Design, Construction and Testing of Portable Systems for Temperature, Humidity and Ammonia Monitoring of Chicken Coop

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Abstract. The air and environment quality have big impact for chicken health. The most dominant component polluting environment of chicken coop is ammonia which is produced by chicken manure. Other environment components that affect chicken health are including temperature and humidity of the air. The problem faced by chicken farmer is that the decreasing of chicken health which leads to the death caused by the bad air and environment condition. These environment variables were usually predicted by the farmer manually. The objective of the publication is to monitor the ammonia, temperature and humidity electronically by using computer-based systems for a chicken coop. The developed systems used DHT 22 sensor as a temperature detector and MQ-135 sensor as ammonia gas detector. The systems also able to control the fan and lamps to maintain temperature and humidity of the chicken coop stable. Data from the sensors then were processed by NodeMCU ESP8266 microcontroller and then was displayed on 20x4 LCD. Afterward, the data was sent to the Android smartphone by using social networking platform Telegram for distance notification systems. Testing results showed that the developed system works well.

1. Introduction

Newly hatched chicken seedlings (one day old), known as day old chick (DOC), in broiler farms, require good treatment so they will be able to grow healthy to produce high egg production or optimal weight and good carcass.

Because of the importance of temperature conditions, the level of temperature in the chicken coop must be known continuously. Temperature data on the chicken coop is used as a basis for consideration of farmer to take action so that the temperature of the chicken coop can be kept constantly at a comfortable range for chicken. In general, the temperature in a coop can be measured manually by using a mercury-based or electronic-based thermometer. Temperature data on the chicken coop may also need to be recorded for the purpose of further analysis related to the management of the coop. Measuring temperature in this way will take quite a long time to read and record the data.

Besides the temperature of the coop, another factor that greatly influences the growth of chicken is the air quality of the coop. The fermentation process of chicken manure mixed with a litter base produces ammonia gas (NH3). The more manure produced by the chicken the more ammonia gas produced. The formation of ammonia gas will be affected by some factors including temperature, moisture, PH and nitrogen content of the litter or manure. The ammonia concentration combined with its exposure time will affect the health of both chicken and the people around especially the worker.
Based on the results of research conducted by [2], [3] it can be noted that the high levels of ammonia gas in the coop affect the resistance of chicken to diseases that can lead to high mortality rates. Also, the high concentration of ammonia in the air of chicken coop reduce feed intake and then slowdown the growth rate, lowering egg production and decrease respiratory function [4].

Microcontroller-based electronic systems can be implemented to detect and record the presence of certain gases in nature automatically to replace the detection and recording manually by people such as for the detection of combustible gases. The results showed that the electronic system can works with sufficient precision and record it in a storage device in the form of a file faster than the manual process [5], [6]. Another research results reported in [7] showed that electronics system was employed for monitoring of air quality. Moreover, electronics based system also was reported to be used for detecting ammonia gas leakage with acceptable performance [8].

Based on the description above, taking into account that temperature, and ammonia gas levels are very important in chicken growth, it is very necessary to always be monitored automatically by using an electronic based system. Monitoring the main parameters of the chicken coop is very important to reduce the mortality rate of chickens, especially during the critical period when the chicks are aged between one day and three weeks due to the unfavorable condition of the coop. By reducing the mortality rate of chicks, it will reduce the losses suffered by farmers while increasing the profit of farmer.

The attempt for monitoring chicken coop environment variable especially temperature, humidity and hazardous gasses electronically has been published in [9] where computer with local network were used for monitoring environment and variables as well as for controlling devices like heating devices, moisturizing devices and ventilation. The research result showed that architecture, user would only be able to monitor the environment variable of chicken coop using designated computer statically, not mobile.

The objective of this publication is to monitor the main parameters of the chicken coop and display them electronically as well as for mobile device (smartphone) using Telegram social networking application so that it can be used as a basis for decision making. The use of mobile phone for displaying data and wifi for data communication in this published work is the main difference of this publication with research result in [9].

