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Measurement Of Ethanol Concentration in Liquid Organic Fertilizer Fermentation Emissions Using The MQ-8 Sensor

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ABSTRACT– Ethanol is beneficial for the sterilization process and increases the rate of photosynthesis. Measurement of ethanol concentration is necessary because ethanol in high concentrations can cause several health problems, such as eye irritation, coughing, lacerations, and ineffective plant sterilization processes. Therefore, a sensor-based measurement system is needed to measure the total gas concentration in liquid organic fertilizer. This research aims to characterize the MQ-8 sensor and analyze the ethanol concentration for the fermentation process. The results of this study indicate that the MQ-8 sensor can work well in measuring the concentration of a single ethanol compound with an accuracy of 91%. The total concentration of ethanol gas in each sample liquid organic fertilizer is measured between 216 ppm to 1583 ppm, depending on the fermented plant.

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Introduction

Fermentation is a process of exploiting the activity of microorganisms that change the biochemistry of a material in the formation of a new product [1],[2] . Materials commonly used in the fermentation process are organic materials such as plant residues and animal waste [3]. One of the fermented products of organic matter is liquid organic fertilizer, commonly used in agriculture. The fermentation process in liquid organic fertilizer is produced from the decomposition process in organic materials [4]. One of the chemical compounds that can be produced from the fermentation process is ethanol [5].

Ethanol compounds are a group of alcohol compounds that have 2 carbon chains [6]. The alcohol content in plant fertilizers is useful for the process of sterilizing plants and increasing the rate of plant photosynthesis. [7],[8],[9]. Measurement of alcohol concentration is necessary because alcohol in high concentrations can cause several health problems, such as eye irritation, coughing, and lacerations [6]. In addition, alcohol concentrations that are too low or too high can cause the sterilization process in plants to be ineffective. At concentrations that are too low, alcohol cannot kill plant pests. Whereas at concentrations that are too high, alcohol will evaporate too quickly into the air [10],[11]. Measurement of the alcohol content formed in the fermentation process, especially the fermentation of liquid organic fertilizer.

Instrumentation systems for measuring alcohol, especially ethanol, in liquid organic fertilizers have been conducted using gas sensors such as the TGS-2620 gas sensor and MQ-8 [12], [13]. The ethanol concentration measurement system from the previous fermentation process has been , which are carried out using the TQS-2620 sensor on glutinous rice fermentation, which can measure the concentration up to 1.63% with an accuracy of 98.33% [12]. This study focuses on measuring the concentration of ethanol gas from the fermentation of liquid organic fertilizer using the MQ-8 sensor. This study aimed to analyze the total concentration and characteristics of the MQ-8 sensor in measuring ethanol gas from fermented liquid organic fertilizer.

Material and Methods

A. System Design

The system block diagram in Fig 1 depicts the research system design. The sensor used is a MQ-8 sensor, which has an embedded signal conditioner. The MQ-8 sensor has sensitivity to hydrogen, methane, and alcohol, with a measurement range of 300 ppm to 10,000 ppm [13]. The system is designed on a PCB placed in an X6 plastic box measuring (18.5×11.5×6.5) cm3. The system is integrated with the Arduino nano Atmega32P. The system voltage source comes from the ±12V supply. The ±12V power supply supplies the Arduino nano voltage and the 12V pump. The sensor voltage source comes from the ±12V supply, converted to ±5V using the LM2596 IC. The sensor is placed in a box measuring (7.5×5×2.5) cm3 in the X6 box. The

system is equipped with an LCD screen to display measurement results.

