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Rule-Based System of Ammonia Gas Detection in Tofu Industry Based on Internet of Things and Cloud

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Abstract

Industry of tofu is one of the driving forces of the economy but also has a negative impact because the waste produced can pollute the environment if not handled properly. Tofu industry waste is usually in the form of liquid waste containing several gases that are harmful to human health such as ammonia. Ammonia is a pollutant gas that causes health problems such as respiratory disorders to death. Therefore, a system is needed that is able to detect ammonia levels in tofu industry liquid waste. The purpose of this study is to develop a system that can monitor and provide real-time hazard notifications if ammonia levels are at a safe threshold. This study uses a rule-based system method for grouping ammonia level data, the Internet of Things (IoT) for real-time data collection devices, and the cloud to store data generated from IoT devices. The results of the study showed that ammonia levels were <200 ppm so that they were included in the alert category because the effects caused could cause irritation to the eyes, nose and throat.

Keywords: Ammonia, Cloud, Internet of Things, Rule-based System

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1. Introduction

Tofu is a type of food that has nutritional value in the form of protein. The tofu industry can help improve the economy, but the tofu industry also has a negative impact because the waste produced can pollute the environment if not handled properly. Tofu waste is usually in the form of liquid waste containing hydrogen sulfide, carbon dioxide and ammonia [1].

Ammonia is a pollutant gas that plays a role in air pollution problems [2] which can cause human health problems such as cancer, heart disease and respiratory disorders [3]. Accurate monitoring of ammonia gas is important because of its very active chemical properties that can affect health [4]. To overcome this, a special system is needed that can detect ammonia concentration.

The Internet of Things (IoT) is the latest technology that is widely used in industry and its applications provide added value. IoT describes a system where the internet is connected to the physical world through sensors [5]. The main components of IoT are sensor devices, data processing, applications and services and security and privacy [6] while the Cloud has an important role in analyzing large data generated by IoT devices [7]. Rule-based system is a system that is created based on algorithms as steps in determining it. This rule-based is also often used as a basis for taking action so that the action can meet the specified target in other words the machine will check the rules and actions, whether the information provided by the user is in accordance with the conditions of the rule [8]. Rule-based rules are usually formulated in if-then format. If represents a certain condition while then represents the action or result that must be carried out if the condition is met [9].

Previous research that supports this research is the Use of IoT and web services in smart farming. In this study, utilizing IoT technology, namely the integration of wireless network sensors in data collection and artificial intelligence can increase productivity and minimize costs and losses [10].

Another study is the design of an IoT-based gas sensor for air quality monitoring. The results of this study developed an IoT device that presents data in real time through website visualization for monitoring methane and carbon dioxide gas [3]. Then research on the analysis of ammonia gas against environmental factors at the Piyungan TPA Yogyakarta. The results of this study show that the level of ammonia gas is still below the standard, namely 1.5 ppm. This is caused by temperature, humidity and wind speed which affect the distribution of ammonia. Although still below standard, many people still suffer from headaches and respiratory disorders [11].

This study combines IoT and Cloud as data retrieval and storage, then the data is extracted based on rules (rule-based) and provides reports via telegram in real-time. This study aims to monitor ammonia gas levels in the tofu industry by presenting concentration data in real-time and providing hazard notifications through an easily accessible system.

2. Methods

In this study, there are several stages that need to be carried out before developing the system. The following are the stages of research shown in **Figure 1**. Based on **Figure 1**, it can be explained that the first stage of this study is problem identification, namely from field studies to determine the location (tofu industry) being studied and literature studies to deepen the concepts and theories used in system development. The second stage is system design which is carried out with the design of the system architecture and flowchart of the system being created. The third stage, namely implementation, is carried out to create a system prototype with a programming language. The last stage is system testing by combining both sensor designs and systems that have been created at the location (tofu industry).

2.1 Problem Identification

The results of the problem identification carried out from the literature study are that the level of ammonia concentration has different effects. The higher the level, the more dangerous it is and can cause death. The effects of ammonia are as shown in **Table 1**.

