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Design Of Automatic Cage Disanitation Based On Esp32 With Mq137 & Dht22 Sensors To Monitor Ammonia

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Abstract

The goat pen sanitation process is generally still carried out manually, making it less effective and efficient, and risking delays in handling when ammonia gas levels increase. This condition can reduce the quality of the pen environment and impact livestock health and productivity. This study aims to design and build an ESP32-based automatic goat pen sanitation system using an MQ137 sensor to maintain pen cleanliness and reduce ammonia gas levels. The method used is Research and Development (R&D), which includes the design, manufacturing, and testing stages of the system. The system utilizes the ESP32 as a microcontroller, an MQ137 sensor to detect ammonia gas (NH_3), a DHT22 sensor to measure temperature and humidity, and a relay and water pump as spraying actuators. Sensor data is processed by the ESP32 to control sanitation automatically. When ammonia levels exceed 25 ppm, the pump will activate spraying and stop once ammonia levels return to normal limits. The results of the study indicate that the system was successfully built and is able to carry out the pen sanitation process automatically according to the design. This system is expected to improve the effectiveness and efficiency of pen sanitation and help maintain the quality of the pen environment in a sustainable manner.

Keywords: ESP32, MQ137, Ammonia Gas (NH_3), Goat Pen Sanitation; Automatic System

INTRODUCTION

The goat farming sector plays a vital role in meeting food needs, but livestock productivity is significantly affected by the environmental conditions of the pen. Accumulation of feces and urine can produce ammonia (NH_3), which is harmful to livestock health, causing respiratory problems, decreased appetite, and reduced productivity. Ammonia levels exceeding the safe limit of 20–25 ppm also impact air quality around the pen. (Ramadhan, n.d.). Most smallholder goat farms still practice manual pen sanitation based on estimates without supporting environmental data. As a result, cleaning processes are often delayed, leading to elevated ammonia levels, which can harm livestock health and produce unpleasant odors.

Research Budiawan et al., (2025) The results showed that the MQ137 sensor has good sensitivity in detecting ammonia gas, making it potentially useful as a basis for automatic control of barn sanitation. This research was conducted on an Etawa goat farm in Ngluweng Hamlet, Selokajang Village, Srengat District, Blitar Regency, which is a smallholder livestock business focused on goat milk production. Increased livestock rearing activities have resulted in increased waste volume in the form of feces and urine, necessitating better barn management. If sanitation is not carried out optimally, the quality of the barn environment will decline and directly impact livestock health and productivity. Based on observations and interviews, it was found that the barn sanitation process is still carried out manually and does not have a structured schedule. This condition causes an increase in ammonia levels, especially during the rainy season when barn humidity increases. In addition, monitoring of barn conditions still relies on smell, so it cannot provide accurate information regarding ammonia levels.

Implementation of an Internet of Things-Based Ammonia Gas Sensor on a Broiler Farm with an Automatic Air Quality Monitoring and Control System. In this study, the development and implementation of an Internet of Things-based ammonia gas sensor system using an MQ137 sensor to detect ammonia gas levels and an ESP32 microcontroller to

control various components such as a buzzer, RTC DS1307, and automatic spraying. The results of the study indicate that the designed system can function well in controlling ammonia gas levels in the coop. When the ammonia concentration exceeds the threshold value of 7.2 ppm, the system will activate water spraying automatically. The implementation of this mechanism has been proven to help maintain coop air quality, thus positively impacting the health and productivity levels of broiler chickens (Budiawan et al., 2025).

Design and Construction of a Chicken Coop Cleaner Using an Internet of Things-Based Conveyor Research on the implementation of a chicken coop cleaner design using a DHT22 temperature sensor and an MQ-135 ammonia sensor, as well as an ESP32 module, shows that the system works well. The percentage of temperature measurement error ranges from 0% to 3.10%, while ammonia measurements reach a range of 7.00 to 40.00 ppm. This system is quite efficient in cleaning automatically and monitoring the coop's environmental conditions in real-time via the Telegram application. Coop management becomes easier thanks to the integration of this technology, reducing workload, and maintaining a clean and healthy coop environment (Rosadi et al., 2024).

