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Development of an Automated Drinking System Using Microcontroller for Broiler Production

Debbie Butch R. Pequeña[1], Arthur L. Fajardo[2], Omar F. Zubia[3], and Roger A. Luyun Jr.[4]

[1]Instructor 1, Bicol University College of Agriculture and Forestry, Guinobatan, Albay, Philippines

[2]Professor 2, Agribiosystems Machinery and Power Engineering Division, Institute of Agricultural and Biosystems Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031 College, Laguna, Philippines (Author for correspondence email: alfajardo@up.edu.ph)

[3]Associate Professor 3, Agribiosystems Machinery and Power Engineering Division, Institute of Agricultural and Biosystems Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031 College, Laguna, Philippines

[4]Professor 1, Land and Water Resources Engineering Division, Institute of Agricultural Biosystems Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños, 4031 College, Laguna, Philippines

ABSTRACT

Although the broiler industry is one of the fastest growing industry in the Philippines, it still lacks automation on its production process. This study sought to develop an automatic drinking system for broiler production that can monitor, control, and record water quality and quantity as well as monitor and record selected environment parameters. The automated drinking system was designed using the Arduino microcontroller and other electronic components for initial and actual field testing. The initial testing included the calibration and determination of system functionality. After which, the system was tested for brooding and near harvest stage at a small broiler house set-up in San Rafael, Bulacan. Water quality parameters, such as the temperature, pH, and turbidity were monitored and recorded during the actual testing. On the other hand, results showed that the annual cost difference of broiler production favored the utilization of the automated drinking system, rather than of manual labor. The study recommends that the automated drinking system be tested to larger broiler houses, with an additional alarm system through GSM. Furthermore, monitoring and recording via the internet can improve the automated system.

Keywords: *Arduino, automated drinking system, broiler drinking system, microcontroller*

INTRODUCTION

The Philippine population is projected to increase to 142 million by 2049 according to Census-based population projections (Philippine Statistics Authority, 2018a). The rapid population growth produces a big challenge especially on the agricultural sector and this is to raise the overall food production enough for the growing population. The rapid population growth produces a big challenge especially on the agricultural sector and this is to raise the overall food production enough for the growing population.

The Bureau of Agricultural Statistics (BAS) and PSA (2018b) data showed that poultry is one of the most progressive animal enterprises today in the Philippines. From January to December 2018, poultry production increased by 5.75 %. Chang

(2007) stated that broiler meat is the most popular among consumers. However, amidst many of the achievements, broiler industry is facing challenges that require continuing innovation on production methods. The Philippine broiler sector is relatively uncompetitive because of higher input costs, low farm productivity, and inefficient marketing system. Without considering the large poultry business sectors, the development of technology was used to the conventional methods. In the present situation, manually refilled galloners were the source of drinking water in the poultry industry. The main problem with this method is that it requires a lot of manual labor and the feed and water supply is not guaranteed to be in ample amount and of good quality. Since water is important, not only should broiler producers exert effort to provide adequate quantity but also quality water that could help boost performance of broilers. Maharjam and Watkins (2016) stated that maintaining drinking water quality for poultry is an important nutritional aspect as birds consume water at twice the level of feed. Checking and monitoring the water on the broiler farm should be done on a regular basis to ensure that the adequate quantity and quality of water is available. In 2013, Tabler stated that a good quality water supply would be useless if birds cannot access it. Since water can have a huge impact on flock performance, it requires constant monitoring. The purpose of any broiler watering system is to provide sufficient water for optimum bird growth and efficiency. Therefore, the Philippine broiler industry must strive not only for greater efficiency but also enhanced production development through mechanization to survive and grow. An automated drinking system broiler production, which used Mechatronics, was developed to handle the problems in broiler production efficiency. Negrete (2018) stated that with the problems in traditional methods of farming and husbandry, the importance of automation to both small and large-scale agriculture should be considered. The use of mechatronic technology such as Arduino could play an important role. Aside from its low cost and versatility, it is an easy to apply technology. The output of the study could be a source material for building a system that would produce a standardized and mechanized broiler drinking system.

The main objective of this study was to develop an automatic drinking system for broiler production. Specifically, it aimed to design and develop the monitoring, recording, and control system for both water quality and quantity parameters and determine the performance of the developed automatic watering system through laboratory test, actual field test and simple financial analysis.

MATERIALS AND METHODS

The automated drinking system for broiler production (Figure 1) was composed mainly of the following: the water sources (the primary source and secondary or emergency water source), the water quality and quantity monitoring, controlling, and recording system (Arduino, LCDs, and other electronic components), the alarm system (buzzer and LEDs), the nipple drinkers, the environmental parameter monitoring and recording system.

A dual water source system was employed in the design of the automated drinking system. The primary source for most of the broiler production in the Philippines came from the tap water available in the area. In a dual-source, the secondary source will temporarily supply the water in case the primary source has issues with water quality and quantity. The secondary source shall have the appropriate water quality, which is purified water. Also, it will have the quantity to supply the water needed while resolving issues in case primary source is not available.

