International Journal on Food, Agriculture, and Natural Resources

Volume 04, Issue 04, Page 62-69
ISSN: 2722-4066
http://www.fanres.org

Original Paper

Design of an E-Nose Detector for Contaminated Gas in Cow Farming Waste

Andrew Setiawan Rusdianto[1], Winda Amilia[1], Laila Adhani Putri Malik[1]*

1) *Faculty of Agricultural Technology, University of Jember 68121, Jember, Indonesia*

*) *Corresponding Author: andrew.ftp@unej.ac.id*

Received: 14 August 2023; Revised: 13 December 2023; Accepted: 23 December 2023
DOI: *https://doi.org/10.46676/ij-fanres.v4i4.213*

***Abstract*— Cattle farm waste is organic waste produced by the livestock industry in the form of feces and can emit gases that cause air pollution. Cow dung contamination can cause environmental problems, disturbing humans and livestock. Hazardous gases produced from the decomposition of livestock manure, namely methane (CH_4), sulfur dioxide (SO_2), ammonia (NH_3), and hydrogen sulfide (H_2S), can cause respiratory diseases, deplete ozone and contribute to the greenhouse effect. Based on these problems, measuring gas levels using an Electronic Nose (E-Nose) tool capable of detecting harmful gases in livestock pens is necessary. The E-nose is a device that mimics the human nose and consists of several gas sensors that can detect environmental odors. The design of the detection and measurement of toxic gases using an electronic nose in this study adopts the Internet of Things (IoT) concept using the Arduino Uno and ESP8266 microcontrollers and MQ-4, MQ-136, and MQ-137 gas sensors to read levels of pollutant gas in units of ppm with an average of 46.25 ppm for the MQ-4 sensor, 1.86 ppm for the MQ-136 sensor, and 4.97 ppm for the MQ-137. The sensors were subjected to functional tests consisting of validity testing, resulting in a calculated r value of 1, meaning that ea^{ch} gas sensor performs its measurement function correctly or validly. The reliability test of the MQ-4 sensor is 0.00, the MQ-136 sensor is 2.442× 10^{-15}, and the MQ-137 sensor is 1.554× 10^{-15}, which means that the data reading from each gas sensor is unstable, less accurate, or unreliable compared to secondary data. However, the designed E-Nose tool can work well and improve farmers' performance in their daily work.**

Keywords*— *E-Nose, cattle farm waste, Internet of Things

I. INTRODUCTION

One of the industrial activities that produce organic waste is animal husbandry. Livestock waste is a product of the livestock business, whose existence is unwanted. Livestock waste consists of many types according to the livestock that produce it. Cattle farming produces waste in feces, urine, grass clippings, straw, leaves, bran, and concentrate [1, 24]. According to [2], cow dung contains methane gas which produces greenhouse gas emissions, thus affecting ozone damage and the health of cattle breeders. Cows produce more methane than sheep and goats. According to [3], an estimated 18% of global greenhouse gas emissions are caused by the livestock industry. Cattle farm waste also produces several gases, including ammonia (NH_3), carbon dioxide (CO_2), and hydrogen sulfide (H_2S), which can cause health problems for farmers.

Hydrogen sulfide gas (H_2S) released into the air will produce an unpleasant odor and decrease ambient air quality. According to [4], hydrogen sulfide gas is a colorless, highly toxic, flammable gas with a characteristic rotten egg odor. In addition, there is also ammonia (NH_3), a colorless gas with a strong odor and is corrosive. The potential danger of harmful gases from livestock manure in society is often overlooked. High levels of hydrogen sulfide gas reaching levels of more than 25 ppm can directly cause a person to lose consciousness or faint and ammonia levels above 50 ppm can cause eye and nose irritation, throat irritation, coughing, chest pain, to shortness of breath. With this limitation, it is necessary to measure gas levels with a tool capable of detecting the presence of harmful gas contamination in cattle pens. It is done so that humans can avoid gas contamination and clean the cage if it exceeds the safe limit of gas that can be inhaled.

Electronic Nose (E-Nose) is a detection and measurement tool for hazardous gases consisting of several gas sensors with the function of detecting an odor or aroma that mimics the structure of the olfactory nerve assembly in the human sense of smell, safe to use, portable and therefore more efficient to help detect contamination that smells in the environment. The Electronic Nose contains various receptors that can identify odors, and their function will be replaced by sensors later [5, 25]. The development of the Electronic Nose generally uses a microcontroller as a digital and analog information processor that connects all physical objects to the internet to communicate and exchange data and will become information for users called the Internet of Things (IoT) concept [6]. This Internet of Things (IoT)-based toxic gas detection and measurement uses an Arduino Uno R3 microcontroller ATmega328P with ESP8266 Wi-Fi, a methane gas sensor MQ-4, a hydrogen sulfide gas sensor MQ-136, and an ammonia gas sensor MQ-137. The design of the Electronic Nose aims to reduce odor contamination in the cattle barn environment to minimize the possibility of respiratory disease outbreaks.

II. MATERIALS AND METHODOLOGY

A. Required Materials

This research was conducted at UPT. Pembibitan Ternak dan Penghijauan Pakan Ternak Dinas Ketahanan Pangan dan Peternakan Kabupaten Jember. This research will use tools, namely Laptops, Arduino IDE, Microsoft Office Word and Microsoft Office Excel, SPSS, Fritzing Software, Sketchup Software, Visual Studio Code, Blynk Applications, Hosting + Domain, MySQL, Mifi, and Stationery. The materials to be used in completing this research are Cow Manure, Arduino Uno R3 Wi-Fi ATmega328P with ESP8266, MQ-4 Sensor, MQ-136 Sensor, MQ-137 Sensor, Jumper Cable 10 cm – 20 cm, Breadboard, experimental box made of acrylic, Buzzer, LCD 20 x 4, Socket and Computer fan 8cm 12V.