IoT-based temperature, humidity, and ammonia control system for chicken coops. This research designs an automated control system for chicken coops by integrating temperature, humidity, and ammonia sensors. This system can activate fans and air conditioners when ammonia levels exceed a threshold. The relevance of this research lies in the concept of threshold-based automation that can be applied to the sanitation process of goat pens (Budiman & Muskhir, 2025).

Implementation of an IoT-Based Air Quality Monitoring System for Enhancing Indoor Environments Research conducted by implementing an IoT system to improve air quality in indoor environments. Although this research is not specific to livestock, the principle of real-time air quality monitoring using NodeMCU/ESP32 is very relevant for the development of a monitoring dashboard (Enal Wahyudi et al., 2025).

IoT-Based Early Warning System for Monitoring and Managing Ammonia Gas and Temperature in Chicken Coops. According to research, an IoT system integrated with artificial intelligence (AI) was developed to optimize environmental conditions in chicken coops. This research is important because it demonstrates the development of an IoT system that not only monitors but also predicts optimal conditions. This concept could be a direction for further development of goat pen sanitation research (Sukma et al., 2025).

Based on the description above, researchers designed an ESP32-based automatic barn sanitation system with MQ137 and DHT22 sensors to monitor ammonia, temperature, and humidity levels. The system is designed to automatically activate spraying when ammonia levels exceed a predetermined threshold, thus increasing the effectiveness of barn sanitation, maintaining environmental quality, and supporting livestock health and productivity.

RESEARCH METHODS

In this study, the researcher used the Research and Development (R&D) research type. The product developed in this study is an automatic cage-based sanitation system. In the development process, the product is designed according to needs that aim to improve academically tested quality. The researcher used stages according to the ADDIE model. The ADDIE model takes a systematic approach. The development model used in this study consists of five sequential stages, namely the analysis stage to identify needs, the design stage to compile the system design, the development or production stage to realize the design into a product, the implementation or delivery stage to implement the product that has been created, and the evaluation stage to measure and assess the performance of the resulting product.

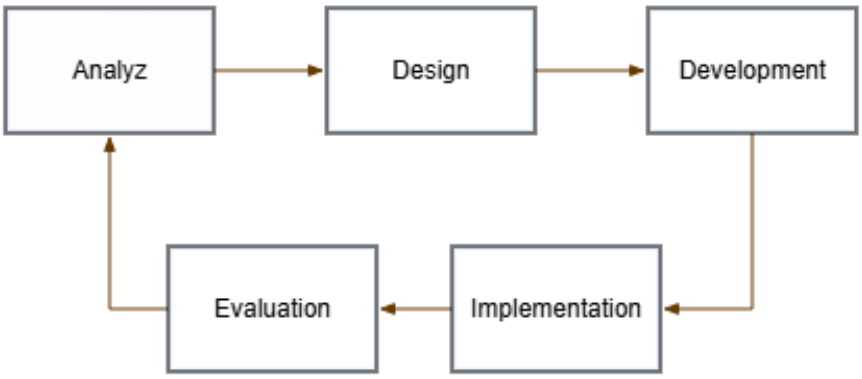


Figure1. Research Steps

In the first stage, the researchers conducted analysis to identify problems in the goat pen sanitation process. During this stage, the researchers observed pen conditions, interviewed farmers, and conducted a literature review on pen sanitation and the use of microcontroller technology. The analysis revealed that the sanitation process was still carried out manually, making it less effective in maintaining pen cleanliness, especially when ammonia gas levels increased. The second stage, design, outlined the system to be developed. This stage involved creating a block diagram and system flowchart, designing the hardware circuit, and designing the software. The main components used included the ESP32 as the system controller, the MQ137 sensor to detect ammonia gas levels, the DHT22 sensor to measure temperature and humidity, a relay as an electronic switch, and a water pump as a spraying actuator.

The third stage, development, was the process of transforming the design into an operational product.