Temperature, pH, and turbidity were the water quality parameters considered in the design to be monitored, controlled and recorded. For the environmental parameters, relative humidity and temperature were considered. For this study, relative humidity and temperature in the broiler house were not included to be controlled. In the design of the water quality and environmental parameters monitoring and control system, the following were considered in the selection of components: reliability, practicality, simplicity, low-cost, available locally, and easy to install, operate and maintain.

Commercially available nipple watering systems for broilers were selected because it became very popular in recent years. Nipple drinkers minimize labor and appropriate for automation system.
Initial testing and actual field testing were conducted. Initial testing included calibration of the sensors using Arduino standards and the functionality testing at different conditions which include water quality and quantity. Percent difference was used to determine the difference in the values during the calibration of temperature, pH and turbidity sensors, liquid level indicator, and water flow meter. T-test was also used in the temperature sensors. The equation used for percent difference was:

$$Percent\ Difference\ (\%) = \frac{Abs(V1 - V2)}{\mathrm{Ave(V1, V2)}} X100$$

Equation 1

On the other hand, actual field testing included the 24-hour dry run and testing on broilers at the brooding and near harvest stage for four days each. The conventional broiler house setup was at San Rafael, Bulacan. About 30 broiler heads for brooding stage and 50 broiler heads for the near harvest stage were used. These broilers were provided with enough feeds and proper ventilation. Size of the house and number of nipple drinkers were adjusted according to the number of heads. Collection of data (temperature, pH, and turbidity) was conducted from ages 2 to 5 days for brooding stage and 28 to 31 days for near harvest stage. Since only one broiler house was used, testing was not simultaneous and testing for chicks took place first. Water samples during the brooding stage part had vitamins while withdrawal took place during the near harvest stage. In the actual testing, primary water source was tap water and secondary water source was purified water. Total water consumed was also monitored daily. All data on for each parameter were recorded on the data logger on a per minute basis to check if the recorded and obtained readings didn't exceed the set acceptable limits. The set acceptable parameters were the following: less than 36 ^{o}C for temperature, 4 – 8 for pH, and less than 5ppm for turbidity for both brooding and near harvest stage. For the actual testing, the minimum, maximum, and average data for temperature, pH, and turbidity during the 24-hour dry run, brooding stage, and near harvest stage were obtained.

Furthermore, a simple financial analysis was performed. The total cost of using the developed automated drinking system was compared to the cost of utilizing gallon containers for manual refilling.

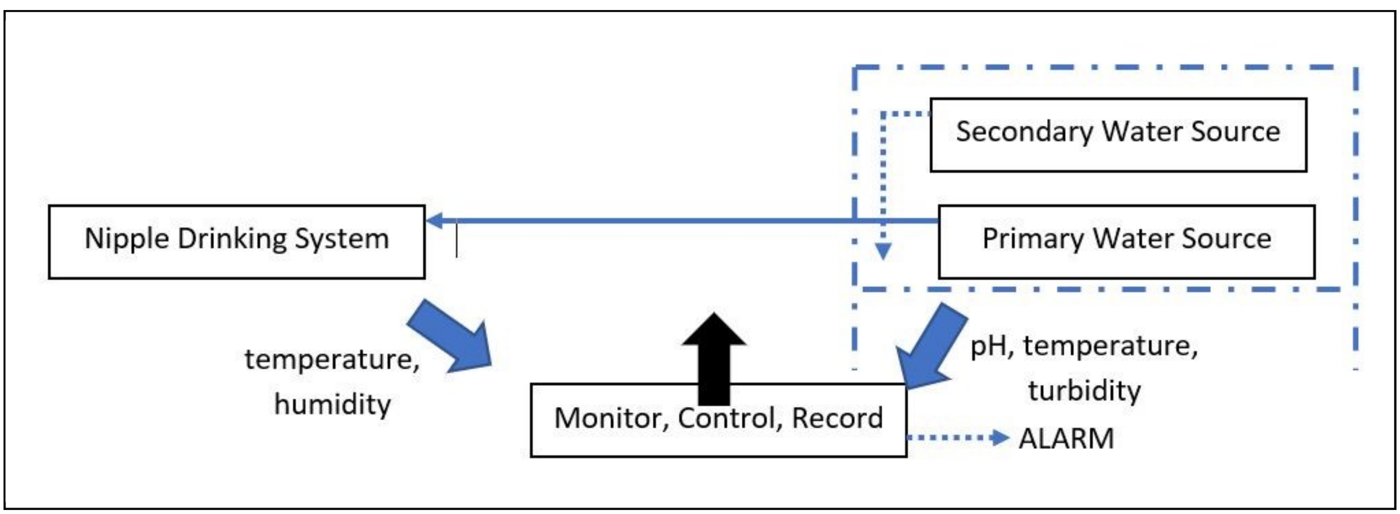


Figure 1. Schematic diagram of the automated drinking system for broiler production