B. Research Stages

Research on the design of the Electronic Nose for measuring gas levels in livestock waste has two research stages, namely the system design stage and the results and analysis stage. The system design stage consists of hardware design, program design, and system testing. The hardware design is carried out by designing an instrument utilizing a microcontroller-based sensor to obtain a real-time recording of information on the amount of polluted hazardous gas around the cattle barn. This instrument is packaged in a test box made of acrylic measuring 20 cm x 20 cm, which is equipped with an LCD to display the sensor output and a buzzer at the top of the test box for a warning sign if the gas detected exceeds the threshold. There is also an 8 x 8 fan that draws air on the back side and on the front, there is an air vent measuring 18 cm x 6 cm as a place for air to escape as presented in Fig.1.

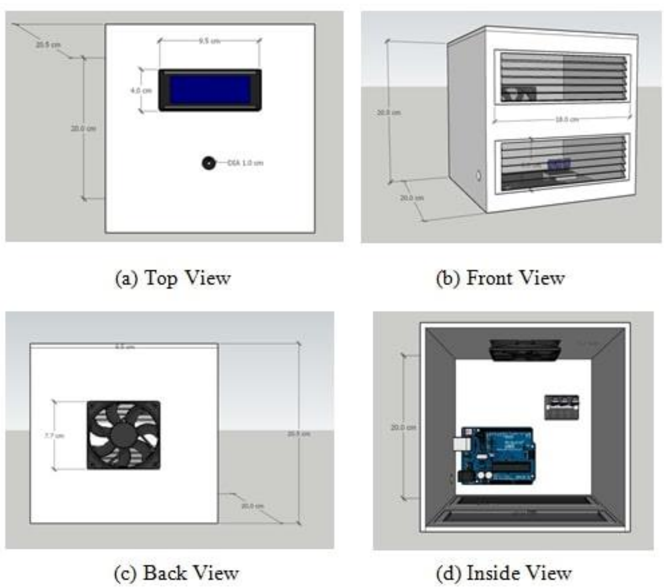


Fig. 1. Design of E-Nose

Inside the experimental box is a whole series of each module, such as the MQ-4, MQ-136, MQ137, LCD, and buzzer sensors connected to the Arduino with the help of a breadboard as presented in Fig.2. The MQ-4, MQ-136, MQ-137, and LCD sensors have four pins, two of which are VCC which is connected to the Arduino 5V pin, the GND pin, which is connected to the Arduino GND pin, and the other two pins, which are connected to the Arduino analog and digital pins. The buzzer has two pins, the positive pin, which is connected to the Arduino digital pin, and the negative pin, which is connected to the Arduino GND pin. The whole series of Arduino Uno R3 WiFi Atmega 328P with ESP8266, which USB connects as a microcontroller, will read the analog results from the sensors MQ-4 (methane gas), MQ-136 (hydrogen sulfide gas) and MQ-137 (ammonia gas) then converted to digital then ppm. The converted data is printed by the LCD and used as a reference for the buzzer to turn on or off, and then the data is sent to Blynk and the web server and stored in the database with detailed operational diagrams for the E-Nose device.

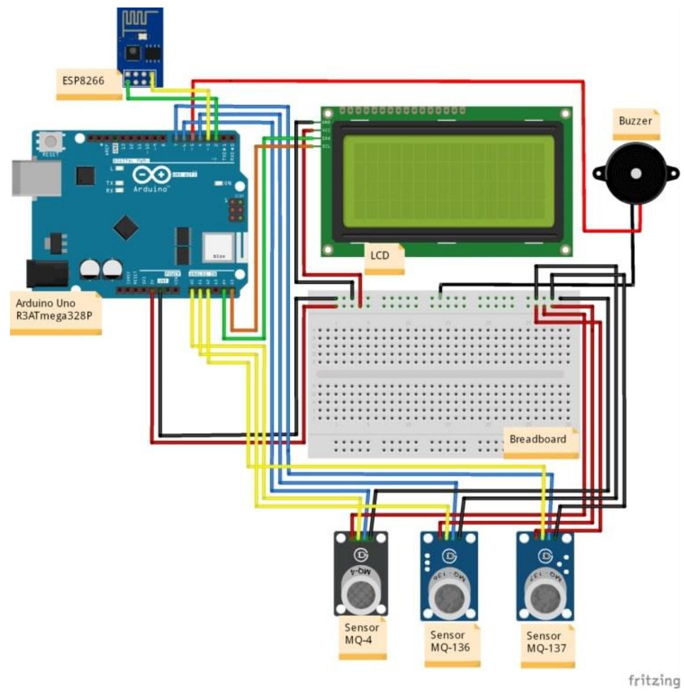


Fig. 2. Schematic of the E-Nose circuit

The operational design of the E-Nose program can work as planned. Designing the microcontroller, Blynk, and web server programming is necessary. Microcontroller programming is done in Arduino IDE software using several libraries, which are compiled into binary code and uploaded to microcontroller memory. Blynk programming is done on a smartphone using the downloaded Blynk application by logging in, adding a template named "Electronic Nose" and creating a Blynk display using 3 Gauge widgets with Virtual Pins.

Web programming is done by uploading the PHP and HTML programming languages to the hosting, which contain commands to receive data from sensors sent by ESP8266 and commands to store sensor data in the MySQL database as well as commands to display data from the MySQL database to the user interface in the form of HTML. The next stage of system design is system testing, which is carried out to determine whether the designed tool works according to the research concept carried out before implementing the Electronic Nose tool in the field to reduce errors and ensure the output produced is as expected. In the first system testing stage, functionality validation performance testing by implementing the functionality of each system component using the blackbox testing method. The blackbox testing process is done by trying programs that enter data in each form. Then the number of functional features running well is calculated and compared with all existing functional features.

