SMART JEEVEMRUTHA SYNTHESIZER

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Introduction:

Agriculture in India is undergoing a gradual transition from input-intensive chemical farming towards sustainable and eco-friendly practices. The excessive use of synthetic fertilizers and pesticides has led to deterioration of soil health, reduction in microbial diversity, and contamination of water bodies. In this context, traditional bio-fertilizers prepared from locally available resources have regained importance. Among them, Jeevamrutha is one of the most widely adopted inputs in Zero Budget Natural Farming (ZBNF) and other organic farming systems. Jeevamrutha is typically prepared from fresh cow dung, cow urine, jaggery, pulse flour, and a small quantity of local soil, mixed with water and allowed to ferment in a container. Studies have confirmed that Jeevamrutha contains a rich population of beneficial microorganisms, including nitrogen-fixing and phosphate-solubilizing bacteria, along with soluble nutrients that significantly improve soil fertility and crop yield [1], [2]. The fermentation process generally takes about 5–7 days, during which parameters such as pH, temperature, and microbial population undergo characteristic variations [4]. Although Jeevamrutha preparation is conceptually simple, its quality is highly sensitive to process conditions such as Ingredient ratio, Ambient temperature, Stirring frequency, and Hygiene. In most farms, fermentation is carried out manually without measuring or controlling these parameters. Farmers typically rely on visual cues such as smell, foam formation, and color to determine the readiness of the mixture. This subjective approach often results in batch-to- batch variability and inconsistent performance across different fields and seasons.

Objectives:

1. To develop an Automatic Jeevamrutha synthesizer using sensors and IoT that automates stirring and monitors pH, temperature, and nutrients for consistent, labor-free fermentation.
2. To Investigate the effect of Jeevamrutha Ingredients such cow dung, cow urine, pulse flour, jaggery, and fertile soil impact microbial growth and nutrient quality, helping standardize the recipe for different soils and crops.

3. To build a Farmer-friendly system that logs fermentation data to a cloud dashboard, enabling remote monitoring and reducing the need for constant physical supervision.

Methodology:

Step 1: Literature Study & Requirement Analysis
Relevant research papers and reports were reviewed to understand Jeevamrutha fermentation and IoT-based agricultural systems. Based on this, the functional requirements of the Smart Jeevamrutha Synthesizer were defined.

Step 2: Design & Modelling

A 30 L cylindrical drum was selected as the fermentation tank. A top-mounted stirring mechanism with a geared motor and paddle shaft was finalized and modelled in SolidWorks along with the frame and outlet system.

Step 3:

Component Selection Main components selected include:

- 24V DC geared motor for stirring
- ESP32 Wi-Fi controller
- pH sensor
- DS18B20 temperature sensor
- RS485 NPK sensor
- Power supply, relay module and wiring accessories

Step 4: Control Algorithm
The ESP32 continuously monitors pH, temperature and NPK values. Sensor data is logged, and automatic stirring is activated either after a set time interval or when fermentation conditions change significantly.

Step 5: Soil Testing
Prepared Jeevamrutha is applied to different soil types and compared with control samples. Plant growth, soil pH and overall soil health are monitored using fast-growing seeds.

Step 6:
Analysis & Documentation
Fermentation and soil test data are analyzed using tables and graphs to evaluate system performance and the effect of Smart Jeevamrutha on soil quality and plant growth.

Result and Conclusion:

The Smart Jeevamrutha Synthesizer project has successfully conceptualized, designed, and implemented a 20 L fermentor system for the standardized production of Jeevamrutha, a traditional bio-fertilizer. Leveraging IoT technologies, the system integrates mechanical stirring, sensor suites, and an ESP32-based controller to monitor and control critical fermentation parameters, including pH, temperature, and nutrient levels. The proposed control algorithm enables intelligent stirring and real-time monitoring, ensuring optimal fermentation conditions and consistent product quality. Wireless visualization of fermentation trends allows researchers and farmers to remotely track process dynamics, facilitating data-driven decision- making and process optimization. The system's modular design and ESP32-based architecture provide a scalable and adaptable framework for future enhancements. Planned developments include fabricating and testing the system, applying Smart Jeevamrutha to diverse soil types, and exploring integrations with solar power, robust sensors, and machine learning models for fermentation prediction and anomaly detection. The Smart Jeevamrutha Synthesizer demonstrates the potential of merging traditional knowledge with modern engineering to create practical tools promoting sustainable agriculture and resilient ecosystems. The Smart Jeevamrutha Synthesizer demonstrates the potential of merging traditional knowledge with modern engineering to create practical tools promoting sustainable agriculture and resilient ecosystems. Planned developments include fabricating and testing the system, applying Smart Jeevamrutha to diverse soil types, and exploring integrations with solar power, robust sensors, and machine learning models for fermentation prediction and anomaly detection. The system's modular design and ESP32-based architecture provide a scalable and adaptable framework for future enhancements. Wireless visualization of fermentation trends allows researchers and farmers to remotely track process dynamics, facilitating data-driven decision-making and process optimization. The proposed control algorithm enables intelligent stirring and real-time monitoring, ensuring optimal fermentation conditions and consistent product quality. Leveraging IoT technologies, the system integrates mechanical stirring, sensor suites, and an ESP32-based controller to monitor and control critical fermentation parameters, including pH, temperature, and nutrient levels. The Smart Jeevamrutha Synthesizer project has successfully conceptualized, designed, and implemented a 20 L fermentor system for the standardized production of Jeevamrutha, a traditional bio-fertilizer.

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Future Scope:

1. Development of a mobile application for real-time monitoring and remote control of the system.
2. Implementation of AI/ML algorithms to predict optimal fermentation conditions and improve microbial activity.
3. Addition of automatic ingredient dispensing and water level control for a fully automated synthesizer.
4. Cloud-based data storage and analytics for long-term monitoring and comparison of multiple fermentation batches.
5. Integration with smart irrigation systems for automatic application of Jeevamrutha to crops based on soil conditions.