RESULTS AND DISCUSSION

Components of the Automated Drinking System

The components of the automated drinking system are presented in Figure 2. The nipple drinkers used was a Qingdao Poultry Nipple Drinker. It is strong and durable and has a feather soft hi-flow nipple with one arm litter guard that could easily be connected to the pipe and water source. The microcontroller used and selected in this study was Arduino Uno. Aside from versatility, its cheap. It came with an open supply hardware features for developing own kit. DS18B20 was used and chosen as temperature sensor. It's a small temperature sensor with a built in 12bit ADC. To measure the alkalinity or acidity of the water samples, Arduino pH sensor was used. Arduino turbidity sensor was used to measure turbidity. It could detect the suspended particles in water by measuring light transmittance and scattering rate. Aside from being low cost, it could support continuous water quality monitoring. For measuring the water consumption and monitoring the amount of water on the primary source, water flow sensors and liquid level indicator were used. For the environment temperature and humidity monitoring, DHT 11 was chosen. DHT 11 is a basic and low-cost temperature and humidity sensor.

The buzzer is an Arduino active buzzer module with working voltage of 3.3 V to 5V, shock source, and sets of fixed bolt hole for convenient installation. Solenoid valves were installed for each water source. The Arduino solenoid valves were 2-way normally open, ½" 12VDC. The valve for the secondary water source is always closed. A water flow meter (for Arduino) was installed after the

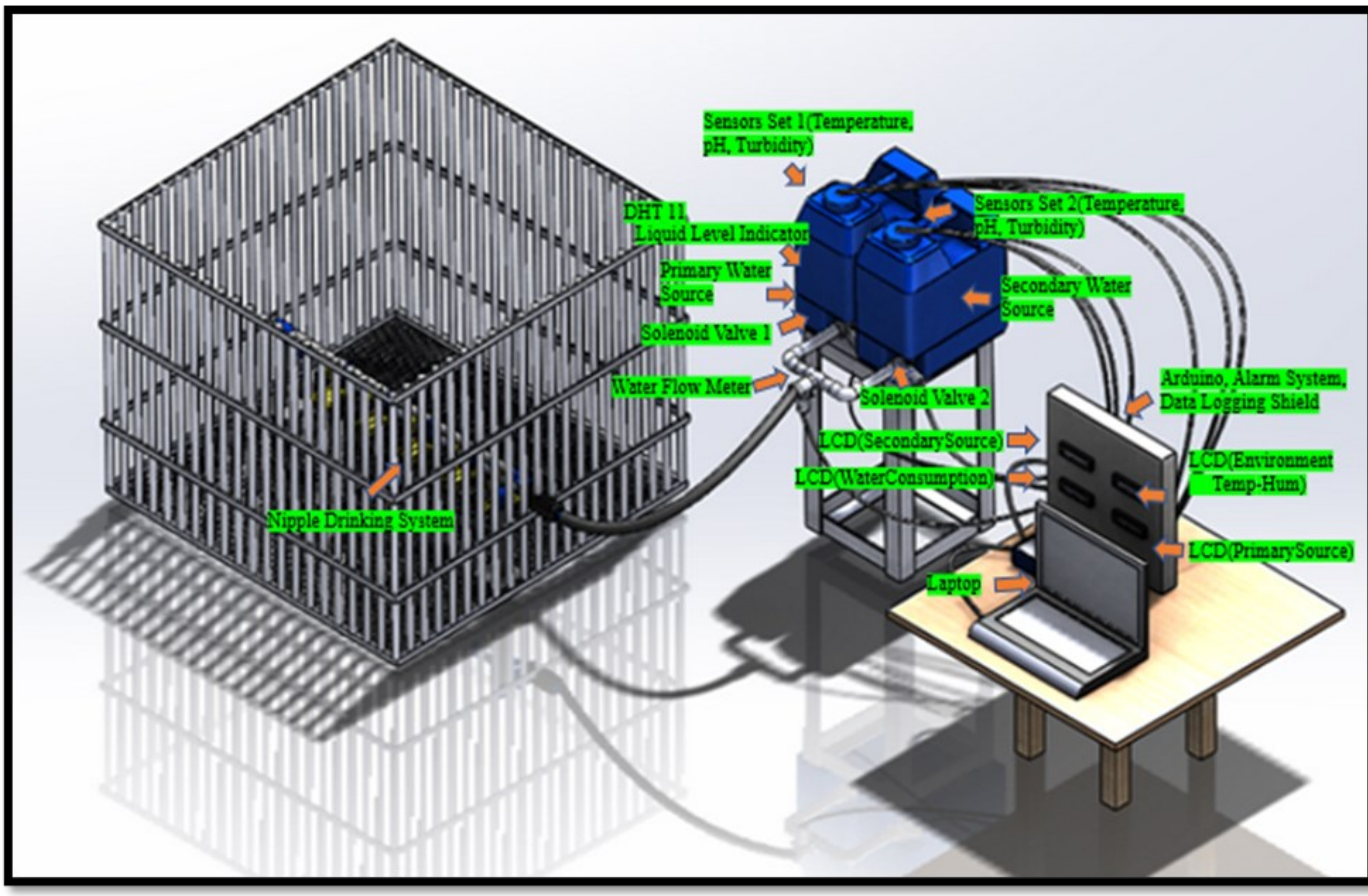


Figure 2. Designed automated drinking system for broilers.

solenoid valves before the water goes to the nipple drinkers. This water flow rate has a working voltage of 5 to 18VDC, can measure working flow rate in L/M or ml/s, and can measure up to 2.0 MPa maximum water pressure. Water level indicator (for Arduino) was installed at the primary water source tank to monitor water availability.

