Precision Poultry Management Using Smart Sensors

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Abstract: Poultry is a crucial food-supplying sector that is growing at a rapid rate in India and in the world. To meet the increasing demand for poultry products there is a need to increase production by minimizing the loss. One of the ways to achieve efficiency in the production of poultry is by using sensors and automation. Automation in this sector is now emerging as an area of interest for many. Monitoring the farm conditions in poultry plays a major role in the process of automation. It is required to maintain suitable environmental conditions for better growth of chicks.We focus on the implementation of a low-cost sensor system that can enhance the efficiency of maintaining apoultry farm. In this article, we summarise a monitoring system for environmental conditions in a poultry farm usingsensors. This system enables real-time monitoring and data collection of key parameters such as temperature, humidity, air quality, etc. The chicken's growth is affected by various environmental factors such as temperature and humidity.

1 INTRODUCTION

The poultry industry has grown significantly over the years and the demand for poultry products has increased worldwide (Bosque et al., 2021). The world market for processed poultry meat was around $252.4 Billion in 2020. The demand for high-quality chicken meat has grown rapidly in recent years. By 2050, the demand for poultry meat would be 40% higher than current demand (Astill et al., 2020).

India is the third-largest producer of chicken eggs and the fifth-largest producer of chicken meat in the world. In 2019-20, India produced 8.86 MMT of chicken meat. In India, the demand for poultry meat is growing by 15-20%. The backyard market is growing at 6-7% and the chicken market at 8-10% per year. In 2020, the Indian poultry market was estimated to be worth more than $14 billion. In 2022, the market value of poultry in India was 28.18 Billion USD. The consumption of meat was found to be more than 4 MMT in 2022. In India, Tamil Nadu is the largest producer of chicken meat with a production of 467.51 HMT. The consumption of meat has also increased in the past years. To meet the growing demand all over the world, production must be maximized sustainably and efficiently. Producing good quality meat and healthy chicken has become an ideal business area for many. Environmental variation can affect livestock production systems (Sinha et al., 2017a). Certain parameters require consistent monitoring for optimized production (Corkery G. et al., 2013). Temperature, humidity, and ammonia are primary conditions to be monitored which can affect poultry production (Ahmadi et al., 2019; Kocaman et al., 2006). High temperatures can cause reduced feed consumption, lower body weight (Sohail et al., 2012) rough feathers, depression, weak legs and diseases such as heat stroke, New Castle disease, E. coli infection, and fowl cholera. High humidity levels can

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cause difficulty in breathing and vision (Hitimana et al., 2018; Mahale 2016). High Ammonia levels cause conjunctivitis and damage the eye cornea (Aziz and Barnes, 2010). Traditional poultry farming methods involve manual inspection, which can be tedious and time-consuming. The development of technology has made it possible to monitor and control the environment in a poultry farm. It can be done by using sensor technology. Sensors are electronic devices that can be used to measure or control various parameters in a poultry farm. Maintaining conditions such as temperature, humidity, ammonia, etc., requires accurate data from automation equipment such as sensors. The purpose of the study is wireless sensor technology (Sinduja, K et al., 2016). The sensor can give accurate information on the physical parameters specified. This information can be used to identify possible causes or mortality or poor growth or disease outbreaks in chickens. Thus we require a monitoring system for optimum production. Smart monitoring system helps in better understanding of poultry growth and health (Orakwue et al., 2022). This sensor technology or monitoring system helps find possible solutions to problems in a poultry farm either by automation or taking preventive measures manually. Proper ventilation (Sheikh et al., 2018) can be one of the ideal solutions for abnormal parameters such as temperature, humidity ammonia concentration etc., in the poultry farm.

2 REVIEW OF LITERATURE

2.1 Poultry Industry

Chatterjee et al. have compared the trends in egg production and per capita availability of eggs and found that the poultry industry suffered from major issues like a rise in the cost of feed, emergence of diseases, and lack in the prices of the eggs. The article also discussed the topic of feed resources and disease management by vaccination and other possible methods like surveillance and monitoring systems. To overcome the challenges in the poultry industry, increasing the adoption of small poultry farms in backyards will rapidly increase the economic status of rural people.

