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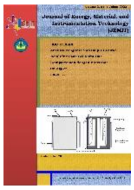

Design of a Website-Based Realtime Noise Monitoring System in the Work Environment as a Support for Occupational Health and Safety (OHS) Data

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Abstract

The level of noise in the work environment is one of the factors that affect workers' performance. Research on noise level monitoring tools has been realized using a GY Max 4466 sound sensor with a website-based ESP Wroom 32 microcontroller. This study aims to determine the noise level in the work environment and to monitor noise levels based on a website to support occupational health and safety data. Data was collected by sound detection in the PDAM Way Rilau Bandar Lampung pump room from 08.00-12.00 WIB. The results showed that the system functioned well, indicated by the average accuracy of the four sensors of 97.07% and the average error value of 2.93%. The noise level data generated from the PDAM Way Rilau pump room is classified as high or dangerous because it has exceeded the noise threshold (NAV) value of 70 dB. The system used on the website is localhost access on a computer that can be monitored in the work environment as supporting data for occupational health and safety (K3).

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Abstrak

Tingkat kebisingan dalam lingkungan kerja menjadi salah satu faktor yang mempengaruhi kinerja para pekerja. Penelitian mengenai alat monitoring tingkat kebisingan telah direalisasikan menggunakan sensor suara GY Max 4466 dengan mikrokontroler ESP Wroom 32 berbasis website. Penelitian ini bertujuan untuk mengetahui tingkat kebisingan di lingkungan kerja dan dapat memonitoring tingkat kebisingan berbasis website guna pendukung data kesehatan dan keselamatan kerja. Pengambilan data dilakukan dengan deteksi suara dalam ruangan pompa PDAM Way Rilau Bandar Lampung dari pukul 08.00-12.00 WIB. Hasil penelitian menunjukkan sistem berfungsi dengan keadaan baik, ditunjukkan dengan nilai rata-rata akurasi ke empat sensor sebesar 97,07% dan rata-rata nilai error sebesar 2,93%. Data tingkat kebisingan yang dihasilkan dari ruangan pompa PDAM Way Rilau tergolong tinggi atau bahaya karena sudah melebihi nilai batas ambang (NAB) kebisingan yaitu sebesar 70 dB. Sistem yang digunakan pada website yaitu dengan akses localhost pada komputer yang dapat dimonitoring dalam lingkungan kerja sebagai data pendukung kesehatan dan keselamatan kerja (K3).

1. Introduction

The level of work accidents in Indonesia due to noise still needs to be addressed. According to Kepmenkes No.1405/MENKES/SK/XI/2002, noise is a problem often encountered by large companies today. The use of machines and work tools that support the production process has the potential to cause noise. Noise is the occurrence of unwanted sounds that disturb or endanger health (Kepmenkes, 2002). According to WHO, in 2015 stated that as many as 466 million people in the world have hearing loss (6.1% of the world's total population), 34 million infect children, and 432 million infect adults. WHO also states that more than 1 billion young people are at risk of experiencing hearing loss due to noise exposure (WHO, 2015). There is a threshold value that the human ear can

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accept without causing disease or endangering health. Based on Permenaker No.13/MEN/X/2011 concerning Threshold Limit Values (NAB) of physical and chemical factors in the workplace. The NAV of noise is set at 85 dB as the highest intensity and is a value that is still acceptable to workers in their daily work for no more than 8 hours a day or 40 hours a week (Kuswana, 2017).

The effect of noise exposure generally depends on the level of noise intensity and the length of time of exposure. The effect of high-intensity noise (above NAV) in the mining business causes damage to the ear, which can reduce the quality of hearing, both temporarily and permanently, from mining lifting equipment and machinery (Utami et al., 2020). Physiologically, high-intensity noise causes health problems, including increased blood pressure (±10 mmHg), increased pulse, risk of heart attack, sensory disturbances, constriction of peripheral blood vessels in the hands and feet, organ balance disorders, and digestive disorders (Amir et al., 2019).

Research related to noise tools has been done before, and the AVR ATMega 8535 microcontroller is generally used. The noise monitoring tool's design consists of an input sensor in the form of a sound sensor using the AVR ATMega 8535 microcontroller as a process, and the output used can be a dot matrix display. The results obtained in this study show that when the sensor detects noise reaching 55 dB, it will be displayed via a dot matrix display (Jmr & Widianti, 2018). Related research was also carried out by Kharis in 2013 using a microcontroller in the form of an ATMEGA 8535 AVR with a sound sensor as input, and what distinguishes this Kharis research is the output in the form of a buzzer. The results of this study are that when the sensor detects noise, the buzzer will turn on as a noise warning alarm (Kharis, 2013).

Based on the problems above, research is necessary to design a monitoring system capable of detecting noise. In this study, the sensor used is the GY Max 4466 sound sensor to detect noise at four object points. The ESP used is the microcontroller WROOM-32 because it has 16 ADC pins, allowing it to run more than one analog sensor. Before use, the sensor will be tested as a monitoring system tool to determine its sensitivity. This noise monitoring system is based on the website in real-time, making it easier to monitor directly for supporting data on occupational health and safety.