The Arduino board is then connected to different LCD to display the different parameters being monitored, controlled and recorded. All data recorded is saved in 32 GB micro SD card. The data stored could be downloaded in a laptop or desktop computer. The Arduino board and the LCD was enclosed in a plastic box.

Initial test

Initial tests were performed prior to the actual field test. The sensors for temperature, pH, turbidity, liquid level indicator, and environment parameters were calibrated. After which, testing of the primary system to different liquid samples were done. As per results, there were no discrepancies for both systems noted during the testing. Results are presented in Tables 1 to 3. The LED and buzzer turned on as per set parameters and code. The valves opened and closed according to the set parameters also. It was noted that considering the sample combination parameters for primary source system, accepted turbidity values recorded ranged from 3.13 to 1.88 ppm with corresponding output of 3.8 to 4 Volts. The range 3.10 to 3.20 Volts triggered the alarm system. Levels of turbidity above 5ppm result in

Table 1. Average percent difference of temperature sensors in hot water

SENSOR	AVERAGE PERCENT DIFFERENCE	P(T<=T) TWO-TAIL	P(T<=T) ONE-TAIL
Sensor 1	1.04%	0.425712	0.851424
Sensor 2	0.92%	0.44038	0.880759

Table 2. Average percent difference (pH sensors)

SENSOR	AVERAGE PERCENT DIFFERENCE
Sensor 1 (4.01)	1.91%
Sensor 2 (4.01)	1.24%
Sensor 1 (7.00)	0.71%
Sensor 2 (7.00)	1.70%

Table 3. Percent difference (turbidity sensors)

SENSOR	PERCENT DIFFERENCE
1	2.35%
2	2.35%

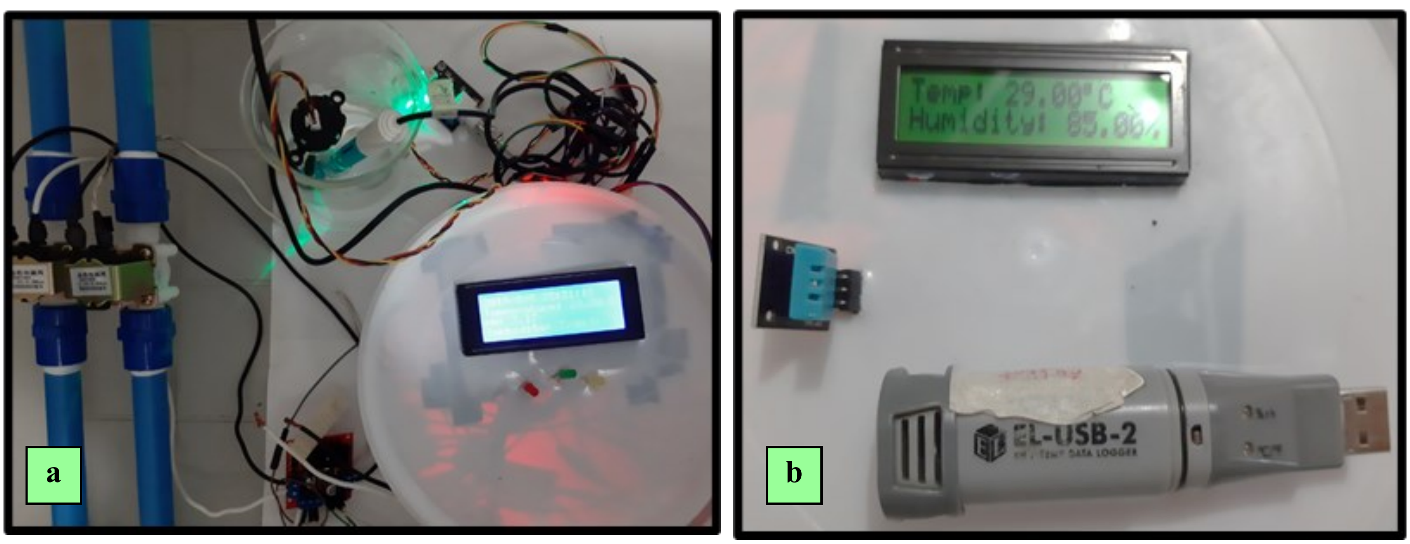


Figure 3. Initial testing of the system
(a) -Set-up for the water quality monitoring; (b) Set-up to monitor temperature and humidity)

unpalatable water and indicate contamination (Hess and Macklin, 2019). According to Jacob in 2015, broilers prefer water with a pH of 6.0 to 6.8 but can tolerate a pH range of 4 to 8. The solenoid valve will be closed and the valve for the secondary source will open. For secondary source system, the range 2.90 to 3.4 Volts triggered the alarm system. Also, the alarm will be triggered if the water level indicator's value is 0. The solenoid valve for the primary source will be closed and the valve for the secondary source will open.