This stage involved assembling all hardware components, programming using the Arduino IDE, integrating sensors with the ESP32, and initial testing of each component to ensure all devices function as designed. The fourth stage, Implementation, is carried out by applying the developed system to the goat pen environment. Testing is conducted to determine the system's ability to detect ammonia gas levels, temperature, and humidity, then automatically activate the spray pump when ammonia levels exceed a predetermined threshold. The implementation results are used to determine whether the system is working according to the research objectives. The final stage, Evaluation, is carried out to assess the overall system performance. Evaluation is carried out through functional testing of the tool, assessments by users and technology experts, and analysis of deficiencies still found during the implementation process. The input obtained at this stage is used as a basis for system improvements and refinements so that the developed tool has more optimal performance and is suitable for application in the goat pen sanitation process.

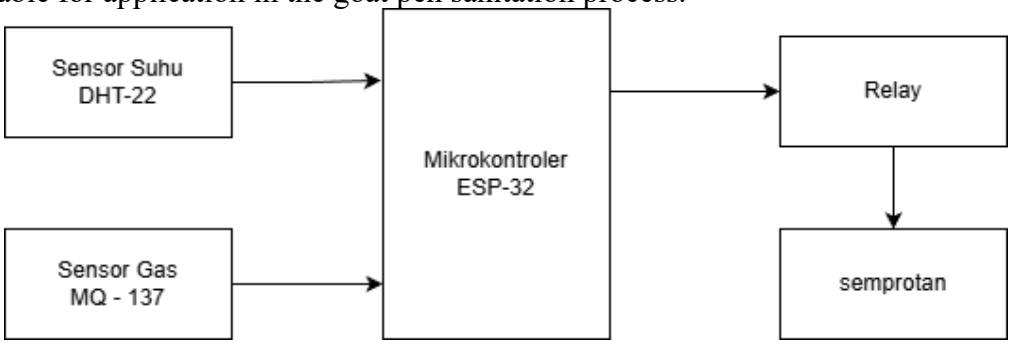


Figure2. Block Diagram

Based on the block diagram in Figure 2, it is explained that the DHT-22 temperature and humidity sensor functions to detect environmental conditions in the pen, specifically temperature and humidity values that can affect the comfort and health of goats. Meanwhile, the MQ-137 gas sensor is used to detect ammonia gas levels produced from urine and feces of livestock in the pen. Data readings from both sensors are sent to the ESP32 microcontroller as a data processing center and system controller. The ESP32 will process sensor data based on predetermined thresholds or a pre-programmed sanitation schedule. If abnormal conditions in the pen are detected, such as high ammonia levels or the sanitation time has been reached, the ESP32 will activate the relay module. The relay functions as an electronic switch that connects or disconnects the power supply to the disinfectant spraying device, so that the spraying process can be carried out automatically.

