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Design and production of an automatic temperature regulation system for a biodigester (Republic of Guinea)

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Abstract

automatic temperature regulation system is crucial to optimize the anaerobic fermentation process and maximize biogas production. In this study, we implemented an automatic system integrating GSM technology to enable remote temperature control and regulation. For this, we installed a temperature sensor inside the biodigester in order to monitor these thermal variations, the data collected by this sensor is transmitted to the central control system via an Arduino Uno module.

The latter compares the received data with predefined thresholds and accordingly sends adjustment commands to the heating system. Operators can monitor and adjust temperature parameters remotely via SMS messages through the SIM800 GSM module. Through this system, the temperature of the biodigester can be maintained at optimal levels, thereby promoting efficient digestion of organic materials and continuous production of biogas, while providing convenient and responsive remote management.

Keywords: Automatic regulation; Biodigester; Temperature; Organic waste; Arduino

1. Introduction

Biodigesters are crucial facilities for the production of biogas from organic materials, but maintaining optimal temperature conditions inside these systems is essential to ensure efficient fermentation and maximize biogas yield. The temperature within a digester is one of the main conditions for the proper functioning of methanization. This must be between very specific temperature ranges. Indeed, a temperature that is too high will lead to the destruction of the microorganisms necessary for the production of biogas, while a temperature that is too low will slow down the methanization process. It is in this context that we chose to regulate the temperature within our biodigester, by an automatic heating system which must operate in a mesophilic range where the temperature is between 20 and 44°C [1]. However, monitoring and regulating the temperature in the biodigester can be a challenge, especially in remote or difficult-to-access facilities.

To meet this challenge, we use a remote automatic temperature regulation system, using GSM (Global System for Mobile Communications) technology, which offers an effective solution by integrating a temperature sensor inside the biodigester, which transmits temperature data to the central data processing unit for real-time adjustment via GSM module.

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In this study, we explore in detail the system operation, advantages and applications of remote automatic temperature regulation system in biodigester via GSM. We also discuss the technical aspects, practical implementation and potential benefits of this technology for the biogas production industry.

2. Materials and methods

2.1. Study framework

This research was carried out in the Electronics laboratory of the Instrumentation and Physical Measurements Department of the Mamou Higher Institute of Technology. This department is one of the six departments of the said institute, created by ministerial decree n°2004/9245/MESRS/CAB of August 25, 2004. It is a public establishment of a professional, scientific, technical and technological nature, relating of the Ministry of Higher Education, Scientific Research and Innovation. It is located in the Telico district , 4 km from downtown Mamou and 270 km from the capital Conakry [2].

2.2. Materials

As part of this work, several materials were used including, among others: the Arduino Uno card, the Sim808 GSM module, the temperature and humidity sensor with serial number DHT11, the relay module, the heating resistor, the LDC display, potentiometer, test plate, connectors, plastic cans, PVC pipes, glues, valves, Teflon.

2.3. System Description

Our automatic heating system is composed of:

- A temperature and humidity sensor that detects and sends temperature and humidity information to the system;
- A heating resistor which allows the temperature detected by the sensor to be lowered or increased in the event of a variation;
- A relay module which controls the switching off and switching on of the heating resistor;
- An Arduino board that processes the information provided by the sensors;
- A GSM (Global System for Mobile Communications) module which sends SMS to users in the event of anomalies or detection of indicated thresholds;
- A 12V power source that powers the entire system.

2.4. Methods

The methodology adapted in this work consists of developing the synoptic and electrical diagram, as well as the program flowchart to understand the operation of the entire system.

To do this, we have created an automatic heating system which can take two states:

- Heating off, - Heating on;
- These states depend on two temperature levels: Minimum temperature 20°C; Maximum temperature 38°C.

2.5. The synoptic and electrical diagram of the system

The synoptic and electrical diagram as well as the system algorithm are presented in the figures below.

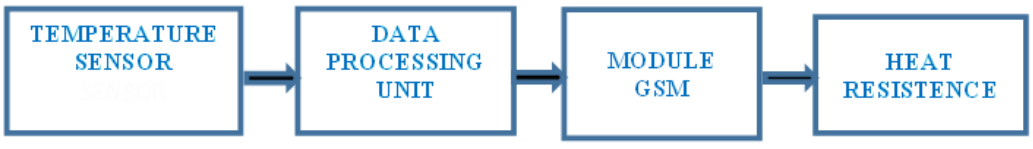

Figure 1 System block diagram

The CPU reads the data from the temperature sensor and if this data exceeds the predefined thresholds, the microcontroller sends alerts to the GSM for automatic temperature regulation and the GSM module in turn sends SMS to the users to take decisions depending on the situation detected. Sending SMS to the user by the GSM module allows the heating system to be turned on or off in real time, which optimizes gas production.

