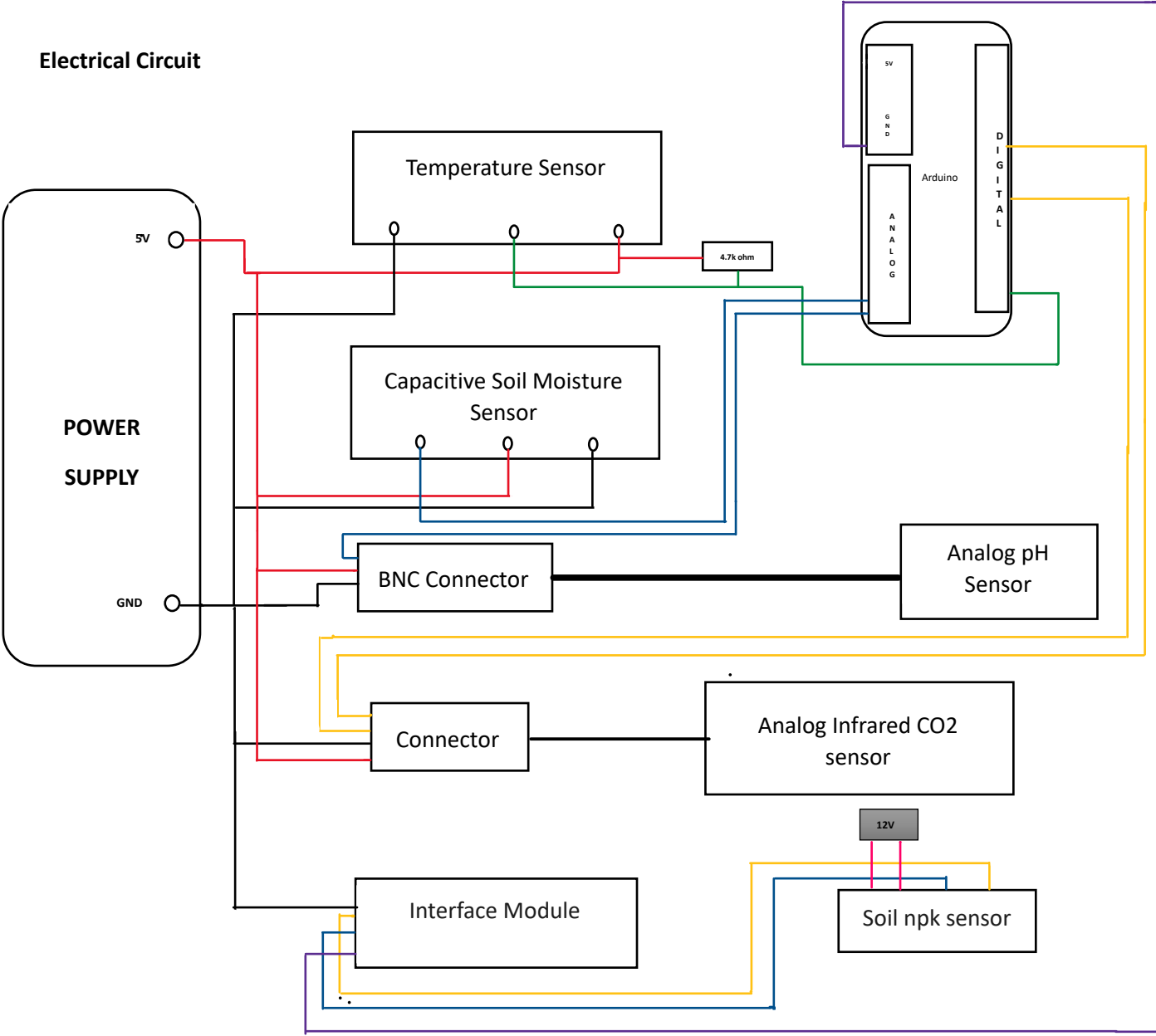




COMPONENTS USED

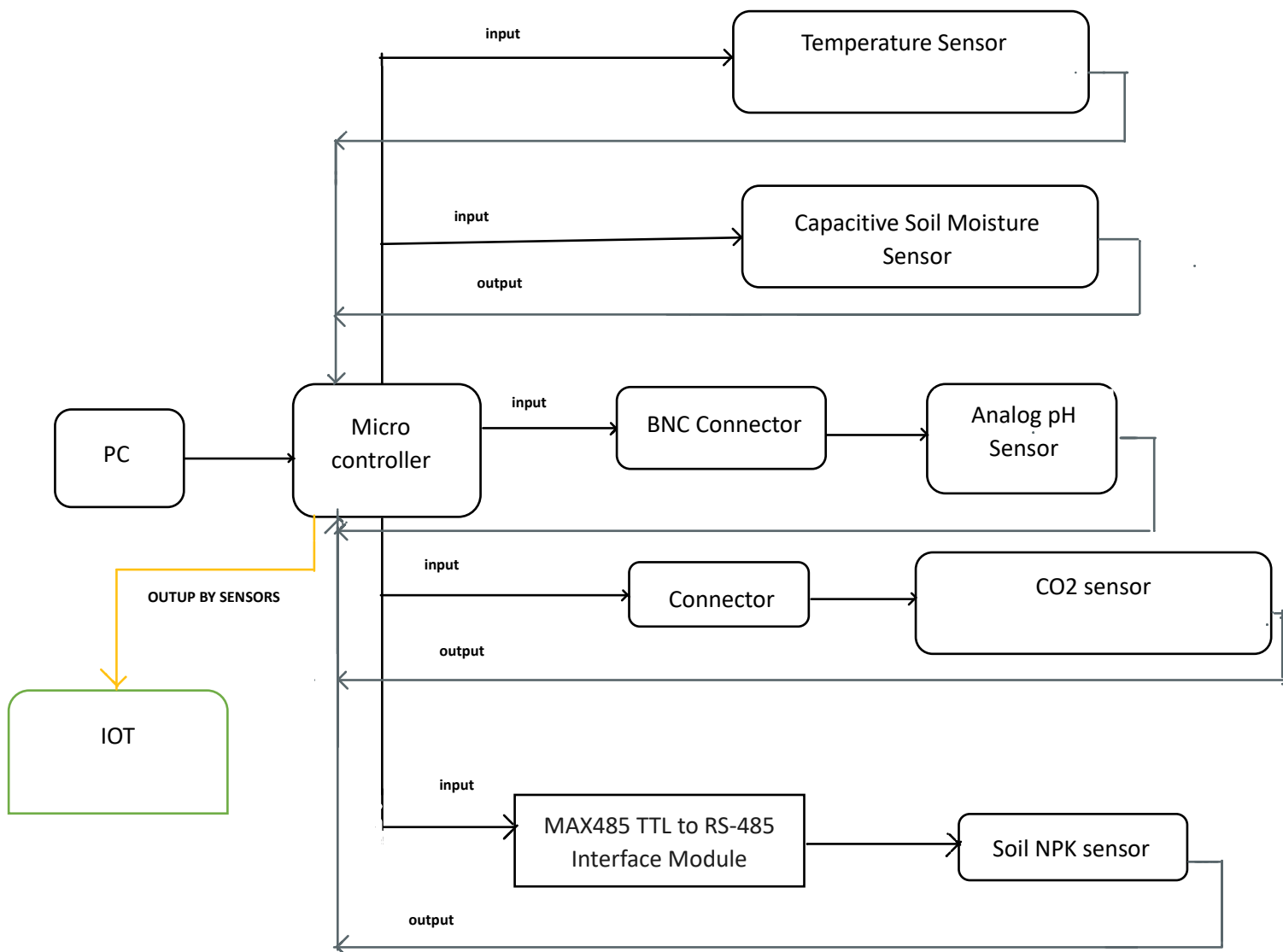
- DS18B20 Temperature Sensor
- Soil Moisture Sensor
- pH Sensor
- CO₂ sensor
- Soil NPK sensor

Electrical Circuit



Output and IOT Diagram

The diagram shows the various components of the circuit and how they are connected to each other. Signal is sent by Arduino to vacillate sensors to perform action then sent output to IOT System