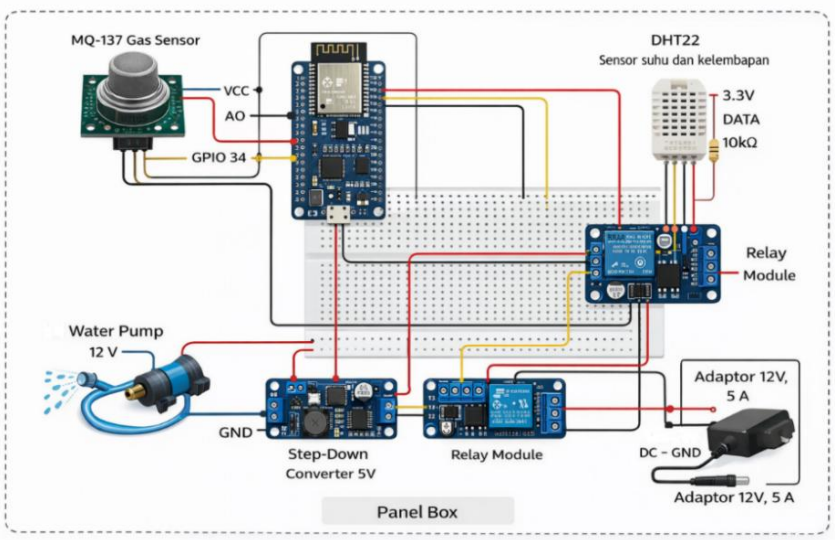


Figure3. System Series

Based on the system circuit in Figure 3, the main components used include an ESP32 microcontroller, an MQ137 sensor, a DHT22 sensor, a relay, a water pump, and a step-down converter module to reduce the voltage. The ESP32 functions as a control center that receives data from the MQ137 sensor to detect ammonia (NH_3) gas levels and the DHT22 sensor to measure the temperature and humidity of the cage environment. The ESP32 processes this data to control a relay that automatically activates the water pump when ammonia levels exceed a predetermined threshold. All components are connected according to the designed pin configuration so that the system can work properly. If there is an error in the circuit installation or pin connection, the sensor reading process and system operation cannot run optimally.

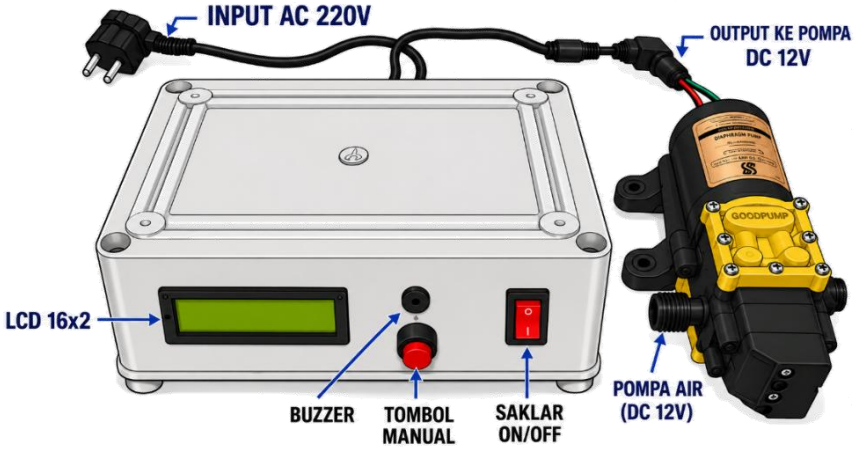


Figure4. Automatic Cage Sanitizer Design

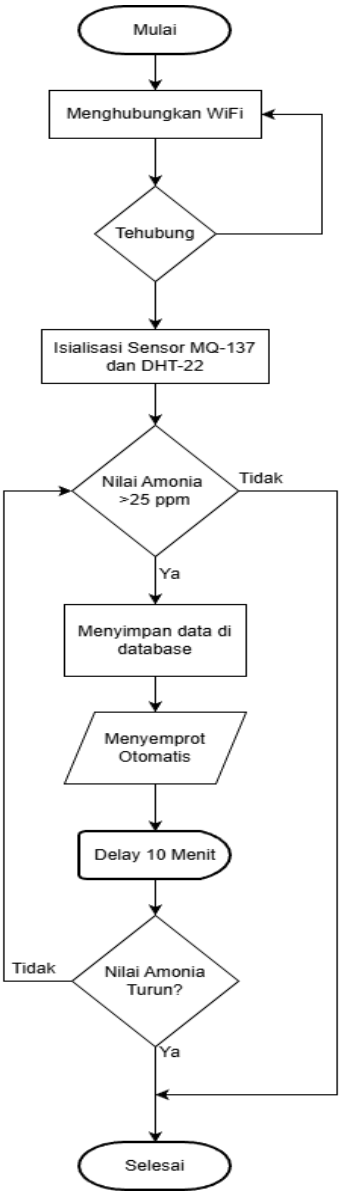


Figure5. System Flowchart

The flowchart in Figure 5 explains the workflow of an ESP32-based automatic cage sanitation system. The process begins by connecting the ESP32 to a WiFi network, then the system initializes the MQ137 and DHT22 sensors to read ammonia (NH_3) gas levels, temperature, and humidity. Once all sensors are active, the ESP32 processes the data obtained to determine the cage's environmental conditions. If ammonia gas levels exceed the threshold of 25 ppm, the readings are stored in a database, and a relay activates the water pump to automatically spray. Spraying lasts for 10 minutes, after which the system reads the ammonia levels again. Once ammonia levels have decreased to normal levels, the pump is turned off. This entire process is repeated so that cage conditions can be continuously monitored and sanitation takes place automatically based on sensor readings.