2.2 System Design

This stage is carried out to design the system. This stage adopts data obtained from the previous stage. At this stage, a system design is carried out in the form of a rule-based system flowchart as in **Figure 2.**

Table 1. Effects of Ammonia [11-13]

Ammonia Level (PPM)	Hazardous Effects
0.5 – 1.0	Odor begins to be detected
2.0	Maximum limit of exposure to ammonia gas odor in residential areas continuously (24 hours) Decree of the Minister of Environment No. 50/MENLH/11/1996
25	Acceptable threshold value (maximum limit) of exposure in the work area 8 hours, Circular Letter of the Minister of Manpower No.02/MENAKER/1978
25- 50	Odor can be detected, generally does not cause impact
50 - 100	Causes mild irritation to eyes, nose and throat, tolerance can occur in 1-2 weeks without causing effects
140	Causes moderate irritation to eyes, no more severe effects for less than 2 hours
400	Causes moderate irritation to throat
500	Levels that cause immediate health hazards – 700ppm moderate eye hazards
1000	Immediate impact on respiratory tract
1700	Causes laryngospasm
2500	Fatal after half an hour of exposure
2500 - 5000	Causes necrosis and damage to respiratory tract surface tissue, chest pain, pulmonary edema, and bronchospasm
5000	Fatal can cause sudden death

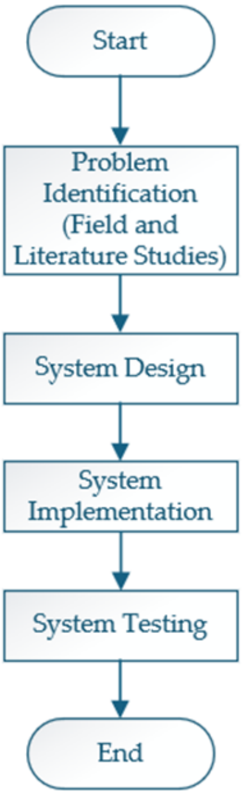

Figure 1. Research Stages

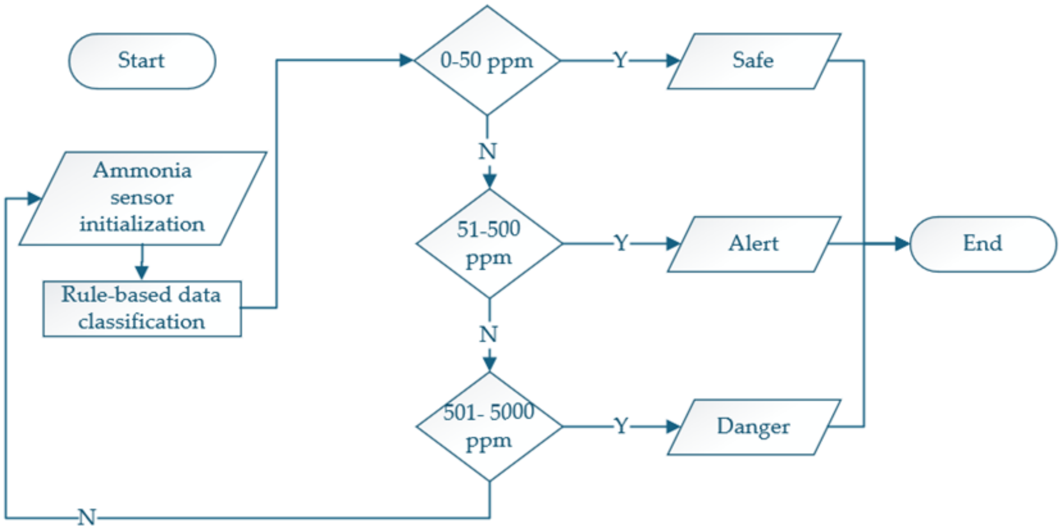

Figure 2. Flowchart Rule-Based System

Based on **Figure 2**, the first step is the initialization of the sensor used to read the ammonia value captured by the sensor. Then the next step is the classification process based on rules consisting of 3 statuses, namely safe, alert and danger. The ammonia level status is safe if the value is 0-50 ppm, the alert status with an ammonia level value between 51-500 ppm and danger if the level value is 501-5000 ppm. If the value is more than 5000 ppm, the sensor is initialized again. This study groups the status based on the effects caused in Table 1.