As per initial results and obtained parameter values during the calibration and testing of the sensors, the systems functioned properly. This indicated the go signal for the actual field test.

Actual test

Before the broiler chicks were loaded to the broiler house, a 24-hour dry run was performed. This was to ensure that the system is ready and there would be no discrepancies. Figure 4 showed the actual set up and the broiler samples. The 24 – hour data collected is shown in Figures 5 and 6.

There were four days data collection for both the brooding stage and the near harvest stage. The graph for the data for the water parameters were shown in Figures 7 and 8 for the brooding stage and Figures 9 and 10 for the near harvest stage. The water supply during the study was enough since no record of 0 and alarms for the liquid level indicator. The water temperature data collected did not exceed limit. As seen on the graphs, the pH data collected during the study did not exceed the limit. Also, the data collected for turbidity did not exceed the limit. No discrepancies and alarms were reported during the data collection. The

Figure 4. Broiler house setup and broiler samples

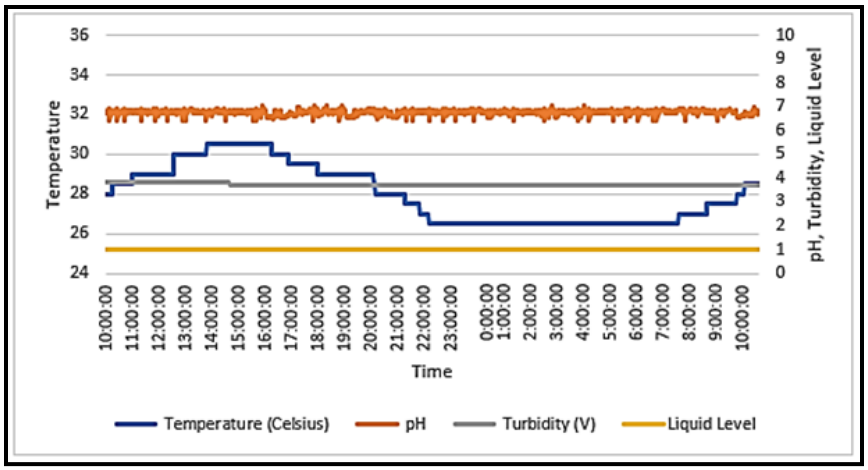


Figure 5. Dry-run data before loading of broiler (primary source)

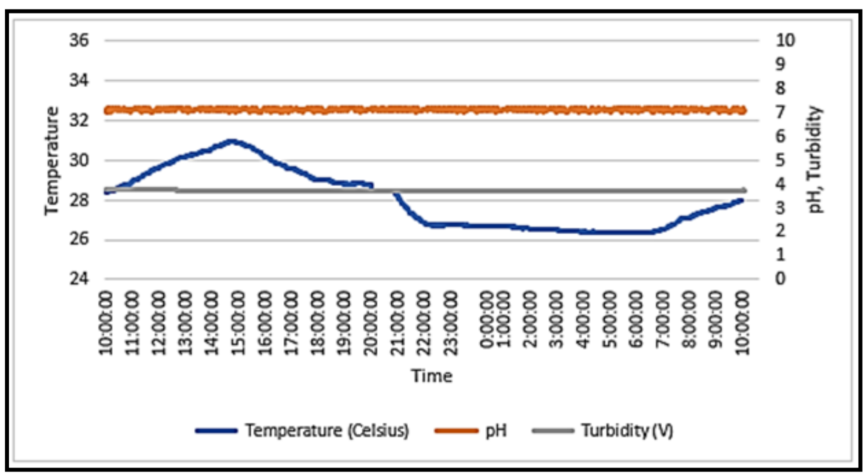


Figure 6. Dry-run data before loading of broiler (secondary source)

data loggers were able to collect pertinent data. Figure 11 showed the environment data. Considering the values of water quality parameters that were collected, safe water was supplied to the broiler.

Table 4 presented the summary of the minimum, maximum, and mean values for temperature, pH, and turbidity. As shown in Table 4, the values recorded using the sensors were within the range of the set parameters. Thus, the recorded values supported that there were no noted alarms during the data gathering for both the brooding stage and near harvest stage since the values obtained were within the limit set.