RESULTS AND DISCUSSION

The result of this research is that the researcher successfully designed and realized an automatic cage sanitation system based on ESP32 with MQ137 and DHT22 sensors. All components, namely ESP32, MQ137 sensor, DHT22 sensor, relay, water pump, are assembled in a panel box so that the system can work in an integrated manner. ESP32

functions as the main controller that receives data from the MQ137 sensor to detect ammonia (NH_3) gas levels and the DHT22 sensor to measure the temperature and humidity of the cage environment. Data obtained from both sensors are processed by ESP32 to automatically control the relay. When the ammonia gas level exceeds the threshold of 25 ppm, the relay will activate the water pump so that the disinfectant spraying process takes place automatically. Once the ammonia level returns to normal conditions, the pump will stop working. Thus, the system is able to help the cage sanitation process become more effective and efficient without requiring manual operation.

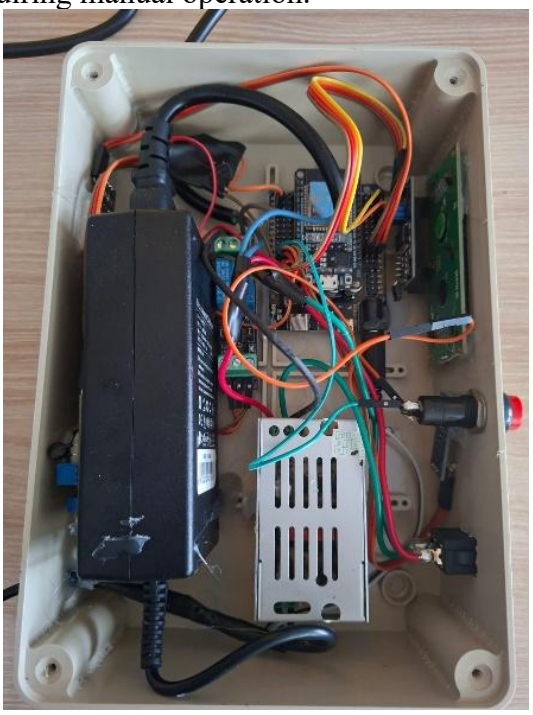


Figure6. Component Placement in the Tool

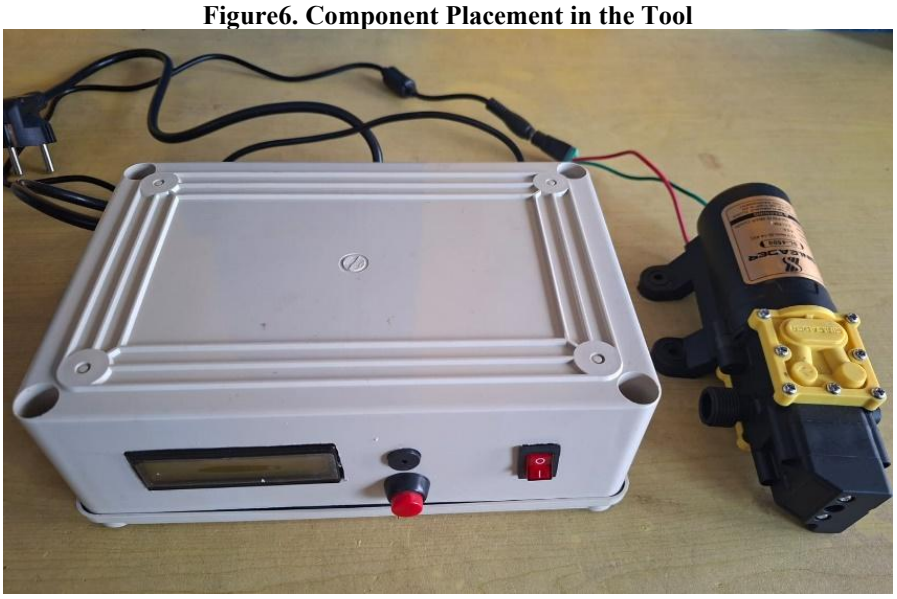


Figure7. Automatic Cage Sanitization Tool Results

Figures 6 and 7 show the assembly results of the ESP32-based automatic cage sanitation system, which has been integrated with all hardware components. The system consists of the ESP32 as a microcontroller, an MQ137 sensor to detect ammonia (NH_3) gas levels, a DHT22 sensor to measure temperature and humidity, a relay as a pump controller, a power supply module, and a water pump as a spraying actuator. All components are placed inside a panel box for safety, tidiness, and ease of operation. The ESP32 is programmed

using the Arduino IDE to process data obtained from the MQ137 and DHT22 sensors. Based on the sensor readings, the system activates the relay so that the pump automatically sprays when the ammonia gas level exceeds a predetermined threshold. After the assembly process is complete, testing is carried out to ensure that the system can automatically respond to changing conditions and return to normal when the ammonia level drops below the threshold. Thus, the system can operate efficiently and does not cause wastage of energy or disinfectant fluid. The following tool test results can be seen in Table 1.



Figure8. Automatic Cage Sanitizer Testing

Table 1. Tool Test Results

No.	Ammonia Level Conditions	Value (ppm)	System Response	Information
1.	Normal condition	≤ 25 ppm	Pompa OFF	Not yet active
2.	Approaching the limit	24 ppm	Pompa OFF	Not yet active
3.	At the threshold	25 ppm	Pompa OFF	Not yet active
4.	Exceeding the threshold	26 ppm	Pompa ON	Spraying is active
5.	High levels	30 ppm	Pompa ON	Spraying is active