Mitra et al., 2021 stated that poultry farm provides 8.8% of employment in India. The poultry industry contributed 16% income of small farm households and 14% income of rural households. It also contributed 4.11% to the total GDP and 25.6% to the Agricultural GDP. The major constraint in the poultry industry was found to be a lack of basic infrastructure. So, a new system should be formed for maintaining the poultry farms, and the government should focus on naturally boosting the growth of the birds.

2.2 Challenges in Poultry Farming

Sridharan. 2017 mentioned the constraints in poultry farming were due to several factors. Farmers faced issues such as labor shortages, electricity, high mortality during the summer season, bird flu, etc. The outcome of the article was found to be the usage of the coal method of brooding as it was found to be economical and more available than electricity or gas. In the conducted study, 47.2% of farmers in Coimbatore managed their poultry farm with the help of family members mostly husband and wife without external labor, thus solving the labor shortage issues.

Rao 2015, found that the constraints in the poultry industry as the high cost of feed materials, outbreak of diseases, inadequate investments, limited access to the core market, disease control, and water and electricity-related issues. The nutrition-related environmental issues were also found to be major issues. The solution to overcome the challenges was to provide training programs and implementation of new policies to implement new scientific technologies.

Mitra et al., 2021, stated the impediments to poultry farming in India as the arsenic feeding to boost growth and weight, growth hormones, poor poultry practices, improper hygiene and management, lack of basic infrastructure, lack of transportation, lack of storage and marketing system as the major challenges in India.

Jeni et al., 2021, mentioned the constraints are due to environmental factors such as heat stress, etc. secondly predation, disease-causing pathogens, parasitic infestation, etc. These constraints resulted in heat stress and nutritional and dietary challenges in poultry farming.

2.3 IoT in the Poultry Industry

Orakwue et al., 2022, presented a systemusing the Internet of Things for monitoring environmental parameters such as temperature, humidity, and air quality. The designed system utilized DHT11, MQ135, and PIR motion sensors with ESP32 microcontroller with a buzzer. The system alerted the farmer by buzzer sound in case of any intruder. It also helped the farmer to turn the lightON or OFF by using the Blynk IoT application from anywhere.

Choosumrong et al., 2019, proposed a monitoring system for temperature, humidity, NH3, and light sensors and recorded the data in an SDcard-based Arduino data logger. Temperature and humidity were checked for the evaporative controller.NH3 and light for threshold values of 4.0 and 90% respectively. The proposed system alerted the farmersby SMS in case the ammonia and light exceeded the limit.

Goswami, et al., 2022, proposed anArduino-based system with Arduino UNO as a microcontroller and a DHT22 temperature humidity sensor for monitoring the temperature. It also has a fogger system to control the temperature if it rises toohigh. It also has an automatic feeding system which can be controlled by the farmers using a remote device.

Ayyappan et al., 2017, has used PIC16F877 as a controller and ESP8266 as a Wi-Fi module. LM35 sensor for temperature detection, SY-HS-220 humidity sensor, MQ6 for ammonia detection, and a fuel level sensor to measure water level in poultry farms. He used the level sensor for the automation of the DC motor automatically turning ON. He designed a system where if the water level reached below 1 liter the motor switched ON. In the case of the temperature, the cooling fan switched ON and for the humidity, exhausting fan switched ON.

Mansor et al., 2018, presented a smart system for poultry farms by using a Master-Slavemodule design. DHT22 temperature sensor andMQ135 gas sensor were used to monitor temperature, humidity, and ammonia levels. If the ammonia levelis near the fan zone, it triggers the fan system and pulls out the gas from the poultry farm. The article stated that the system was implemented in Myra farms & services and tested.