For the system architecture built using IoT technology by utilizing an ammonia sensor connected to an Arduino microcontroller that is already connected to the internet/wifi network. Then the data taken by the sensor is stored in a cloud database. The database is processed with a rule-based algorithm and then visualized in a website-based system that can be used to monitor ammonia levels in real time. If the level falls into the alert and danger status category, it will be sent via telegram. The description of the system architecture built is as shown in **Figure 3**.

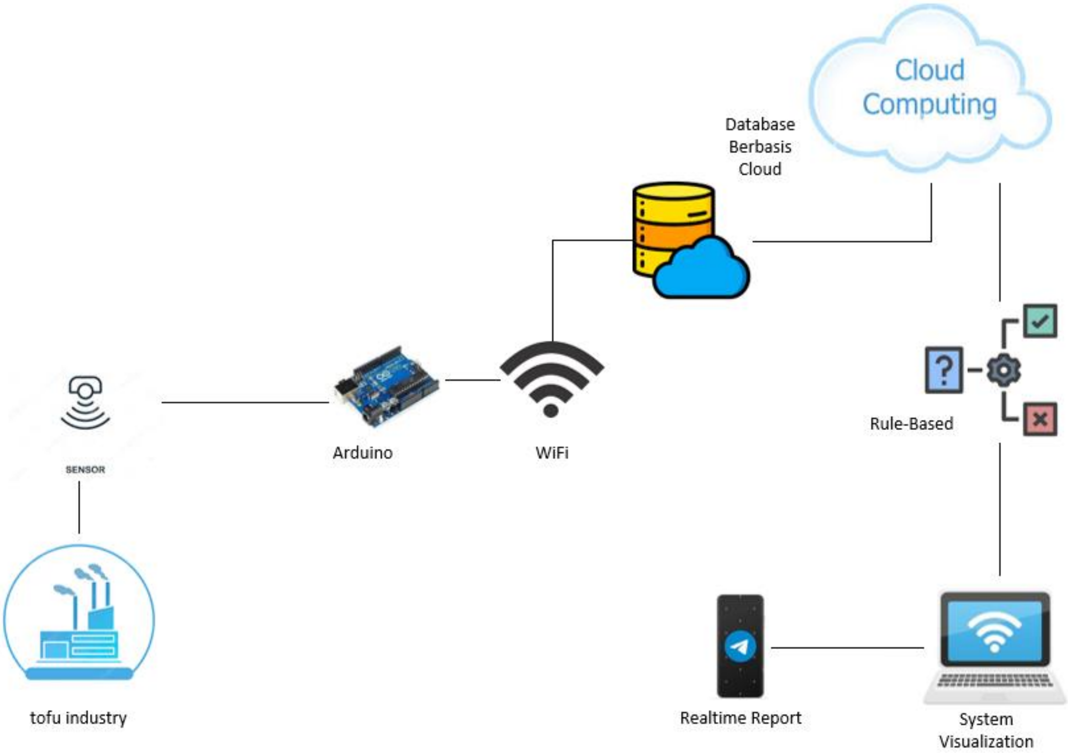

Figure 3. System Architecture

3.Results and Discussion

The results of this study are in the form of a system integrated with IoT devices and Cloud databases that display a visualization of the main dashboard containing real-time ammonia gas levels, status and effects caused as in **Figure 4**. In addition, the system also displays visualizations in the form of graphs in **Figure 5** and notifications via telegram if the status is alert/danger as in **Figure 6**.