The amount of water consumed by broiler is very important since it gravely affects the performance of the flock. Low water consumption would indicate poor weights. Thus, the importance of water consumption monitoring was conducted. In this study, water consumption was recorded daily as summarized in Figure 12 and 13. Results showed average consumption of 0.13 L/chick

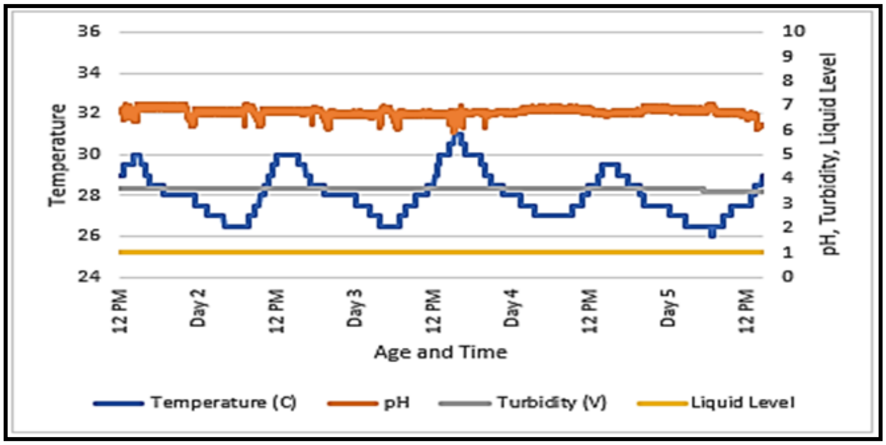


Figure 7. 4- day primary source water data during brooding stage

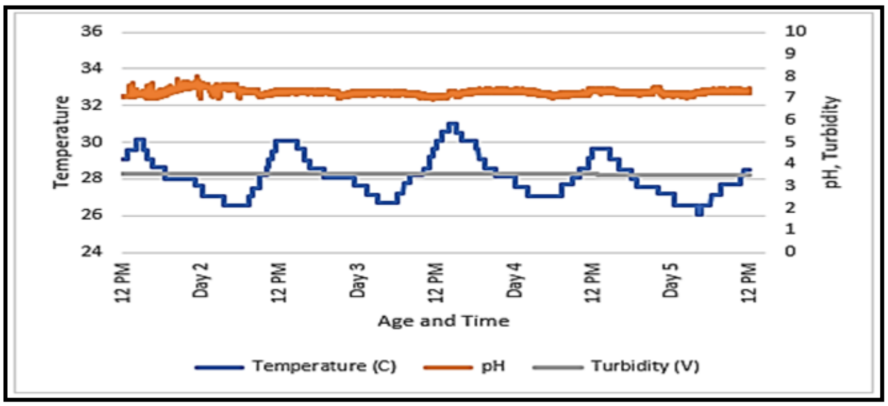


Figure 8. 4- day secondary source water data during brooding stage

Table 4. Summary of minimum, maximum, and mean values of temperature, pH, and turbidity

TEST	TEMPERATURE (C)			PH			TURBIDITY (V)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Primary Source: 24-hour dry run	26.50	30.50	27.98	6.41	7.05	6.76	3.70	3.80	3.72
Secondary Source: 24-hour dry run	26.37	30.94	28.06	7.00	7.22	7.11	3.70	3.80	3.71
Primary Source: Brooding Stage	26.00	31.00	28.03	5.92	7.09	6.74	3.50	3.60	3.59
Secondary Source: Brooding Stage	26.07	31.03	28.14	6.93	7.99	7.27	3.50	3.60	3.58
Primary Source: Near Harvest Stage	26.50	31.00	28.18	6.04	7.04	6.74	3.60	3.70	3.69
Secondary Source: Near Harvest Stage	26.58	31.12	28.29	6.94	7.97	7.26	3.60	3.70	3.69

during the brooding stage and 0.94 L/chicken during the near harvest stage. Average values of water consumptions were within the minimum and maximum water consumption requirement for broiler water consumption (www.poultrysite.com).

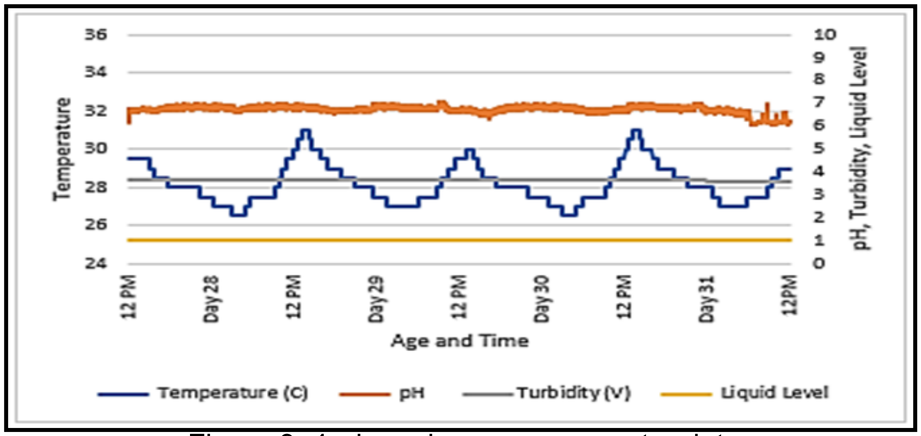


Figure 9. 4- day primary source water data during near harvest stage

Simple Financial Analysis

The drinking system was financially evaluated. Nipple drinking system and fountain drinkers were considered for automated and manual, respectively. One personnel for one broiler house was allotted for biosecurity purposes. For laboratory water quality testing, it was set that once a year testing will be done for the automated system and twice per grow for manual system. Other assumptions are presented in Table 5. The total cost of producing the automated drinking system alone was PhP 43,340.00. As per computed total costs, there was a difference of about PhP 190,963.00 in favor of the automated drinking system (Table 6).