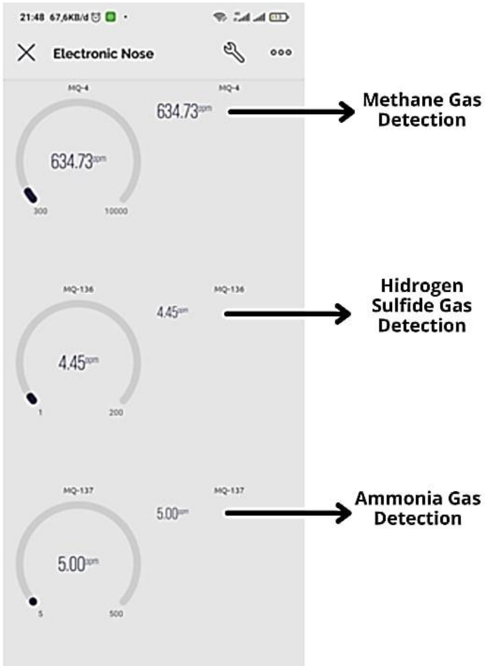


Fig. 3. Blynk programming view

Testing the system that is running well, the next step is to conduct field testing by implementing the E-Nose device at the UPT. Pembibitan Ternak dan Penghijauan Pakan Ternak Dinas Ketahanan Pangan dan Peternakan Kabupaten Jember for one week. Field testing scenarios for measuring gas levels in livestock pens were carried out by placing the device in the livestock pens for 2 hours with variations in placement at a height of 30 cm, 60 cm, and 80 cm in four different positions as presented in Fig.4. The functional test carried out in this study was the calculation of validity and reliability tests using two data variables, namely standard ppm and measured ppm for each sensor. The validity test was carried out to determine the accuracy of each sensor in carrying out its measuring function. In contrast, the reliability test was used to measure the stability of each sensor in measuring (reliable).

The next stage is the results and analysis, which consists of analyzing performance test data, implementation data analysis, and functional test results. At the data analysis stage, the performance test is carried out to determine the error rate of the designed tool, then proceed with data processing and analysis. Testing the functionality aspect uses the Guttman scale as a measurement scale used for definite and consistent answers, namely Yes or No. According to [7], the calculation for the functionality aspect is used to analyze the data from the functionality test. In this analysis, variable A is the number of instrument items that answered "No" or has a value of 0. Meanwhile, variable B is the number of instrument items that answered "Yes." Alternatively, it has a value of 1. The functionality value is good if X is close to 1.

In the analysis stage, the data on implementing the Electronic Nose device in livestock pens are stored on the database server and then displayed on the Blynk application and website. The data obtained is then carried out by analyzing the suitability of the tool designed with the real conditions in the field and, finally, the functional test results. Functional test results are calculated for the validity value by inputting the measured ppm variable resulting from the MQ-4 sensor, MQ-136 sensor, and MQ-137 sensor with standard ppm obtained from secondary data, then calculating the reliability value calculated using SPSS software.

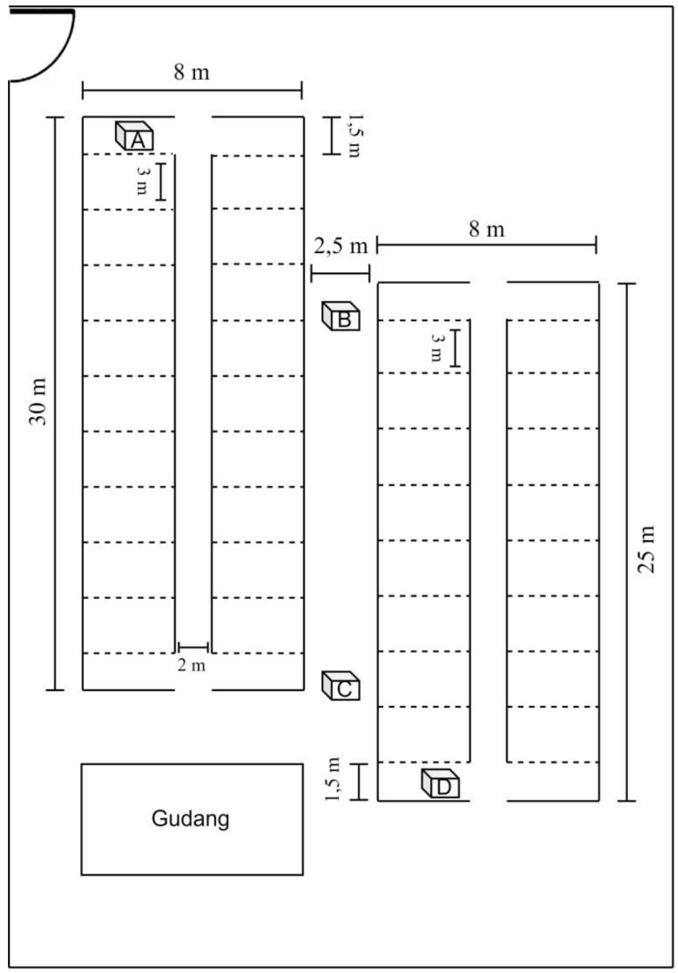


Fig. 4. Variations position layout of the E-Nose tool

III. Results and Discussion

A. Program Design Results

The microcontroller used in the tool design is Arduino Uno R3 ATmega328P with ESP8266 which is an Arduino UNO combination that combines the ATmega328P microcontroller, the ESP8266 module, which supports Wi-Fi 802.11 b/g/n 2.4 GHz for wireless networks, the CH340G USB-TTL converter with 5V power and 500mA, 32 Mb flash memory, 9-24 volt VIN DC Jack ports and 6 analog pins and 14 digital I/O pins on a single board [8]. According to [9], Arduino Uno R3 Wi-Fi

ATmega328P with ESP8266 has eight switches to choose from 4 possible switch modes.