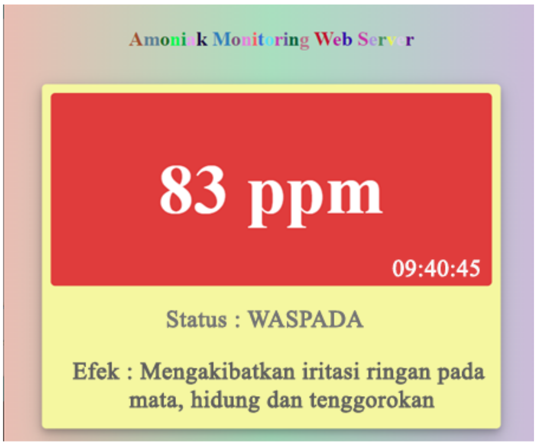

Figure 4. System Dashboard

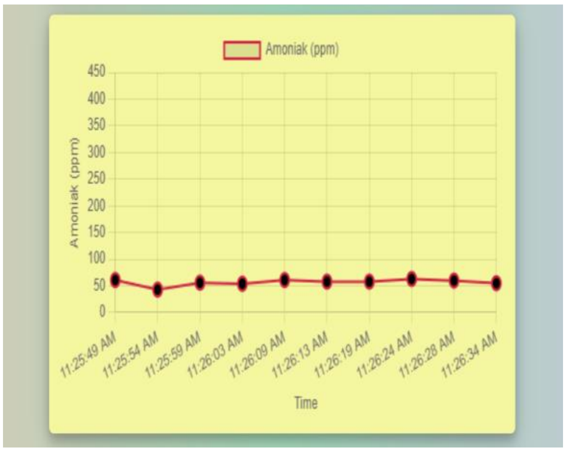

Figure 5. Ammonia Level Graph

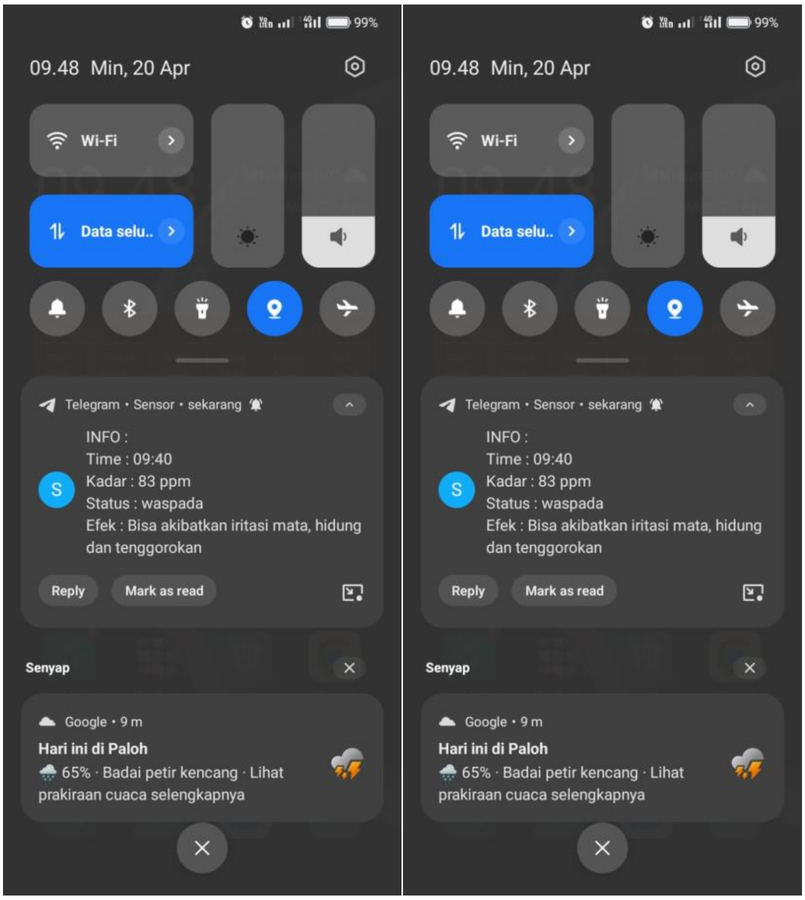

Figure 6. Telegram Notification

The following are the results of monitoring ammonia gas levels obtained from 08.00 WIB to 16.00 WIB by placing the sensor 10 cm above the tofu industry liquid waste. Data is taken every 10 minutes and stored in the cloud as in Table 2.