2. Method

2.1. Design process
The design process of the monitoring system consists of four main stages, namely architecture design, hardware design, software design, construction design and testing.

2.2. Tools and materials
The main hardware and software tools used in the design process were including: (1) NodeMCU ESP8266 V3 microcontroller, (2) DHT22 sensor, (3) MQ-135 sensor, (4) Relay, (5) fan, (6) lamp, (7) real time clock (RTC), (8) Arduino IDE and (9) social networking Telegram.

2.3. Systems architecture
The block diagram showing the architecture design of the system from sensors to the display of mobile device can be seen in figure 1.

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Figure 1. Diagram blok representing systems architecture.
The NodeMCU microcontroller is used as the main processor or brain of monitoring system for temperature, humidity, NH3 levels and remote control of fans and lights. Components for detecting temperature and humidity is DHT 22 while for NH3 gas content is MQ-135. Then, the data of the sensors reading are processed by using NodeMCU Microcontroller. Next, resulted data are displayed on the LCD 20x4 (20 columns and 4 rows) as well as on Android smartphone by using Telegram social networking application for remote monitoring. Besides for displaying the resulted data, Telegram application is also used as remote control of fan and lights in order for stabilization when the temperature and humidity of the chicken coop are not appropriate. Less humid of the chicken coop will prohibite the formation of ammonia. The fan, when it is turned on, functions like a ventilation that provide fresh air for the chicken coop. The fresh air will decrease the concentration of ammonia in the atmosphere of chicken coop [10]. Less ammonia in the chicken coop will decrease the death rates and produce healthier chicken so that increase the profit [11]. Figure 2 shows a wiring diagram of hardware components implementing system architecture depicted in figure 1.

2.4. Software design
The microcontroller handles all computation process by using software programmed in it. The general computational process of software in the NodeMCU microcontroller is described in figure 3.
The initial step in the computing process is to connect NodeMCU with a wireless internet network (wifi). After it is connected, NodeMCU will read the output data generated by the DHT 2 sensor, MQ-135 sensor and RTC. Then these data will be processed into final data in the form of temperature, humidity and ammonia gas levels which are then displayed on a 20 x 4 LCD viewer. Figure 4 shows the computation flow diagram of the remote ignition mechanism for fans and lights using a smartphone and then displays reports on temperature, humidity, ammonia gas concentrations, the status of whether fan and lights are on or not using the Telegram social networking application.
Figure 4. Flowchart of program for controlling lamp and fan remotely and display the data and status by using Telegram.

After successfully connected to wifi, the microcontroller will wait whether the user will command to turn on the light and the fan. After that, microcontroller will wait whether the Telegram application asking to send the data or not, if yes then microcontroller will send the data to Telegram to display, otherwise the program is finished.

2.5. Construction design
The hardware circuits involving NodeMCU microcontroller, RTC, relay, regulators (7805 and 7812 as source of 5 and 12 DCV power source respectively) and transformer CT 12 V. All of these components are then placed in an acrylic box with size of 17 centimetres in length x 12 centimetres in width x 8 centimetres in height. The RTC is used for displaying the time and date of the device. The box is equipped with AC socket to enter the source from main power line, the switch to turn off and turn on the appliance, the outlet to enter from the fan and the lamp after the relay.

3. Results and discussion
3.1. The resulted systems
Figure 5 shows actual outer view of the resulted systems in an acrylic box. Placing the hardware set in an acrylic box will protect the hardware set from water, dust and other external interference.

Figure 5. Actual view of resulted systems.

3.2. Testing scenario
The resulted system was then tested to monitor environmental conditions in laying chicks which have dimensions of 16 meters in length (P) x 9 meters in width (L) x 3.5 meters in height (T) which can be
seen in figure 6. The coop has a capacity of 2000 chicks made of the gable roof because it is suitable for use in areas with high humidity levels.