The microcontroller is programmed using the Arduino IDE by entering a C language program into the microcontroller to function according to instructions. Several libraries, such as Software Serial, ESP8266HTTP Client, and BlynkSimpleEsp8266, are added to the program so the microcontroller runs properly. The library sends MQ sensor readings from Arduino to NodeMCU, then sends them to the Blynk website and application. Connecting the microcontroller to the website and the Blynk application requires code input, including the website hostname or domain name, Blynk auth, Wi-Fi SSID, and Wi-Fi password.

Some program code on the microcontroller functions to regulate the reading process using the analogRead function, conversion using the adc and ppm functions, presenting data to the LCD using the lcd.print function, and sending data to a web server and database using the digitalWrite function according to research needs. The program code declares the ppm safe threshold and the buzzer current connection as an over-high ppm warning. Next, the MQ sensor reading program code is converted from analog to ppm units. After the conversion process, the next program code is generated to send the converted data to the Arduino Uno R3 ATmega328P with ESP8266 microcontroller and displayed on the LCD.

```
void loop(){
  //baca hasil sensor analog
  MQ4OutA = analogRead(pinMQ4A);
  MQ136OutA = analogRead(pinMQ136A);
  MQ137OutA = analogRead(pinMQ137A);
  //Konversi dari analog ke adc/vrl lalu ke ppm
  float ratioMQ4 = ratio(adc(MQ4OutA), RLMQ4, ROMQ4);
  float ppmMQ4 = ppm(ratioMQ4, mMQ4, bMQ4);
  float ratioMQ136 = ratio(adc(MQ136OutA), RLMQ136, ROMQ136);
  float ppmMQ136 = ppm(ratioMQ136, mMQ136, bMQ136);
  float ratioMQ137 = ratio(adc(MQ137OutA), RLMQ137, ROMQ137);
  float ppmMQ137 = ppm(ratioMQ137, mMQ137, bMQ137);

  //convert ke string
  skorMQ4 = String(ppmMQ4);
  skorMQ136 = String(ppmMQ136);
  skorMQ137 = String(ppmMQ137);

  //kirim ke esp8266
  String send = ""; send += ppmMQ4; send += ";"; send += ppmMQ136; send += ";";
  send += ppmMQ137; send += ";"; send += ratioMQ4; send += ";"; send += ratioMQ136;
  send += ";"; send += ratioMQ137;

  ss.println(send);

  delay(10000);
}
//function convert dari analog ke digital/volt
```

Fig. 5. Arduino IDE application programming

The converted data is received by the Arduino Uno R3 microcontroller ATmega328P with ESP8266 and is continued by sending the conversion data to the web server to be stored in the MySQL database and the Blynk application to be monitored in real-time. The program code on the web server is made to receive data from the Arduino Uno R3 ATmega328P with ESP8266 microcontroller, store data in the MySQL database, and read data from MySQL which is then displayed on the website. Making the program code using the Visual Studio Code application and then uploading it to Hosting.

B. *Design Results of E-Nose Detector of Contaminated Gas in Cattle Farm Waste*

E-Nose is designed to detect air pollution from the impact of cow dung, which refers to the overall design of the sensor components and their modules. The E-Nose design process was carried out before the testing phase by implementing it in a cow pen packaged in an acrylic-based experimental box with a side length of 20 cm x 20 cm. At the front of the experimental box, there is a fan that functions to suck air in so that it passes through the sensor and will flow out through the ventilation holes at the back of the experiment box. At the top of the test box is an LCD module measuring 20 x 4 to make it easier to read data and a buzzer to give a warning signal.

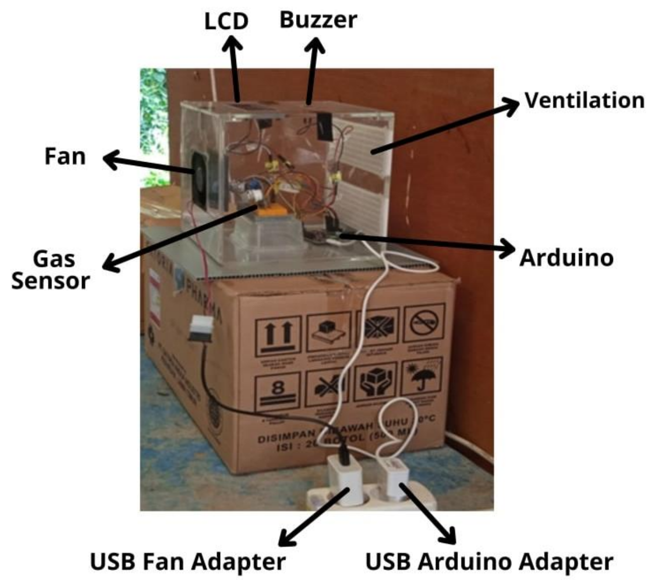


Fig. 6. Overall Monitoring System Design

Based on the design that has been done, the results of the performance of interconnected components, namely the Arduino Uno R3 ATmega328P with ESP8266 microcontroller, will give a yellow LED light. It indicates that the microcontroller has received power from the power supply and has been connected to the Wi-Fi network. Sensor reading data will be displayed directly via the LCD screen and wirelessly via the Blynk application and website. Suppose the microcontroller and the Blynk application are connected. In that case, an online notification will appear on the Blynk application display. Then when the microcontroller is connected to the website, it will display data from the microcontroller that has been stored in the database at certain time intervals in the table on the website.

C. *System Testing Results*

1. Tool Performance Test

The tool's design will be tested for performance to ensure it can play a role according to its function so that sensor data readings can be recorded and presented on the data presentation component. Performance tests were carried out before implementing the tool in the cowshed. If there are components that do not work in the tool performance test, repairs can be made by repairing the circuit or cable connections. In this study, a functionality validation test was carried out on each module of the E-Nose series. The results of the functionality validation test showed that variable A has a value of 0 and variable B has a value of 7, so a value of X = 1 is obtained. According to [7], it fulfills the functionality aspect and is good so that the E-Nose tool is feasible to implement in cattle farms.