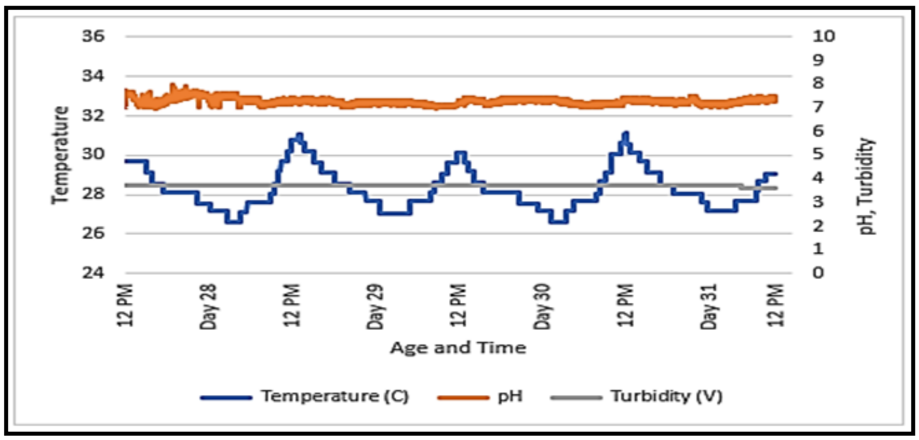
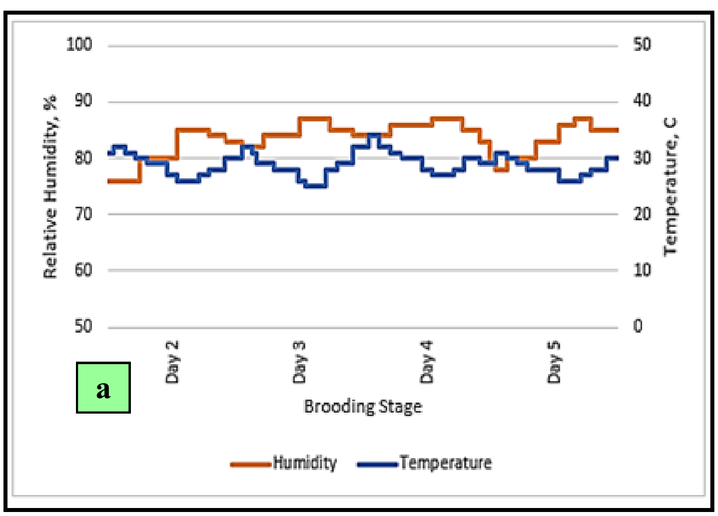


Figure 10. 4- day secondary source water data during near harvest stage



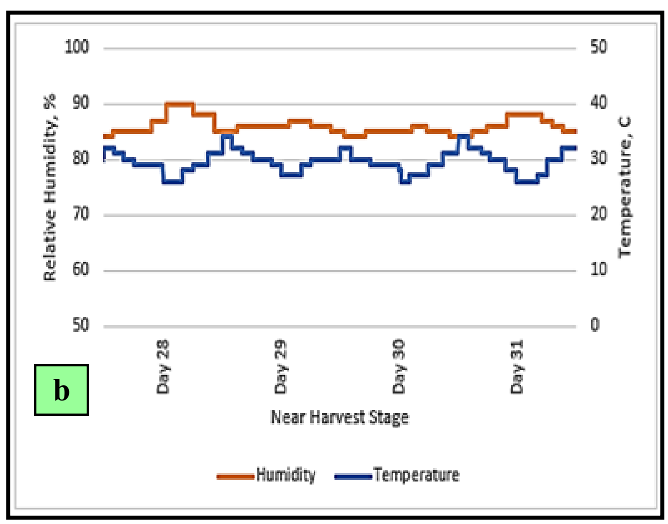


Figure 11. Environment temperature and humidity, (a) brooding stage, (b) right: near harvest stage

Table 5. Selected parameters and assumptions for the financial analysis

TYPE OF BROILER HOUSE	SMALL COMMERCIAL CONVENTIONAL
Wages (Maintenance/Flockman), PhP daily	350.00
Number of Heads inside the house	5000
Grows per year	9
Feed Conversion Ratio (FCR)	1.40-1.60
Livability, %	95
Price of chicks per head, PhP	20.00
Target Liveweight, kg	1.6
Price of liveweight (PhP), per kg	87.00
Starter Feeds	20 bags/thousand; PhP32.00/kilo
Grower Feeds	30 bags/ thousand; PhP25.00/kilo
Electric Consumption, per Kw in php	10
Electricity Bill, per grow	
a. Brooding 7W Light, 24 hours for 7 days on, 50 pcs (PhP)	588.00
b. After brooding 7w Light, 18 hours for 24 days on, 50 pcs (PhP)	151.20
c. Automation	667.56
Water bill	PhP 216.15 per 500L
Growing period	5500L/thousand birds
Cleaning Time	10,000L
Simple Raw Water Quality Testing as per LARC, PhP	7,300
Repair and Maintenance Cost	10% of Initial Cost
Tax and Insurance	12% of income