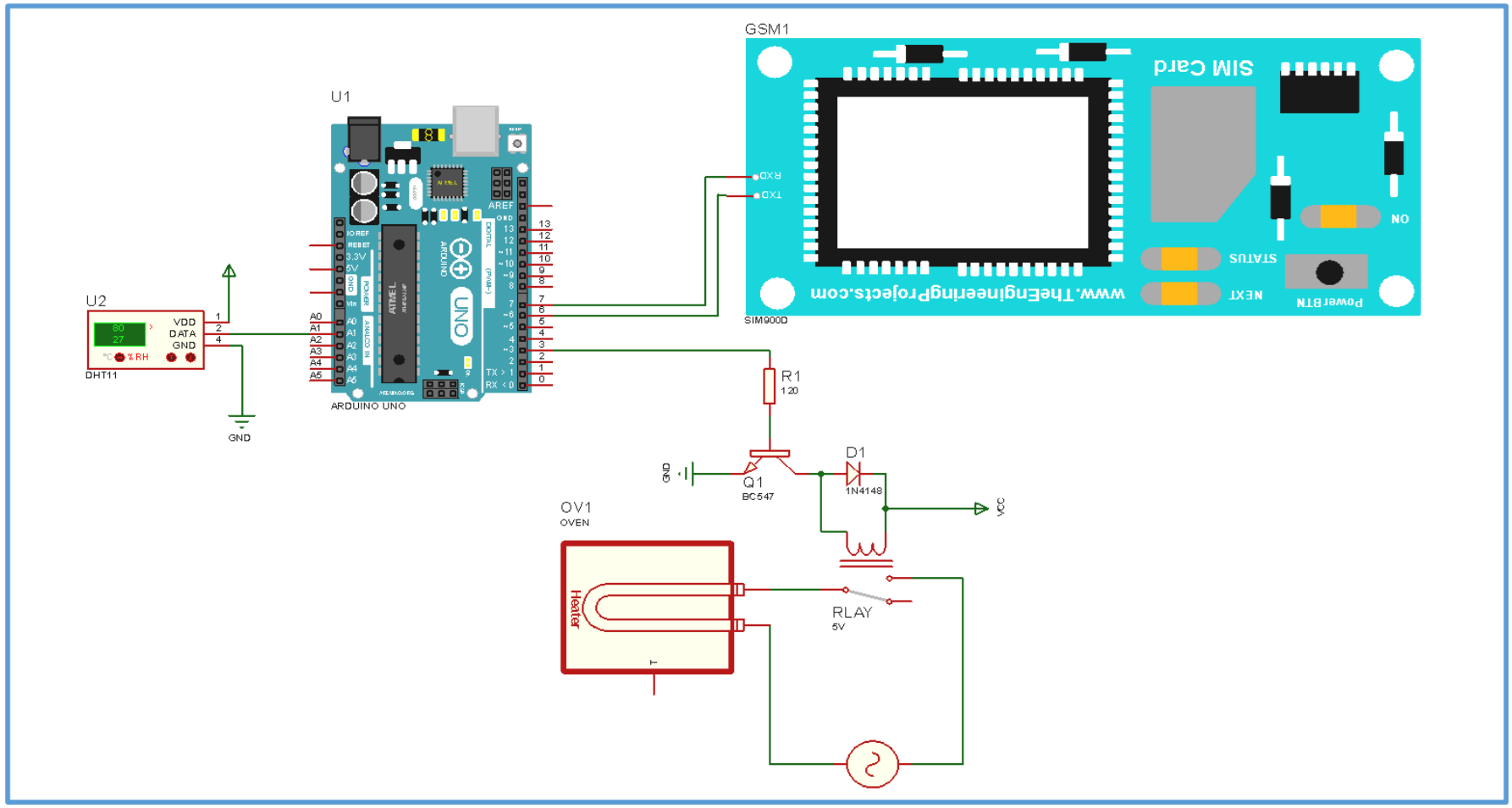

Figure 2 System electrical diagram

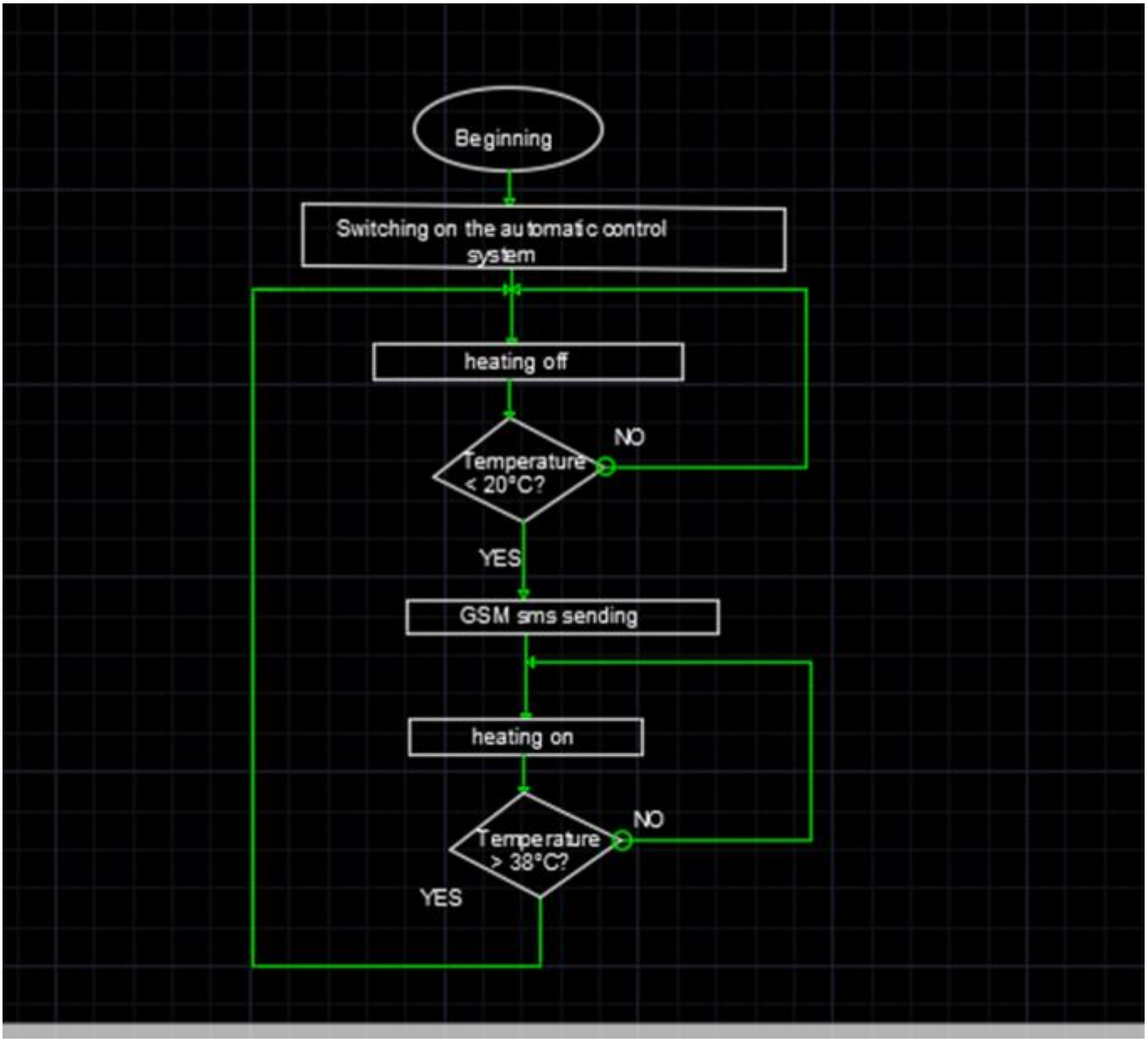

Figure 2 System operation algorithm

The heating system operates according to the flowchart above depending on the temperature status:

- Powering on the automatic heating control device.
- The heating is stopped.
- If the temperature is below 20°C, the GSM module sends an SMS to the user to turn on the heating. If the temperature is above 38°C, the heating remains off.
- As long as the temperature remains below 20°C, the heating remains in working order.
- When the temperature exceeds 38°C, heating is stopped.

The phase of the heating resistor is the normally open of the relay module, its neutral is connected to the neutral of the sector and the phase of the sector is connected to the common of the relay module. The relay module is in turn connected to pin 2 of the Arduino.

The entire system is powered by a regulated 12V power source.