2. Implementation of the E-Nose Tool in Cattle Farm

The tool's implementation is carried out by field testing, taking data on real conditions in the cattle barn when the designed components are ready. Data transmission is carried out in real-time, which can be monitored from the Blynk application by breeders, and the recording is stored on an easily accessible web server. Implementation is carried out at UPT. Pembibitan Ternak dan Penghijauan Pakan Ternak Dinas Ketahanan Pangan dan Peternakan Kabupaten Jember, located in Arjasa District, Jember Regency, starts at 09.00 WIB – 15.00 on Thursday, 16 March 2023 until Wednesday, 22 March 2023.

Retrieval of reading value data with 2-minute intervals of data collection for 2 hours, then the data results are stored on the web server. The tools were placed at a height of 30 cm, 60 cm, and 80 cm with the help of cardboard in four different corners of the cage, namely position A in front of the cage, positions B and C in the middle of the cage and position D behind the cage. Retrieval of reading value data with 2-minute intervals of data collection for 2 hours, then the data results are stored on the web server. The tools were placed at a height of 30 cm, 60 cm, and 80 cm with the help of cardboard in four different corners of the cage, namely position A in front of the cage, positions B and C in the middle of the cage and position D behind the cage.

Fig. 7. Position of E-Nose Device Placement in Cattle Farm

The E-Nose tool that has been placed in a predetermined position is powered by a USB cable to turn on the fan, and the Arduino Uno R3 WiFi ATmega328P with ESP8266 marked with a green LED, so the tool can start taking data on the amount of gas contamination in units of ppm. The buzzer will sound if the ppm value on the MQ-4, MQ-136, or MQ-137 sensor exceeds a predetermined threshold. Data recorded by Arduino Uno R3 Wi-Fi ATmega328P with ESP8266 will be sent to the Blynk application and web server in real time.

3. Gas Sensor Reading Results

1). MQ-4 Sensor

The test results in the cattle barn are presented as shown in Fig.8. The results of the ppm readings at each position and altitude can be seen if the MQ-4 detects methane gas. The graphic lines fluctuate (unstable). It happens because, according to [10], methane gas has a mild nature, so the wind easily carries it because its density is less than that of air, so the reading results for methane gas levels are unstable. The average results of the MQ-4 sensor readings in units of ppm are presented in Table I, that the methane gas detected in the cattle barn is at the front position of 78.49 ppm, middle position of 42.75 ppm, and rear position of 17.52 ppm. According to [11], the LMD (laser methane detector) tool was used in their research to record the average CH_4 concentration on cattle farms with five events of 97 ppm, the lowest being 21 ppm and the maximum being 303 ppm.

TABLE I. MQ-4 SENSOR MEASUREMENT RESULTS

No	Position	Measured PPM
1.	Front	78.493
2.	Middle	42.754
3.	Behind	17.523
Average		46.256

Source: Primary Data

According to [12], the air in the pens that accommodate herds of dairy cows has a high methane content of up to 100 ppm, so the results of measurements and detections by the MQ-4 sensor for methane gas are by secondary data, which is below 100 ppm. Methane is not harmful and is not expected to harm human or animal health and productivity in normally ventilated buildings, but it contributes to global warming [13]. According to [14], Methane in the range of 0 – 500 ppm does not affect a person's body, but according to [15], the highest concentration in cow dung is methane gas of 65.7 kcal/m^2.

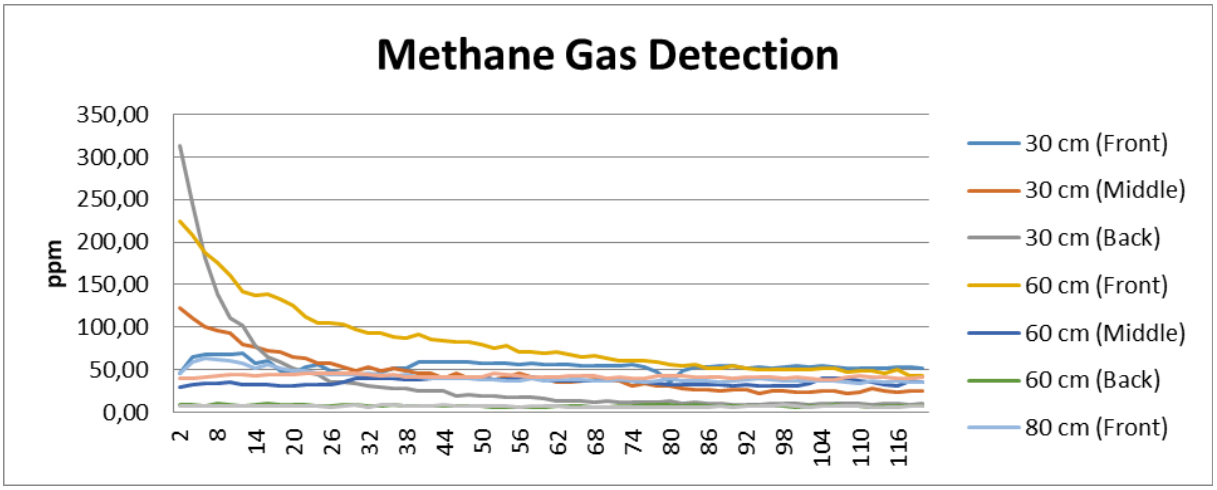
2). MQ-136 Sensor

The test results in the cattle barn are presented as shown in Fig.8. The results of the ppm readings at each position and altitude can be seen if the MQ-136 detects hydrogen sulfide gas. A graphic line is found that tends to be stable. It happens because, according to [16], hydrogen sulfide has a density that is heavier than air, so it tends to collect in low places. It causes the readings of the MQ-136 sensor to stabilize below 10 ppm. According to [17], on average, hydrogen sulfide in the air is less than 0.001 ppm, both naturally occurring and caused by human activities. The average results of the MQ-136 sensor readings in units of ppm are presented in Table II, that the hydrogen sulfide gas detected in the cattle barn is the front position of 1.49 ppm, middle position of 3.48 ppm, and rear position of 0.61 ppm.