Table 2. Ammonia Sensor Data

Time	Concentration (PPM)	Status	Effect
08.00	12	Safe	Initially no odor is detected, until an odor is detected. The odor can be noted, generally does not cause any impact.
08.10	14	Safe	Initially no odor is detected, until an odor is detected. The odor can be noted, generally does not cause any impact.
08.20	19	Safe	Initially no odor is detected, until an odor is detected. The odor can be noted, generally does not cause any impact.
08.30	24	Safe	Initially no odor is detected, until an odor is detected. The odor can be noted, generally does not cause any impact.
08.40	37	Safe	Initially no odor is detected, until an odor is detected. The odor can be noted, generally does not cause any impact.
08.50	44	Safe	Initially no odor is detected, until an odor is detected. The odor can be noted, generally does not cause any impact.
09.00	49	Safe	Initially no odor is detected, until an odor is detected. The odor can be noted, generally does not cause any impact.
09.10	53	Alert	Causes mild irritation to eyes, nose and throat.
09.20	67	Alert	Causes mild irritation to eyes, nose and throat.
09.30	71	Alert	Causes mild irritation to eyes, nose and throat.
09.40	83	Alert	Causes mild irritation to eyes, nose and throat.
09.50	99	Alert	Causes mild irritation to eyes, nose and throat.
10.00	119	Alert	Causes mild irritation to eyes, nose and throat.
...	...	...	...
15.30	134	Alert	Causes mild irritation to eyes, nose and throat.
15.40	161	Alert	Causes mild irritation to eyes, nose and throat.
15.50	153	Alert	Causes mild irritation to eyes, nose and throat.
16.00	106	Alert	Causes mild irritation to eyes, nose and throat.

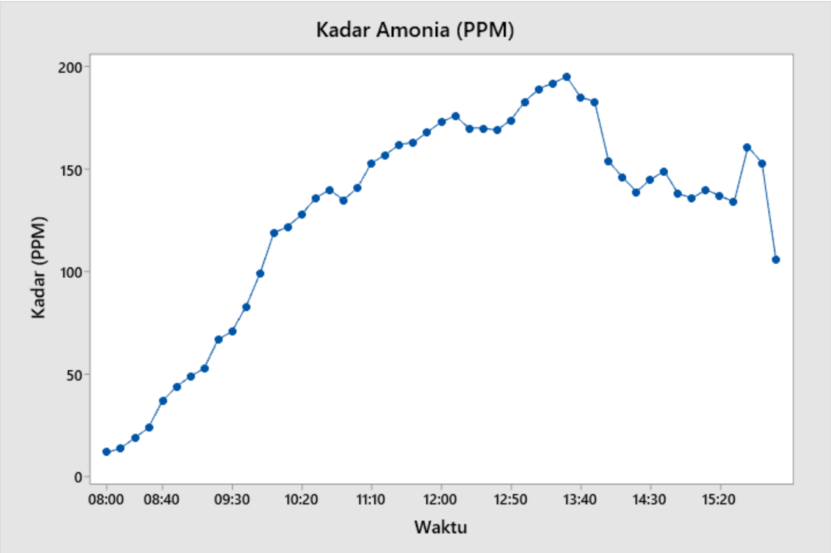

Figure 7. Ammonia Level Chart

Based on **Table 2**, if visualized in the form of a graph of ammonia levels as in **Figure 7**. In this graph, it can be seen that ammonia levels increase every time reaching <200 ppm. This is classified as alert status which has the effect of causing eye, nose and throat irritation if exposed for a long time.

4. Conclusion

Based on the results of research that has been done from the development of an ammonia gas detection system with a rule-based system algorithm based on the internet of things and cloud, the system that is built can take data through an ammonia sensor that is integrated with the cloud to store data and then classify it based on the rules that have been made. And the system is able to monitor ammonia levels and provide alert/danger notifications via telegram in real-time. In addition, the results of the ammonia level study showed a significant increase every time.

For further research, it is expected to use more than one sensor and add other gas variables/parameters and use artificial intelligence methods to optimize the system that is built.

Authors' Declaration

Authors' contributions and responsibilities - The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation, and discussion of results. The authors read and approved the final manuscript.

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Competing interests - The authors declare no competing interest.

Additional information - No additional information from the authors.

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