3. Results

The results obtained during this research are effective and promising, they demonstrate the significant advantages of GSM technology. We have successfully developed and implemented our automatic remote temperature regulation system in a biodigester via GSM, which reduced the user's travel time for digester monitoring and costs, thus providing a reliable solution and effective to improve biogas production and simplify the management of biodigestion installations. The following figure shows the system created .

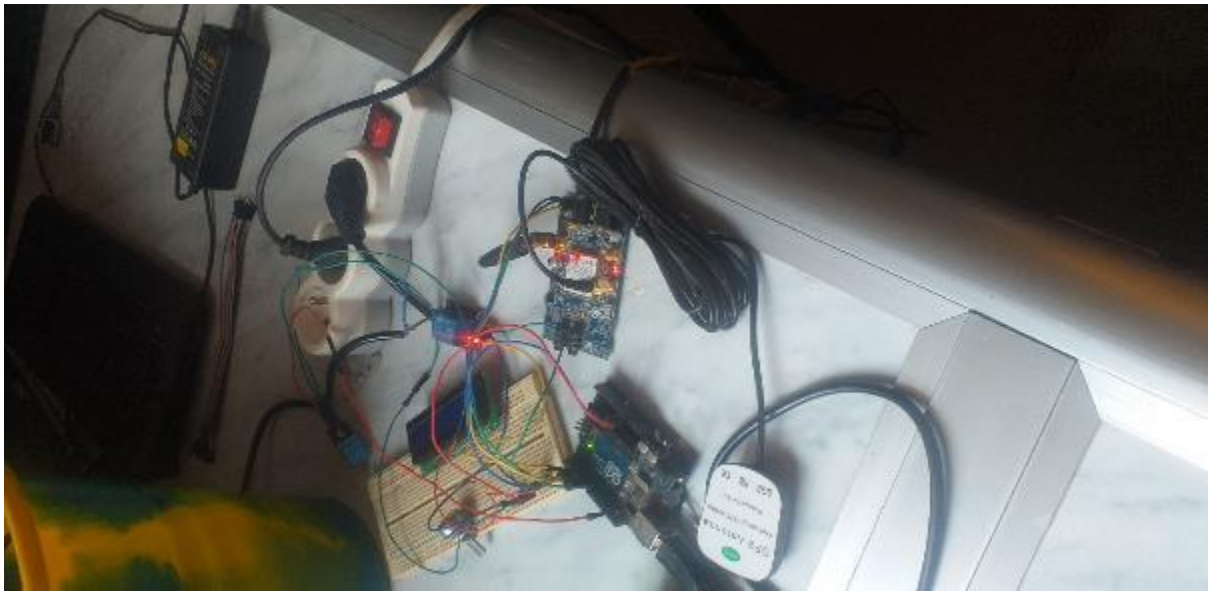

Figure 3 Creation of an automatic heating system

Our system successfully maintained the biodigester temperature within optimal ranges for anaerobic fermentation, thereby promoting continuous and efficient biogas production.

With real-time monitoring of the temperature sensor and remote adjustment capability via the GSM module, the system demonstrated high responsiveness and precise temperature control, enabling rapid corrections during temperature variations. This transmission of temperature data via GSM has proven to be reliable and stable, even in remote or hard-to-access environments, ensuring continuous monitoring and remote management without interruption. The operation of the system depending on the temperature level on the Arduino serial monitor is shown in Figures 5 and 6.