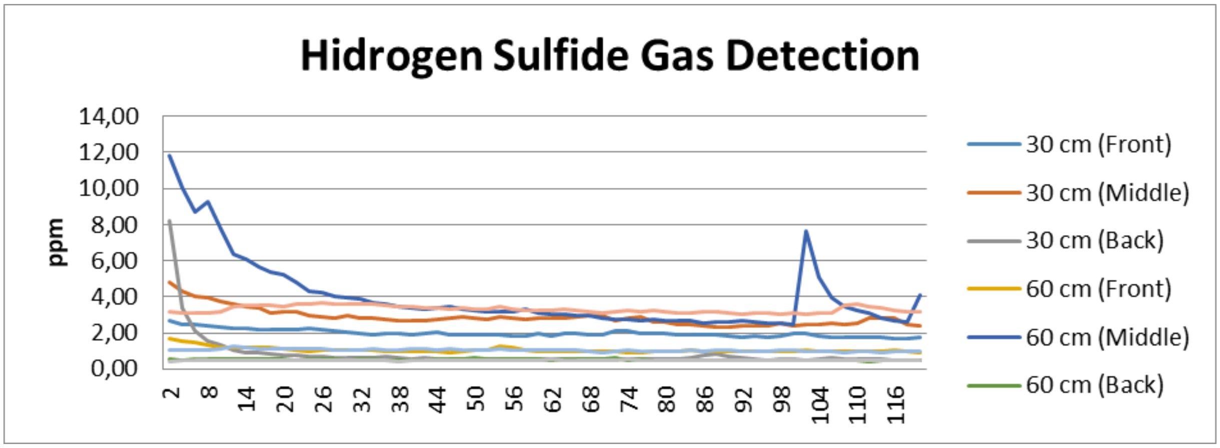
TABLE II. MQ-136 SENSOR MEASUREMENT RESULTS

No	Position	Measured PPM
1.	Front	1.496
2.	Middle	3.481
3.	Behind	0.619
Average		1.86

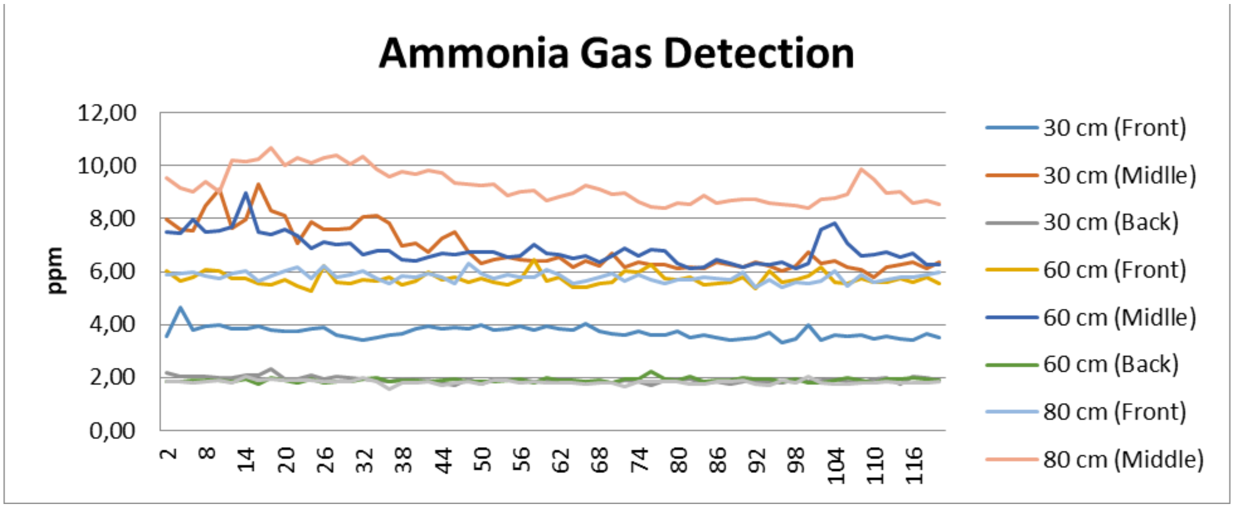
Source: Primary Data



(a)



(b)



(c)

Fig. 8. Recording results of each position

According to [18], the recommended measurement of Hydrogen sulfide gas for cattle farming is around 3 ppm, so the results of measurements and detection of the MQ-136 sensor for Hydrogen sulfide gas, are by secondary data, namely below 3 ppm which is still classified as safe for inhalation. Human and harmless. Hydrogen sulfide content in cattle pens exceeding 20 ppm will make it difficult for livestock to eat and cause digestive disorders. If it is above 50 ppm, which is classified as high, it will cause dangerous diseases to cause death [13].

3). MQ-137 Sensor

The test results in the cattle barn are presented as shown in Fig.8. The results of the ppm readings at each position and altitude can be seen if the MQ-137 detects ammonia gas. The graph lines are stable. It happens because, according to [19], ammonia is lighter than air, so it easily spreads through air circulation. Still, ammonia is difficult to produce in stables, so it is difficult to spread. It depends on the number of livestock and if ammonia gas is detected due to the relatively low temperature in the cages and the environment around the farm due to humid conditions [20]. The average results of the MQ-137 sensor readings in units of ppm are presented in Table III, that the ammonia gas detected in the cattle barn is the front position of 5.15 ppm, middle position of 7.89 ppm, and rear position of 1.88 ppm.