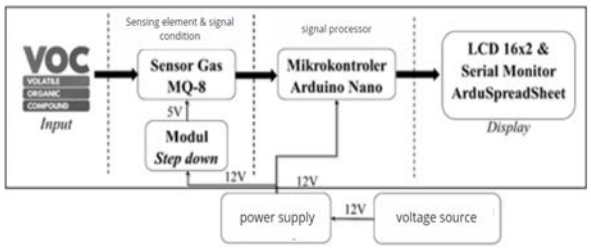


Figure 1. Block diagrams system

B. Calibration

The calibration was conducted to obtain the gas concentration equation as a function of the ratio resistance based on the MQ-8 sensor datasheet. The ratio is obtained by comparing the sensor resistance value at the time of measurement (Rs) with the sensor resistance when exposed to 1000 ppm of alcohol gas (R0) [13]. The value of Rs can be determined using equations 1 and 2 [14], [15].

$$Rs\ gas\ = \left(\frac{Vc}{VRL} - 1\right) \times RL \quad (1)$$

Based on equation 2.1, Vc represents the sensor input voltage of 5V. RL (load resistor) is a voltage divider owned by the sensor. The RL value is written on the MQ-8 sensor datasheet. The VRL value represents the sensor's analog voltage value. The sensor's analog value, 0 to 1024, is converted to a VRL voltage of 0 to 5V. The VRL value is calculated using equation 2.2.

$$VRL = \left(\frac{analog\ sensor}{1024}\right) \times 5V \quad (2)$$

Sensor calibration is performed based on the following scheme:

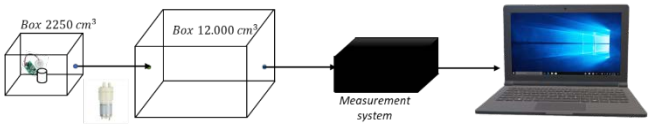


Figure 2. Scheme of calibration and test

A 2250 cm3 and 12000 cm3 box was prepared as an evaporation box and measurement box. The compound is placed in a vessel and sonicated using an ultrasonic atomizer in an evaporating box. Evaporation time is adjusted to the evaporation rate of the compound. Compound evaporation time adjusted to the desired concentration. Evaporation time is determined through several stages of the following calculations. First, determine the 1 ppm of gas volume in the measurement box using Equation 3.

$$\frac{Vt}{Vx} = 1\ ppm \quad (3)$$

Based on Equation 4, Vx is the volume of 1 ppm obtained from the volume of the measurement box (Vt) 12000 cm ^{3} divided by 1 ppm. Next, the ideal gas equation can determine the mass compound for the concentration of 1 ppm.

$$\frac{PV}{RT} = \frac{gr}{Mr} \quad (4)$$

According to the ideal gas equation, P states the ideal gas pressure is 1 atm, V is a measurement box volume, R is the ideal gas constant of 0.08205 L atm/mol K, and T is the room temperature around 25 ° C converted to Kelvin units. gr/Mr is another form of writing the mole value of the compound, where gr is the mass compound, and Mr is the mass relative molecule of the compound, namely 46.07 gr/mol for ethanol. The evaporate rate is the mass fluid that forms x volume of gas. Next, specify duration evaporation with count rate evaporation compound using equation 5.

$$ER = \frac{\Delta m}{\Delta t} \quad (5)$$

Evaporation of the ethanol was conducted using a sonification method. The gas was injected into a measurement box by flowing using a pump of 1 m/s speed. The injection duration is determined by equation 6.

$$t = \frac{Vp}{u\pi r^2} \quad (6)$$

Based on equation 7, V_P represents the volume of the evaporation box, u is the pump speed, which is 1 m/s, and πr^2 is the circular cross-sectional area of the pump. The sensor calibration was carried out for several ethanol concentrations in the measurement range. Each measurement ratio is plotted in an approximation curve. The measured gas concentration value is obtained from the equation of the approximation curve. In this study, the curve used is an exponential curve, which produces a gas concentration equation of 8 [16].

$$y = a\ ln\ (x)\ + b \quad (7)$$

$$y\ = e^{ax+b} \quad (8)$$

Where y is the change ratio (Rs/Ro), and x is the measured gas concentration. Accuracy measurement is represented in the form of a percentage. Accuracy is determined using equation 9 [17].

$$Accuracy\ Percentage = 100\% - \bar{e}\% \quad (9)$$

The value error measurement is obtained by comparing the gas concentration measured by the system with the theoretical gas concentration.

$$error(e)\% = \frac{Measure\ value - calculated\ value}{calculated\ value} \quad (10)$$

C. Measurement Concentration

The measurement of the ethanol concentration was carried out following the scheme in Figure 2. We used organic fertilizer fermented liquid as the samples. Six samples included the fertilizer for the leaves, fruits, jakaba, amino acids, rice turmeric, and potassium.