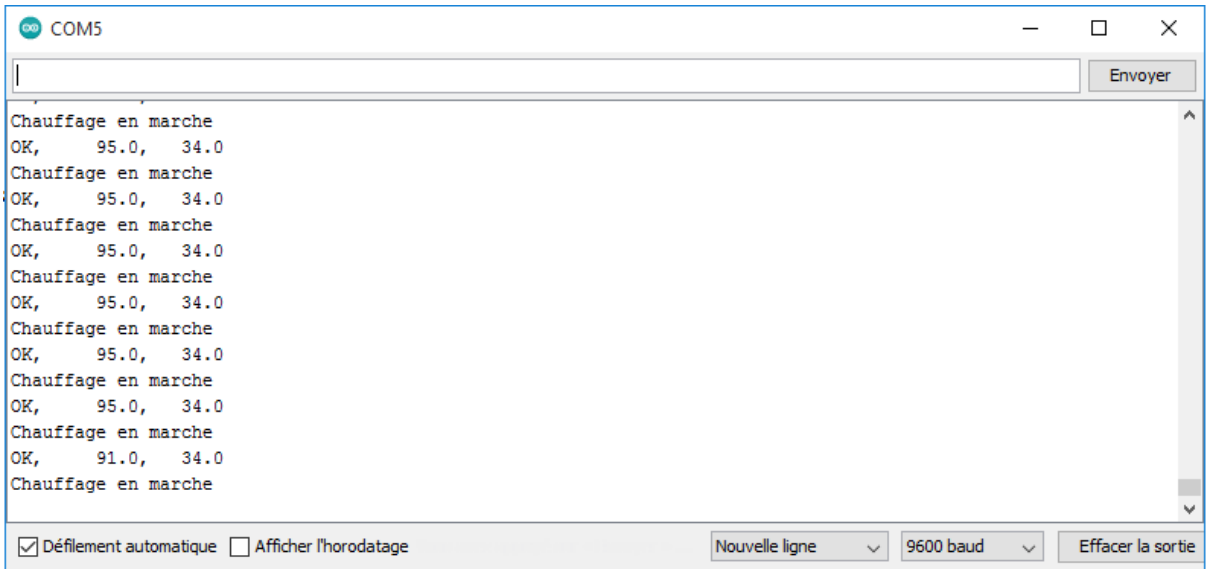

Figure 4 Powering up the system on the serial monitor

The remote user interface, accessible via SMS messages, was user-friendly and intuitive, allowing operators to easily monitor and control the system from anywhere at any time.

By proactively maintaining optimal temperature conditions, the system helped optimize the use of organic resources and maximize biogas yield, while reducing the risks of harmful thermal fluctuations.

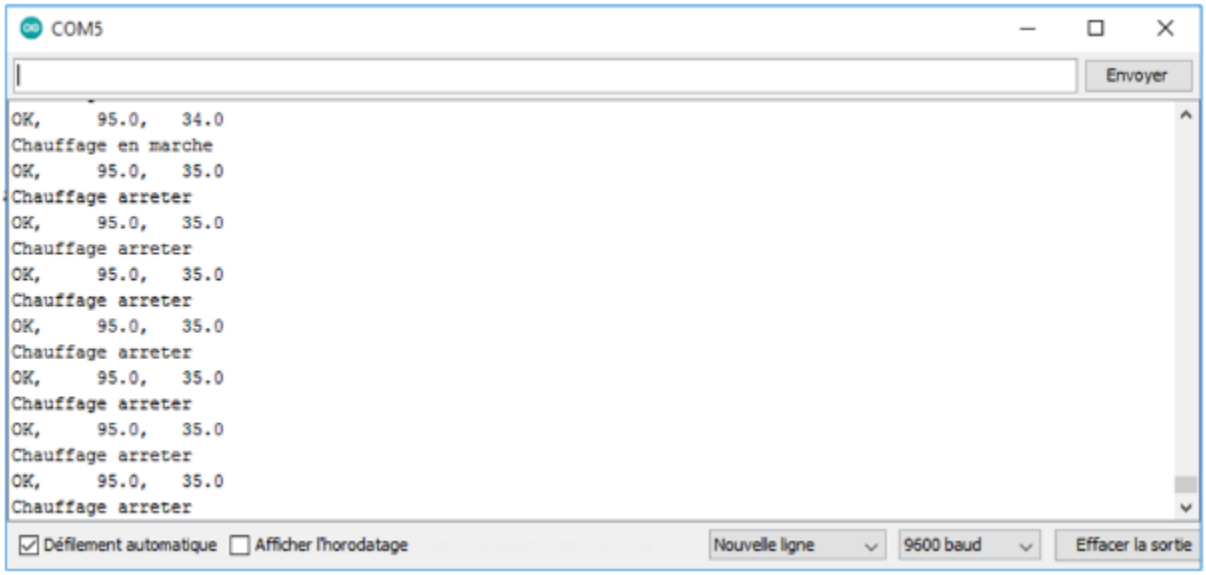

Figure 5 Shutting down the system on the serial monitor

4. Conclusion

In conclusion, the automatic system for remote regulation of the temperature of a biodigester via GSM represents an important advance in the management of biodigestion installations, offering significant advantages in terms of operational efficiency, environmental sustainability and economic profitability. This promising technology paves the way for smarter and more efficient solutions to combat climate change, sustainable biogas production and organic waste management.

Compliance with ethical standards

Conflict of Interest Disclosure

No conflicts of interest to disclose.

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