TABLE III. MQ-137 SENSOR MEASUREMENT RESULTS

No	Position	Measured PPM
1.	Front	5.153
2.	Middle	7.899
3.	Behind	1.882
Average		4.978

Source: Primary Data

According to [18], the recommended measurement of Ammonia gas for cattle farms is around 15 ppm, so it can be said that the results of measurements and detection of the MQ-137 sensor for Ammonia gas are by secondary data, namely below 15 ppm which is still classified as safe for humans and inhaled by humans and not dangerous. On the farm scale, if the air quality is poor, it will be dangerous to the health of farmers because ammonia dissolves easily in water, which, if inhaled into the mucous membranes of the nose and eyes, will cause irritation. Eight hours of work [21]. According to [13], ammonia concentrations between 10 – 20 ppm in livestock pens are not expected for production activities because humans can diagnose ammonia between 5 – 20 ppm, so it is not recommended for farmers to work in pens if the ammonia gas level is above 10 ppm. It is recommended to clean it immediately.

4). Functional Test

The output of the MQ-4, MQ-136, and MQ-137 sensors is in the form of a gas unit, namely ppm, which is then used to test the validity and reliability using the SPSS application by inputting the measured ppm variable from each sensor with standard ppm to find out the extent of accuracy and measure the stability of each sensor in measuring (reliable). Functional testing of the MQ-4 sensor uses two variables, measured ppm and standard ppm, a total of three data obtained from field testing of all positions using the Pearson Product Moment correlation formula with an r-value of 1. According to [22], if the calculated r-value is equal to one or more of the r-tables with a level of 5%, indicating that the variable used is valid, then it can be said that the information on the measured ppm value and the calculated ppm on the MQ-4 sensor corresponds to what should be measured. The reliability test was then carried out using Cronbach's Alpha, resulting in an r count of 0.000, which, according to [23], is said to be unreliable or unreliable if the reliability value is between 0.00 - 0.20. The ppm value measured by the MQ-4 sensor cannot be relied upon for stability when compared to the standard ppm from secondary data.

Functional testing of the MQ-136 sensor uses two variables, namely measured ppm and standard ppm, a total of three data obtained from the results of field testing of all positions using the Pearson Product Moment correlation formula with an r-value of 1. According to [22], if the calculated r-value is equal to one or more of the r-tables with a level of 5%, indicating that the variable used is valid, then it can be said that the information on the measured ppm value and the calculated ppm on the MQ-136 sensor corresponds to what should be measured. The reliability test was then carried out using Cronbach's Alpha, resulting in an r count of 2.442×10^{-15}, which, according to [23], if the reliability value is between 0.00 - 0.20, is said to be unreliable or unreliable. The ppm value measured by the MQ-136 sensor cannot be relied upon for stability when compared to the standard ppm from secondary data.

Functional testing of the MQ-137 sensor uses two variables, namely measured ppm and standard ppm, a total of three data obtained from the results of field testing of all positions using the Pearson Product Moment correlation formula with an r-value of 1. According to [22], if the calculated r-value is equal to one or more of the r-tables with a level of 5%, indicating that the variable used is valid, then it can be said that the information on the measured ppm value and the calculated ppm on the MQ-137 sensor corresponds to what should be measured. The reliability test was then carried out using Cronbach's Alpha, resulting in an r count of 1.554×10^{-15}, which, according to [23], if the reliability value is between 0.00 - 0.20, is said to be unreliable or unreliable. The ppm value measured by the MQ-137 sensor cannot be relied upon for stability when compared to the standard ppm from secondary data.

IV. CONCLUSION

Based on the objectives of the research conducted regarding the E-Nose Design of Contaminated Gas Detectors in Cattle Farm Waste, the following conclusions are drawn:

1. The design of the E-Nose tool can be implemented in cattle pens with the IoT concept to provide information on the output of the MQ-4, MQ-136, and MQ-137 sensors in ppm units in real-time with an easy-to-read display by users via smartphones and data stored in a database server. It can be seen via the web as data tables, equipped with a buzzer as a warning if one of the sensors has exceeded the threshold without opening the smartphone device with a buzzer sound signal. The design of the E-Nose tool is declared feasible because the results of the functionality validation show the number 1. The E-Nose tool can function properly and can be implemented.

2. Data on the functional results of the E-Nose tool in detecting Methane gas using the MQ-4 sensor produces an average unit quantity of gas that is 46.256 ppm, detecting Hydrogen sulfide gas using the MQ-136 sensor produces an average unit quantity of 1.86 ppm, and detecting Ammonia gas using MQ-137 produced an average gas quantity of 4.97 ppm. The validity test is valid for all sensors with a calculated r value 1.00. However, the reliability value is 0.00, so the stability of all sensor data readings cannot be relied upon when compared to the standard ppm from secondary data.

ACKNOWLEDGMENT

We as researchers, thank you for the cooperation of UPT. Peternakan dan Penghijauan Pakan Dinas Ketahanan Pangan dan Peternakan Kabupaten Jember.

REFERENCES

[1] M. Farid, "Pendampingan Pengelolaan Limbah Kotoran Sapi Menjadi Pupuk Organik Kepada Peternak Sapi di Desa Pandanarum Kecamatan Tempeh Lumajang," *Khidmatuna J. Pengabdi. Masy.*, vol. 1, no. 1, p. 59, 2020, doi: 10.54471/khidmatuna.v1i1.998.

[2] R. Zuroida and R. Azizah, "Sanitasi kandang dan keluhan kesehatan pada peternak sapi perah di Desa Murukan Kabupaten Jombang," *J. Kesehat. Lingkung.*, vol. 10, no. 4, pp. 434–440, 2018.

[3] K. Dopelt, P. Radon, and N. Davidovitch, "Environmental effects of the livestock industry: The relationship between knowledge, attitudes, and behavior among students in Israel," *Int. J. Environ. Res. Public Health*, vol. 16, no. 8, 2019, doi: 10.3390/ijerph16081359.

[4] E. Hartini and R. J. Kumalasari, "Faktor Risiko Paparan Gas Amonia Dan Hidrogen Sulfida Terhadap Keluhan Gangguan Kesehatan Pada Pemulung Di TPA Jatibarang Kota Semarang," *J. Kesehat. Lingkung. Indones.*, vol. 14, no. 1, pp. 52–58, 2015.