3 MATERIALS AND METHODS

This study focuses on integrating various sensor modules using a common microprocessor. The integration of the sensor is to sense the parameters and produce it in a single common platform. This system focuses on sensing Temperature, humidity, Ammonia, and Carbon dioxide as the primary parameters. It also measures smoke levels. Each parameter is sensed and measured in respective units such as ˚C, Fahrenheit, percentage, ppm, etc. The system is to be connected to a Wi-Fi to get the data. The data can be obtained in an IoT platform. It also enables us to get alert notifications and buzzer sounds in case any of the environmental parameter values is beyond the threshold level specified. Also, we use a camera module to monitor the farm visually. It can be monitored in a live stream website specified in the following topics using the IP address generated by the module.

3.1 Hardware

This system uses an ESP 8266 Microcontroller, DHT 22 Temperature and humidity sensor, MQ-135 air quality sensor, and ESP 32–Cam module.

ESP 8266 is the main processor of the system which receives processes and records the data in the device. It enables the user to connect to Wi-Fi to collect data and transfer it to any platform. It works on a 3.3 V input voltage. It uses a Serial Peripheral Interface (SPI), which is a short-distance communication interface. It is used in place of an Arduino board as a low-cost replacement.

DHT22 is a temperature and humidity recording sensor that has a higher accuracy than currently used DHT11 sensors. It gives output as a calibrated digital signal. It works in an input range of 3.3 V to 6 V. It can measure temperatures of range - 45˚C to 125˚C with an accuracy of ±0.5˚C. It can measure humidity from 0% to 100%. The unit oftemperature that can be detected using DHT22 is Celsius and Fahrenheit. The ideal condition fordetection is 20˚C ±2˚C and 65% humidity.

MQ135 is a gas-detecting sensor that candetect gases like Ammonia, Carbon dioxide, Sulfur, Benzene, Alcohol, smoke, and other harmful gases. It works on an input voltage of 5 V. It can give both analog and digital output. It is highly sensitive to Ammonia, sulfur, and Benzene. It can detect ammonia from a range of 10 ppm to 1000 ppm. It is a low-cost alternative for MQ137. MQ137 is specifically designed for industrial purposes which can detect up to a level of 5 ppm accurately and it is very expensive to buy and install.

ESP 32 camera module is used to here record the mobility pattern of the birds. It has a voltage regulator chip. It works on an input voltageof 5 V. It supports an SD card and has a holder in which we can save the data of video or image recorded. It also supports Wi-Fi image uploads and can also live stream the video using an IP address. It can also support face recognition features. We can adjust the resolution of the live stream. It helps to identify the health patterns of chicks. It can also detect the presence of any predators on the farm.

We used a buzzer connected to the ESP8266 board. It can produce alert sounds if any of the specified parameters is recorded abnormally. It can produce different sounds according to the frequency of electrical pulses it receives. It can produce a periodical beep sound as well as a continuous sound depending on the codes. We are using an electromagnetic buzzer in an input voltage of 5 V. The sound is produced through magnetism with a 2 kHz frequency.

A. ESP8266

B. ESP 32 cam

C.DHT22 Sensor

D. MQ135 Sensor

Figure 1 - Hardware devices used

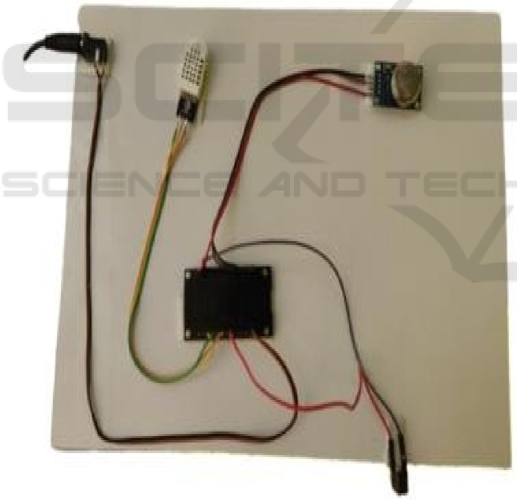

Figure 2 - Hardware setup of sensors

3.2 Software

This system uses the Arduino IDE platform for coding. We use C++ as the programming language in the Arduino IDE platform. Blynk IoT platform is used to get the data from the sensor system. Blynk creates a Graphical Interface by providing the data in widgets. It is an app that allows users to create custom interfaces for IoT devices, making it an excellent choice for monitoring poultry farm variables.