![Figure 6](image)

**Figure 6.** The dimension of the chicken coop for performance testing and the configuration of the systems inside the chicken coop.

Laying DOCs age from one day to 21 days initially are placed in a coop with a size of 5x7 meters and the entire roof wall is covered with a tarp so that the chicks are warm while the floor is sown in rice husk and above it is covered by paper. At the time of testing, the resulted system was placed in the middle of the coop (figure 6) while the lamps were placed hung of the roof spready throughout the enclosed area.

### 3.3. Testing of temperature and humidity testing

The temperature and humidity sensor used in this system is the DHT 22 sensor. In order to gain its validity, it is necessary to do a comparison between the measurement results using DHT 22 sensor and using the commercial available Thermo Hygrometer which is sold on the market. Testing of temperature and humidity measurements were done with a time span of five minutes. The test results showed that for the measurement of humidity the resulted system has an error of 0.337% while for the measurement of the temperature the tool has an error of 4.32% when compared with the results of measurements using a Thermo Hygrometer. Then the resulted system was tested for 14 days with the temperature and humidity data collection was carried out three times a day with the following time: (1) in the morning: between 06.00 am and 07.00 am, (2) afternoon: between 12.00 at noon and 13.00 pm, and (3) night: between 19.00 pm and 20.00 pm. The testing was done by looking the measurement result directly at the LCD and at Telegram display. The test results showed that the tool provides linear measurement results when compared to Thermo Hygrometer.

### 3.4. Testing of ammonia measurement

The emergence of respiratory disease cases in many chicken farms is caused by high levels of ammonia gas in chicken coop. Ammonia levels and their characteristics that can be recognized directly are as follows: (1) 20 ppm odor starts to smell, (2) 25-30 ppm odor is getting clearer, (3) 40-60 ppm sharp odor, 70-100 ppm can cause nasal irritation, (5) 200 ppm can cause eye irritation. The developed systems was tested in a stable environment for 14 days. Data is recorded three times a day: morning, afternoon and night. The results of observing NH3 ammonia gas in the coop can be seen in Table 1.

| Day (i-th) | Ammonia concentration (ppm) |
|------------|-----------------------------|
|            | Morning | Noon | Night |
| 1          | -       | 101   | 99    |

Table 1. Results of ammonia concentration measurement using developed systems for 14 days.
3.5. Testing of telemonitoring and telecontrolling

The NodeMCU microcontroller used in this published research is equipped with an ESP 12E module that can be used for internet connection. To be able to connect to the internet, NodeMCU must be connected to a hotspot or router. Therefore the distance between the hotspot or router and the resulted system is very influential on the success of data communication since the bandwidth will decrease in accordance with the longer distance. The test results showed that the maximum distance of the hotspot with the device to stay connected is 20 meters with poor connection quality while the maximum distance for good connections is 10 meters.

In fact, in controlling fan and lights through the Telegram application on Android smartphone there is a delay between the time commands of the Telegram application was send and the actual time of lamp and fan turned on. The time delay occurs because the transmission depends on the quality of the signal from the hotspot / router to the resulted systems. In general, time delay also occur because the distance from the hotspot / router with the device is getting further, the longer the distance the longer time delay will be longer. The test results for 5 trials with the distance less than 10 meters showed that the time delay has an average of 34.6 seconds.

4. Conclusion

Based on the test data have been done, it can be concluded that environment monitoring system and control of chicken coop for temperature, humidity, ammonia (NH₃) gas level have been successfully developed and connected to Android smartphone. The test results showed that for the measurement of humidity the resulted system has an error of 0.337% while for the measurement of the temperature the tool has an error of 4.32% when compared with the results of measurements using a Thermo Hygrometer. Test of wireless data communication suggested that hotspots / routers must be a maximum distance of 20 meters from the resulted system so that data transmission and control can run smoothly. Monitoring and control using Telegram application was successfully implemented with the time delay of 34.6 seconds in average.

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