Based on Figure 2, the measurement began with measuring the mass of the fermented emission liquid before sonication. Then, the fermented emission liquid is sonicated for 5 seconds in the sonication box. After that, the fermentation gas was injected into the experiment box. Then,

the valve in the box was opened, and the ethanol concentration measurement was conducted. The measurement was carried out for each sample.

Results and Discussion

A. Calibration

The sensor calibration was carried out using ethanol with different concentrations according to the scheme in Figure 2. There were 5 gas concentration points, namely 300 ppm, 600 ppm, 1000 ppm, 5000 ppm, and 10,000 ppm. The five concentrations were obtained from the sonication of ethanol liquid for 4.5 seconds for 300 ppm, 9 seconds for 600 ppm, 15 seconds for 1000 ppm, 75 seconds for 5000 ppm, and 150 seconds for 10,000 ppm. The measurement results obtained were processed using Microsoft Excel and displayed in a comparison chart of the measured ratios with calculated concentrations. The R0 value obtained is 0.539

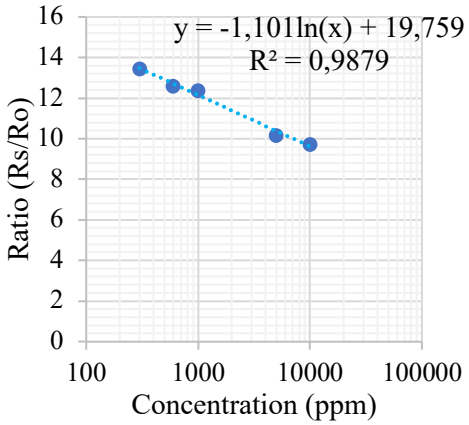


Figure 3. The calibration results of the sensor for ethanol concentration

The value of R^2 = 0.9879 represents the measured data having good linearity. Figure 3 presents the trendline equation y = -1.101ln(x) + 19.759 if the x and y of this equation are the measured concentration and ratio values. Then, the equation for the concentration of ethanol gas is as follows.

$$x\ (concentration) = e^{\left(\frac{Ratio-19{,}759}{(-1{,}101)}\right)} \qquad (11)$$

After obtaining the ethanol gas concentration equation, the measured concentration of ethanol gas can be known. In measuring the calculated concentration of 300 ppm, the measured concentration is 323 ppm. Then, at the calculated gas concentration of 600 ppm, the ethanol concentration was measured at 678 ppm. The gas concentration was 1000 ppm, and the ethanol gas was measured at 922 ppm. Furthermore, when the gas concentration was set of 5,000 ppm, the sensor measured a gas concentration of 5,848 ppm. Finally, on the the set concentration of 10,000 ppm, the sensor measures of 10,561 ppm. The difference between the measured and theoretical concentrations is presented graphically in Figure 4.