3.3 Methodology

To begin, the hardware configuration includes using the ESP8266 as the processor to link the MQ-135 gas sensor, which can detect various parameters such as ammonia, carbon dioxide, smoke level, benzene, alcohol, and so on, and the DHT22 temperature and humidity sensor. This can be accomplished by following the sensor pin-out circuit diagrams and attaching the relevant wires to the ESP8266 board in the right pins. In the early phases, jumper wires are utilized to test the sensors. The ESP8266 microcontroller requires an adaptor for a consistent 5 V supply. The Serial Peripheral Interface (SPI) pins, as well as the power and ground pins, can be used to link the ESP32-CAM to the ESP8266 board. The circuit diagram is given in Figure 3. It depicts the wire connections between the various components used for this system.

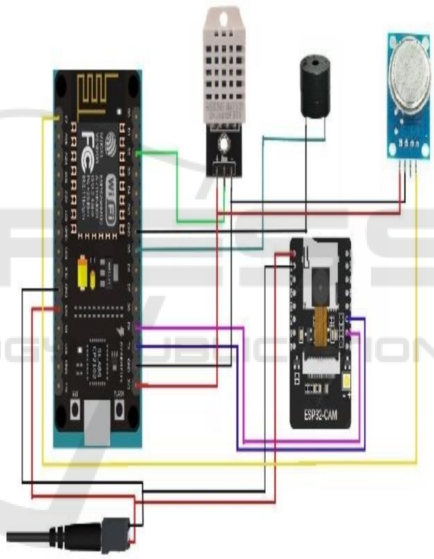

Figure 3 – Circuit Diagram

Once the hardware is in place, applications for data collecting and video streaming can be created. The Arduino IDE platform can code the ESP8266, and libraries can connect with the MQ-135 and DHT22 sensors. The ESP32-CAM can be programmed using the ESP-IDF, and libraries to interact with the camera can be utilized. After compiling and correcting any mistakes, the codes are submitted to the board. The code is executed, and the output is collected from the serial monitor port. The baud rate is set as 115200.

This system requires and utilizes a Wi-Fisystem. The ESP32 cam and the device should be connected in the same Wi-Fi for getting the live stream in a web browser using the IP address generated but the ESP32 cam in the serial monitor output.

The sensors are used in a poultry cage whichhad 160 chicks in it. The study was carried out till the chicken was sold. The sensors are attached inside the cage at a certain height to prevent damage caused by the chicks. The power source was made available for the sensor system and Wi-Fi module from a switch box attached just outside the cage. ESP8266 and Wi-Fi require a separate power supply which was given by a multi-pin holder. A 5V adapter was used separately for both ESP8266 and Wi-Fi.

One popular way to visualize the data collected from the sensors is to use the Blynk app. The data collected from the sensors can be sent to theBlynk app using the ESP8266's Wi-Fi connectivity, and the app can be used to display the data in a user- friendly format. Blynk IoT platform enables us to view current data and download previous data. It can also show the data graph of the parameters we use forup to 1-month duration. We can set the threshold limit and can enable the notification if the parameter value exceeds it. It allows the user to get the notification in mobile by vibrating and also sends a mail if opted. We can adjust the notification timer refreshing to avoid continuous alert messages. We can also get the live stream data by using a URL in a widget. It also enables a user to make further automations in the same Blynk platform. It supports multiple users using the same login credentials toaccess at the same time.