6.	Very high levels	40 ppm	Pompa ON	Spraying is active
7.	After spraying	≤ 25 ppm	Pompa OFF	Back to normal

The results of the overall system test, shown in Table 1, indicate that the device operated properly according to the workflow and programming logic established during the design phase. When ammonia levels reached 25 ppm or less, the system deactivated the water pump, preventing the spraying process. This indicated that ammonia levels remained within limits considered safe for the barn environment. When ammonia levels approached the thresholds of 24 ppm and 25 ppm, the pump remained deactivated because it had not yet exceeded the predetermined limit.

Conversely, when the MQ-137 sensor detected ammonia levels exceeding 25 ppm, the system responded by automatically activating the water pump. This was evident in tests at 26 ppm, 30 ppm, and 40 ppm, where the pump was on and the disinfectant spraying process was underway. Pump activation was carried out via a relay controlled by the ESP32, which serves as the data processing center. After the spraying process is complete and the ammonia level drops to 25 ppm or less, the pump stops operating and the system returns to normal.

Test results indicate that the system can effectively detect variations in ammonia gas levels and take appropriate action based on predetermined concentration limits. Therefore, the designed device can automatically sanitize goat pens, helping maintain air quality and environmental cleanliness.

CONCLUSION

The design of an automated goat pen sanitation scheduling system using an ESP32 microcontroller, MQ137 sensor, DHT22 sensor, relay, and water pump has been successfully developed. The system is able to monitor ammonia (NH_3) gas levels, temperature, and humidity in real-time and control the sanitation process automatically based on data obtained from the sensors. When ammonia levels exceed the threshold of 25 ppm, the system activates the spray pump via a relay and stops the spraying process once the ammonia levels return to normal. The integration of all components results in an automated monitoring and sanitation process without the need for continuous manual operation. The implementation of this system can reduce delays in handling due to increased ammonia levels, help maintain air quality and environmental conditions in the pen, and support the creation of a healthier rearing environment for livestock. Thus, the developed system has the potential to be an effective and efficient solution in improving Internet of Things (IoT)-based goat pen sanitation management and can be further developed by adding remote monitoring features and continuous environmental data analysis.

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