OUTCOME OF THE PROJECT

Nutritional value of vermicompost

The nutrients content in vermicompost generally depends on the waste material or base substrate that is being used for vermicompost preparation. Similarly, earthworm species used in vermicomposting may also influence the quality of vermicompost (Chowdeppa et al., 1999). Vermicompost produced from banana wastes (leaves, pseudostem) and cattle manure in the ratio of 8: 1 on an average contained 1.5, 0.4 and 1.8% N, P₂O₅ and K₂O, respectively (Ushakumari et al., 1999). Similarly, vermicompost prepared from different organic materials such as sugarcane trash, ipomea, parthenium, neem leaves and banana peduncle is highly nutritive and increased rice productivity and improved soil fertility status (Vasanthi and Kumaraswamy, 1999). So, the nutritive value of vermicompost is highly dependent on base substrate used for its production. However, average nutrient concentration in the vermicompost is given in Table.

Nutrient	Content
Organic carbon	9.15 - 17.98 %
Total nitrogen	1.5 - 2.10 %
Total phosphorus	1.0 - 1.50 %
Total potassium	0.60 %
Ca and Mg	22.67 - 47.60 meq/100g
Available S	128 - 548 ppm
Copper	2 - 9.5 ppm
Iron	2 – 9.30 ppm
Zinc	5.70 – 11.5 ppm

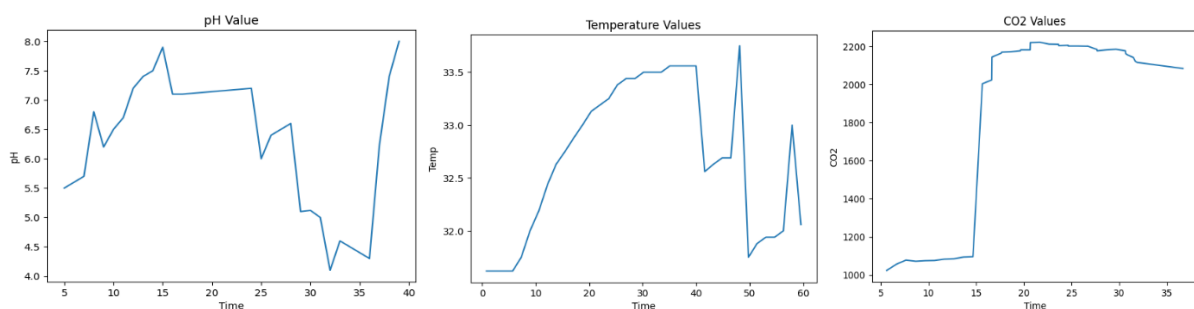
Comparison between nutritive value of vermicompost and farmyard manure:

The nutrient profile in vermicompost is generally higher than traditional compost (Boral et al., 1997) and it reduced the application of inorganic fertilizer to a significant extent. However, nutritive value of vermicompost varies according to the type of organic waste used.

Element	Vermicompost	Farmyard manure
C:N Ratio	15.5	31.3
N (%)	1.6	0.5
P (%)	0.7	0.2
K (%)	0.8	0.5
Ca (%)	0.5	0.9
Mg (%)	0.2	0.2
Fe (mg kg ⁻¹)	175	146.5
Cu (mg kg ⁻¹)	5.0	2.8
Zn (mg kg ⁻¹)	24.5	14.5
Mn (mg kg ⁻¹)	96.5	69.0

Effects of vermicompost on soil organic matter:

Earthworm casts ingested soils often have much higher content of soil organic carbon and nutrients availability as compared to surrounding soils (Lee, 1985). The studies undertaken by Maheswarappa, (1999) revealed that vermicompost addition in soil enhanced organic carbon status, decreased bulk density, improved soil porosities and water holding capacities, increased microbial populations and dehydrogenase activity in the soils. It has been documented that organic matter content in worm casts was about four times more than in surface soil with average values of 48.2 and 11.9 g kg⁻¹ soil, respectively (Khang, 1994). Moreover, earthworms contribution to N turnover in cultivated soils ranged from 3 to 60 kg ha⁻¹ year⁻¹ (Crossley, 1988; Bostom, 1988), thereby enhancing N availability to plants (Tiwari et al., 1989; Hullugalle and Ezumah, 1991).



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