Finally, the ESP32-CAM can be used forvideo streaming, allowing farmers to monitor their poultry farms. The ESP32-CAM can be programmed to send video data to a server, which can then be accessed by the Blynk app or can be accessed by the IP address generated by compiling and running the code. The IP address can be obtained from the serial monitor port of the Arduino IDE platform at a baudof 115200. This feature can be particularly useful for monitoring the behavior of the birds, identifying potential health problems, and detecting anyenvironmental issues that may affect their growth. The working steps are expressed as a flow chart in Figure 4.

3.4 Threshold Values

To initiate the alert message system we have to feed the threshold values to the sensor system. The threshold values are tabulated in Table 1. The threshold values are set in the Blynk IoT platform. If the reading exceeds the threshold level, the application sends us an alert notification to the mobile. The alert messages and the readings of the parameters are given in Figure 5.

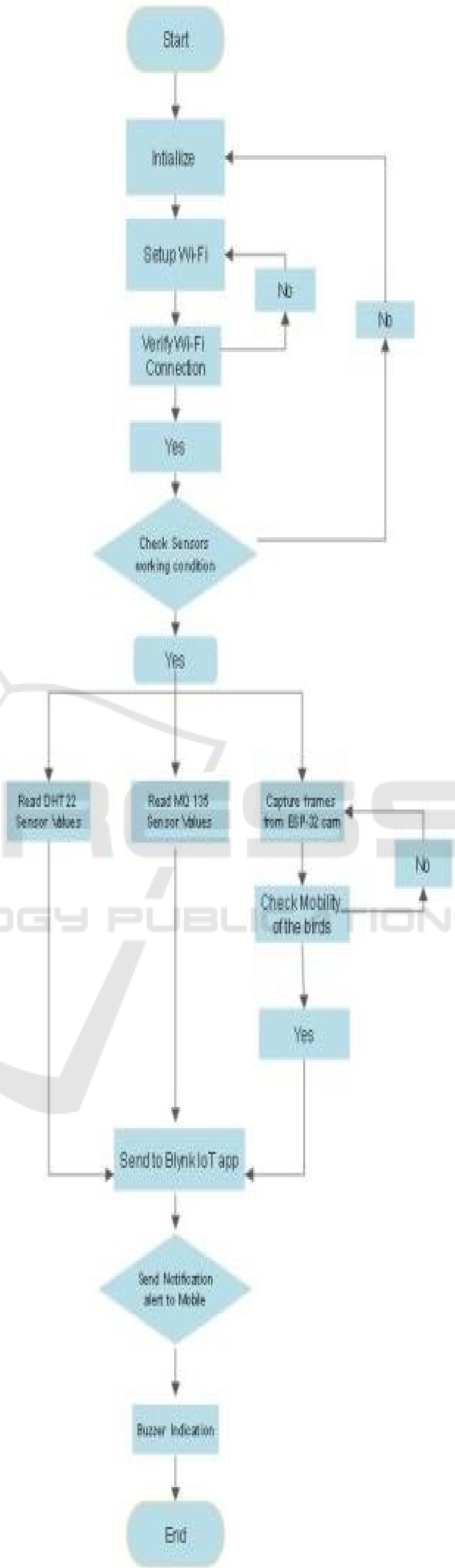

Figure 4 - The flowchart of the designed system.

Table 1 - Threshold levels of various parameters

Parameter	Threshold Range/Value
Temperature	35˚C
Humidity	80%
Ammonia Gas	25 ppm
Carbon dioxide	10 ppm
Smoke Level	5 pm

3.5 Application

The proposed system is cost-efficient. It can help in quick identification and address issues like spikes in temperature or humidity or ammonia or carbon dioxide levels. The system is easy to use and doesn't require deep knowledge. It can be used both in small-scale and large-scale farms. It also can be used in disease detection and management. The designed system helps in maintaining a suitable environment for better growth of chicks. The increased production of chicks and eggs thus generated higher income to farmers.