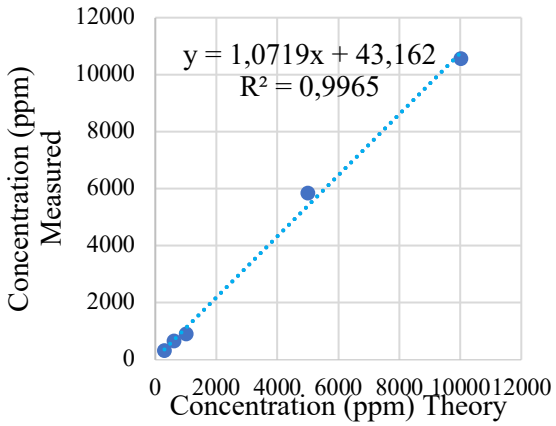


Figure 4. Comparison Concentration of ethanol gas measurable and theoretical

B. Measurements

The measurement of the concentration of ethanol gas from 6 samples of organic fertilizer fermentation emissions resulting from sonication of liquid organic fertilizer for 5 seconds was conducted in 3 repetitions. The measurement results are shown in Figure 5. Based on Figure 5, it is shown that the lowest ethanol gas measured in fermented fruit emissions was 216 ppm, obtained from the sonication of liquid organic fertilizer weighing 0.022 grams. The highest concentration of ethanol gas was measured from the sonication of fermented leaves weighing 0.014 grams, equal to 1583 ppm. The next highest concentration of ethanol gas comes from the jakaba fermentation emissions weighing 0.072 grams, which is 1231 ppm. Then, in Figure 5, it is shown that the emission of amino acid fermentation produces ethanol gas of 1173 ppm, which is obtained from 0.01 grams of sonicated amino acid fermentation liquid. Then, in the emission of sour turmeric fermentation, the ethanol gas concentration was measured at 984 ppm, obtained from the sonication of the fermented liquid weighing 0.25 grams. Finally, in the emission of potassium fermentation, the concentration of ethanol gas was 919 ppm. This value resulted from the sonication of 0.017 grams of fermented liquid. It became the second-lowest concentration of ethanol gas that the sensor managed to measure from the six samples of fermented emissions.

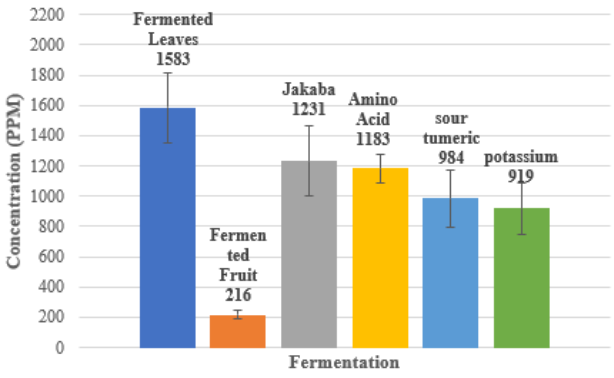


Figure 5. Measurement results ethanol gas concentration from emission fermentation

The sensor measurement results for a single ethanol compound in the calibration process are plotted in Figure 3 and 4. In Figure 3 and 4, the R^2 value in each graph is around 0.99, which means that the linearity obtained is high. In Figure 3, a comparison graph of the measured ratio with ethanol gas according to the theory of calculations is made to find an equation for the relationship between the concentration of ethanol gas and the ratio measured by the sensor. The graph in figure.4 is made to prove the accuracy of measurement results using a sensor. Based on a comparison of measured ethanol gas concentrations and the theory in Figure 4, the gas accuracy is 91%. The measurement of fermentation emissions begins with sonicating the fermented liquid for 5 seconds for each sample. Even though the sonication duration for each sample is the same, the mass of the sonicated liquid is different because of the difference in the evaporation rate of each sample. Each fermented liquid sample has a different composition, so the compounds in each sample liquid are also different. The sensor with a layer of sensing element SnO_2 produces a different response every time it is exposed to a different gas. Therefore, the measurement of fermented emission samples produces a measured concentration with a different deviation for each sample.

Conclusion

Based on the research results, it can be concluded that the MQ-8 sensor can be used to measure the concentration of ethanol gas from the fermentation process of liquid organic fertilizer. The characteristics of the MQ-8 sensor used in the study have an accuracy of 91% of the calibration results. The total concentration of ethanol gas in each liquid organic fertilizer sample was measured between 216 ppm to 1583 ppm. Each sample of liquid organic fertilizer has a different measurement deviation due to differences in the response between the layers of the sensing element SnO_2 sensor when exposed to each sample of liquid organic fertilizer.

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