CONCLUSION AND RECOMMENDATIONS

The developed automated drinking system was able to monitor, control, and record water quality and quantity data during the initial and actual field tests with no discrepancies and alarms, hence, water quality data were within the expected and set limits. Enough and good quality water were supplied to the broilers throughout the duration of tests. The surrounding environment temperature and humidity data were monitored and recorded as well. The annual cost difference of broiler production favored the automated drinking system over the conventional

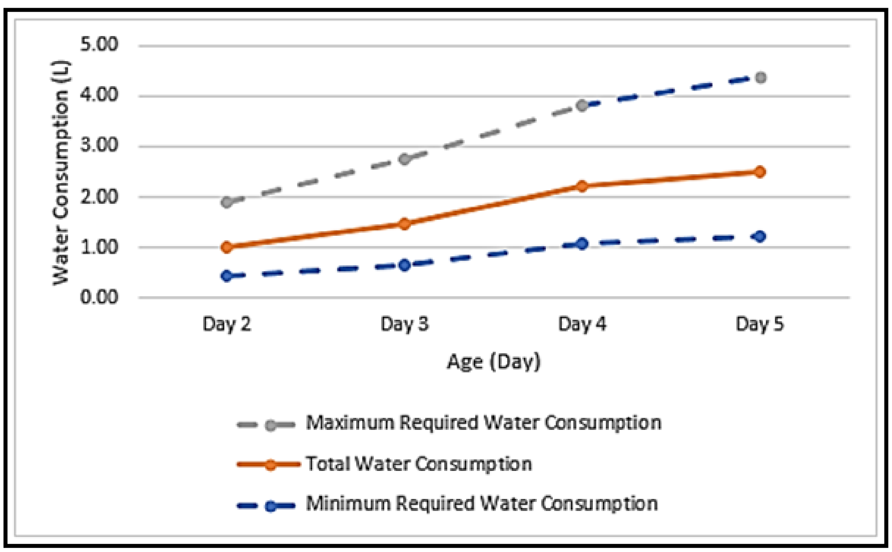


Figure 12. 4-day water consumption (brooding stage)

system; thus, the use of automation could be considered in small broiler production in the Philippines.

To further improve the study, it is recommended that the automated drinking system should be tested on bigger broiler houses. Furthermore, an additional alarm system through GSM could also be considered. Lastly, monitoring and recording thru the internet could help improve the system.

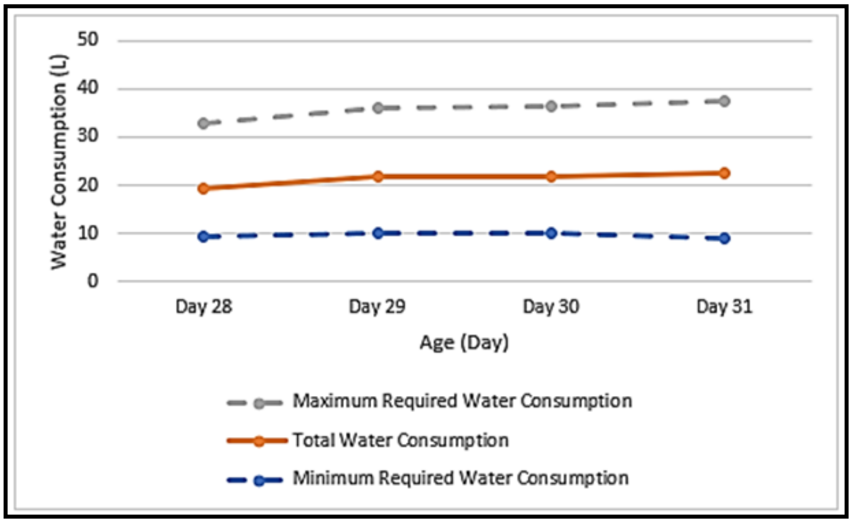


Figure 13. 4-day water consumption (near harvest stage)

Table 6. Yearly broiler production cost of automation vs manual

ITEM	AUTOMATED, PhP	MANUAL LA-BOR, PhP
Drinking System	43,340.00	20,000.00
Total Chick-in price	900,000.00	900,000.00
Feed Consumption	3,127,500.00	3,127,500.00
Electricity Bill	12,660.84	6,652.80
Water Bill	14,590.13	16,049.14
Personnel's Wages	138,600.00	138,600.00
Water Quality Testing	7,300.00	131,400.00
Total Chick-in price	4,243,990.97	4,338,742.93

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