4 RESULTS

From the study, we present a system of sensors that can detect various important parameters such as Temperature, humidity, ammonia, Carbon Dioxide, and air quality. The study was carried out with 160 chicks in a cage system. The system can give alert messages via notification and mail. It can also produce sound from the buzzer attached to the microcontroller. This system is made of ESP8266 Processor and Wi-Fi. We can get the live video stream or images from the OV2640 website using the IP address. The data of specified parameters collected can be downloaded from the Blynk IoT platform. Data for one month can be downloaded from the Blynk platform. The data are downloaded in CSV file format which gives the readings of various parameters with time stamps. We can also monitor the parameters reading as a graph for 3 months. The minimum and maximum values for various parameters are found in this study and have been tabulated in Table 2. The temperature in the daytime time found to be more than 35˚C at most times and around 27˚C at night times. The minimum temperature recorded is found to be 21.29˚C and the maximum is 39.1˚C. The humidity recorded goes to a minimum level of 8.49% and a maximum of 92.5%. The ammonia level was recorded to be around 16 ppm (approx.). Figure 4 shows the alert notification message from the Blynk platform. The alert message shown in Figure 5 is due to the exceeded threshold level of parameters such as temperature and CO2. Figure 6 shows the parameter readings in the Blynk IoT Platform. The widget appears as a meter which shows the level in the specified unit. The temperature reading shows 35.7˚C which is higher than the threshold level. The humidity is recorded as 41.8% which is less than the optimum humidity level required. Parameters such as Ammonia level, CO2, and Smoke level are all below the threshold levels.

The sample data we derived from the Blynk IoT application can be seen in Figure 7. It shows the date and time in the first column, ammonia level (ppm), CO2 concentration (ppm), Temperature (in C and F), humidity (%), and smoke concentration (ppm) in the successive columns. Figure 8 shows the image of chicks in a cage captured from the ESP32 cam in the OV2640 website. The resolution of the video stream from the camera is 320 x 240 pixels.The resolution can be changed manually. Figure 9 depicts the Temperature graph during the period of study. We can see the variations. It rises above 34˚C during the day and falls below 27˚C during night time. Figure 10 shows the graph of humidity (%). Wecan see a rise in humidity during the night and a fall in humidity below 60% during the daytime. Figure 11shows the ammonia concentration (in ppm) as a graph. We can see that the concentration is observed to have very little changes in the range of 13-17 ppm (approx.). Figure 12 shows the variations in carbon dioxide concentrations as a graph which varies from 6-10 (ppm).

The overall minimum, maximum, and average values found in the farm are tabulated in Table 2.

Table 2 - Overall data from the Blynk IoT app

Parameters	Minimum Value	Maximum Value	Average Value
Temperature	21.29˚C	39.1˚ C	30.65˚C
Humidity	7.45%	92.5%	57.16%
Ammonia level	4.61 ppm	41.66 ppm	16.01 ppm
Carbon dioxide	1.39 ppm	86.2 ppm	7.75 ppm
Smoke	1.06 ppm	1.26 ppm	0.48 ppm