[5] D. D. Novita, A. B. Sesunan, M. Telaumbanua, S. Triyono, and T. W. Saputra, "Identifikasi Jenis Kopi Menggunakan Sensor E-Nose Dengan Metode Pembelajaran Jaringan Syaraf Tiruan Backpropagation," *J. Ilm. Rekayasa Pertan. dan Biosist.*, vol. 9, no. 2, pp. 205–217, 2021, doi: 10.29303/jrpb.v9i2.241.

[6] B. Suryadharma, A. S. Rusdianto, and Z. Zuhriasa, "Design and Construction of Broccoli (Brassica Oleracea, L.) Storage Box Using Thermoelectric Technology," *J. La Lifesci*, vol. 2, no. 4, pp. 25–31, 2021, doi: 10.37899/journallalifesci.v2i4.413.

[7] T. N. Sari, "Analisis Kualitas dan Pengembangan Sistem Informasi Akademik Berbasis Web Menggunakan Standard ISO 9126," *J. Inform. dan Komput.*, vol. 1, no. 1, pp. 1–7, 2016.

[8] W. Shalannanda, I. Zakia, E. Sutanto, and Fahmi, "Implementation of the Hardware Module of IoT- based Infant Incubator Monitoring System," *Univ. Prince Edward Isl.*, pp. 13–17, 2021.

[9] T. Suryana, "Mengirim Data Hasil Pengukuran Humidity dan Temperature Sensor DHT11 dengan Arduino UNO WiFi R3 ATmega328P ESP8266," Bandung, 2021.

[10] D. Amalia and M. Saepudin, "Jarak Rumah Ke Tempat Pembuangan Akhir, Kualitas Fisik Rumah Terhadap Kadar Gas Metana (CH4) Dalam Rumah Di Kelurahan Batulayang Kecamatan Pontianak Utara, Kota Pontianak," *Bul. Penelit. Sist. Kesehat.*, vol. 19, no. 4, pp. 243–249, 2016.

[11] J. Rey *et al.*, "Comparison Between Non-invasive Methane Measurement Techniques in Cattle," *Animals*, vol. 9, no. 8, p. 563, 2019.

[12] P. B. R. Nisbet-Jones *et al.*, "Is The Destruction or Removal of Atmospheric Methane a Worthwhile Option?," *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.*, vol. 380, no. 2215, p. 20210108, 2022, doi: 10.1098/rsta.2021.0108.

[13] S. Karaman, Z. Gökalp, and others, "Indoor Air Quality in Animal Housing Systems (gas, odor and dust)," *Curr. Trends Nat. Sci. Vol*, vol. 6, no. 12, pp. 267–271, 2017.

[14] D. Macasaet, A. Bandala, A. A. Illahi, E. Dadios, and S. Lauguico, "Hazard Classification of Toluene, Methane and Carbon Dioxide for Bomb Detection Using Fuzzy Logic," in *2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*, 2019, pp. 1–6.

[15] M. A. Fitri and T. K. Dhaniswara, "Pemanfaatan Kotoran Sapi dan Sampah Sayur Pada Pembuatan Biogas Dengan Fermentasi Sampah Sayuran," *J. Res. Technol.*, vol. 4, no. 1, pp. 47–54, 2018.

[16] A. Adriana, "Analisis Kualitas Udara Serta Keluhan Pernapasan pada Pemulung di Sekitar TPA Tamangapa Kota Makassar," Universitas Hasanuddin, 2021.

[17] C.-H. Chou *et al.*, "Toxicological Profile for Hydrogen Sulfide and Carbonyl Sulfide," Atlanta, Georgia: Division of Toxicology and Human Health Sciences, 2016.

[18] Z. Sakawi and L. Ismail, "Managing odour pollution from livestock sources in Malaysia: Issues and challenges," *Geografia*, vol. 11, no. 13, 2015.

[19] R. D. Anggoro, "Pengaruh Penggunaan Jenis Litter Sekam Padi dan Serutan Kayu Terhadap Suhu Litter, pH, dan Kadar Amonia Pada Kandang Closed House Universitas Lampung," FAKULTAS PERTANIAN, 2022.

[20] A. S. Raharjo and Z. Jamal, "Rancang Bangun Pengendali Dan Pengawasan Gas Amonia Pada Peternakan Ayam Berbasis Arduino Mega 2560 R3," *J. Ris. Rekayasa Elektro*, vol. 1, no. 2, pp. 71–78, 2019.

[21] M. Hassouna *et al.*, "Measuring emissions from livestock farming: greenhouse gases, ammonia and nitrogen oxides." INRA-ADEME, 2016.

[22] Gusmaniarti, "Pengaruh Pembelajaran Sentra Seni dan Kreatifitas Terhadap Perkembangan Sosial Emosional Anak Kelompok A di RA Roudlotul Hamdi Rembang Pasuruan," *Pedagog. J. Anak Usia Dini dan Pendidik. Anak Usia Dini*, vol. 4, no. 2, pp. 56–61, 2018.

[23] M. Sari, "Sistem Monitoring Gas Polutan pada Industri Pengolahan Kayu Barecore Berbasis ATMega32 Menggunakan SMS Gateway," Universitas Brawijaya, 2022.

[24] R. Babu Aremanda, S. Debretsion, S. Tesfalem, and R. Menghisteab, "Competence of Cow Manure as a Sustainable Feedstock for Bioenergy and Biofertilizer Production," vol. 4, no. 2, pp. 59–67, Jun. 2023, doi: https://doi.org/10.46676/ij-fanres.v4i2.135.

[25] T. Mien Nguyen et al., "Non-intrusive quality appraisal of Differentiation-induced cardiovascular stem cells using E-Nose sensor technology," Biosensors and Bioelectronics, vol. 246, pp. 115838–115838, Feb. 2024, doi: https://doi.org/10.1016/j.bios.2023.115838.