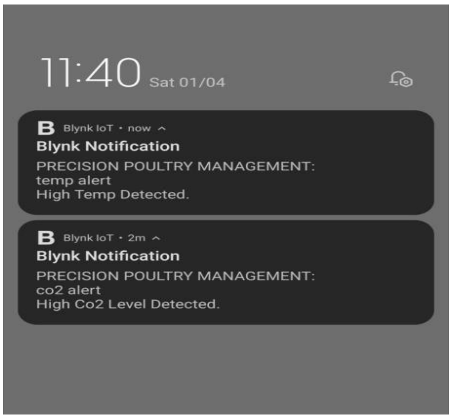

Figure 5 - Alert Message from the Blynk IoT app

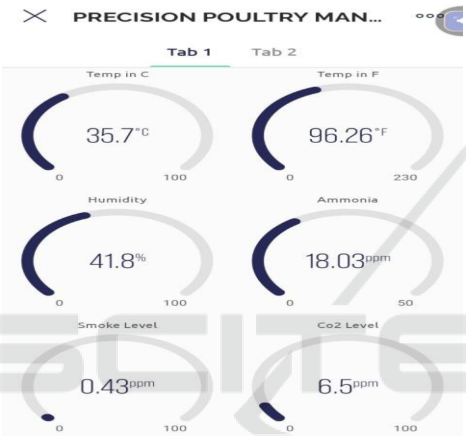

Figure 6 - Data of various parameters in Blynk Interface

Time	Ammonia Level	Co2 Level	Temp in Celsius	Temp in F	Humidity	Smoke level
4/10/2023 16:29	17.417	6.503	35.1	95.18	42.7	0.449
4/10/2023 16:28	17.62294444	6.50488889	35.06666667	95.12	42.561111	0.444055556
4/10/2023 16:27	17.587	6.66905556	35	95	42.394444	0.447777778
4/10/2023 16:26	17.825	6.43064706	34.86666667	94.74588235	42.323529	0.439222222
4/10/2023 16:25	18.03105882	6.34355556	34.68888889	94.44	42.5	0.436352941
4/10/2023 16:24	17.99694444	6.38911111	34.67777778	94.42	42.6	0.439111111
4/10/2023 16:23	17.37166667	6.55233333	34.91666667	94.85	42.744444	0.438722222
4/10/2023 16:22	17.655	6.57416667	35	95	42.7	0.4435
4/10/2023 16:21	17.587	6.55138889	34.98888889	94.98	41.077778	0.442888889
4/10/2023 16:20	17.57761111	6.48116667	34.87777778	94.78	42.344444	0.452166667

Figure 7 – Sample table of data from Blynk IoT app

Figure 8 – Image of poultry cage from ESP 32 Cam module

Figure 9 – Temperature Graph (in ˚C)

Figure 10 – Humidity Graph (in %)

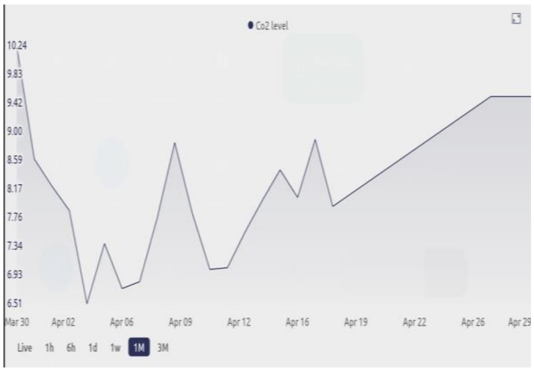

Figure 11 – Ammonia Concentration Graph (in ppm)

Figure 12 – Co2 Concentration Graph (in ppm)

4.1 Discussion and Conclusion

The designed system is cost-effective and can be easily affordable for the farmers. In past years, the environmental conditions in the poultry farm were not monitored properly. We all know that the environmental parameters in the poultry farm can affect the growth and health of the birds, it also affects egg production. If the environmental parameters are maintained properly, we can enhance egg production. We can also reduce the mortality of the birds. So, the designed system has the capability of monitoring the various environmental parameters and real-time monitoring of the birds through video streaming in the Blynk IoT app and it also as a feature of sending notification alerts to the poultry farmers if any environmental parameters are not in the optimum level. The designed system helps the farmers to understand poultry farming more easily and also improves the economic status of the farmers.

This is an innovative technology that has the potential to serve as a bridge in connecting traditional farming practices with modern automation techniques. It can change the previously followed management practices. Thus, it is an ideal system to monitor the growth of chicks continuously.

In this study, we have found that the temperature in this locality is much higher than the threshold values given in Table 1. Also, the humidity is very low and does not meet the minimumrequirement of 60%.

In the future, this system can be enhanced by the addition of automated intimation techniques and disease detection. This can also be extended to management practices like automated ventilation by fans. Automation by sprinklers in case of high temperatures or low humidity can be used.

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