2. Research Methods

2.1 Overall Design of the Tool

The hardware is designed to monitor noise using a Max 4466 multi-sound sensor as an input circuit, ESP WROOM-32 as a process, and then transferred to a web server as output. The following is a system design block diagram presented in **Figure 1**.

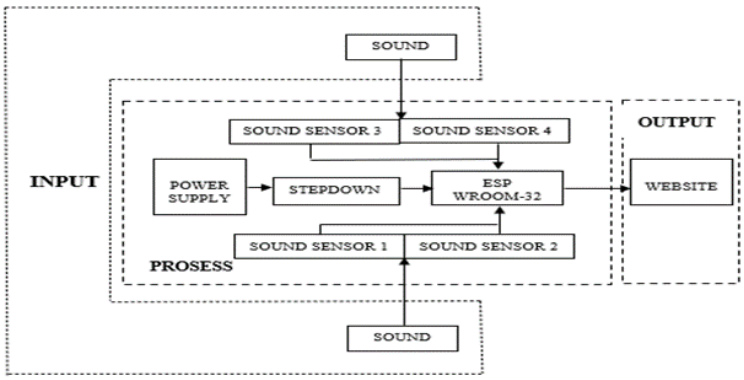


Figure 1. Block diagram system planning

In **Figure 1**, the system design block diagram explains that the sound sensor will receive sound (input) in the factory or room. When the sensor receives the sound, the input is converted into a digital form as a noise level, which the ESP WROOM-32 will process. However, before that, the microcontroller circuit is first coupled with a step-down to control the incoming current from the power supply. Then, the output from the microcontroller is forwarded to the laptop and displayed on a Website-based monitoring website.

In the research, the sensor used to detect noise is the GY Max 4466 sound sensor, which uses the ESP WROOM-32 microcontroller as a data processor. The sensor circuit used is shown in **Figure 2**.

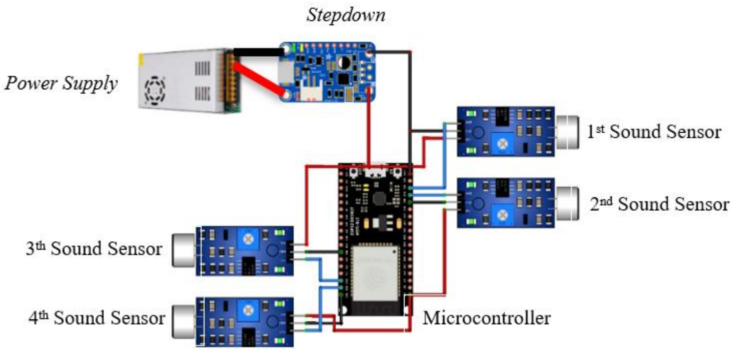


Figure 2. Sensor Circuit

Figure 2 is a schematic form of the monitoring system tool that will be made. Connect the power supply to the step-down before the pins on each sensor are connected. The ground (-) step-down is connected to the microcontroller ground, and Vcc (+) is connected to the Vin microcontroller. Stepdown functions as a current controller from the power supply to the microcontroller so that the incoming current can be according to the microcontroller input, namely 3V-5V. Furthermore, the pins on each sound sensor will be connected to the ESP WROOM-32 microcontroller. Beginning with installing the ESP WROOM-32 to the breadboard, then installing the GND (ground) pin on the GY Max 4466 sound sensor, connecting it to ground on the microcontroller using a jumper, and then connecting the Vcc sensor pin to the microcontroller Vin pin, and finally connecting the output pin to the sensor to the microcontroller GPIO pin. The following is a 3D design of the noise tool presented in **Figure 3**.

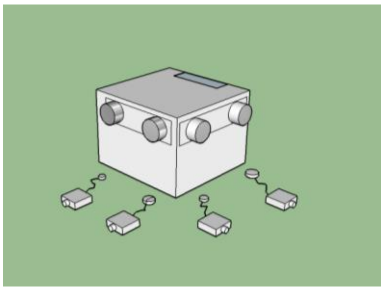


Figure 3. Noise Device Design.

The tool design in this study will be realized in the form of acrylic material. The acrylic frame will be cut first according to the size of the tool components; after that, the acrylic is bent by heating first and then matched with the tool components. After that, we made holes in the acrylic with a drill. The first four holes were made in this acrylic hole because it adjusted to the design and size of the port for the sound sensor. Then, another hole will connect the USB, power supply, and PCB housing. When finished, the tool design will be accurate and can be used.

3. Results and Discussions

3.1 System Design Implementation

The sound sensor detects the noise level (dB) in the work environment. It is equipped with a microphone as a voice detector and an amplifier as an amplifier. The max 4466 sound sensor converts the sound into an analog-digital converter (ADC) value. Tests on the microphone are carried out to determine whether the sensor can respond adequately when sound is detected. The sound sensor is connected to the Wroom-32 ESP with a distance of 1 m between the sensor and the sound source, as shown in **Figure 4**.

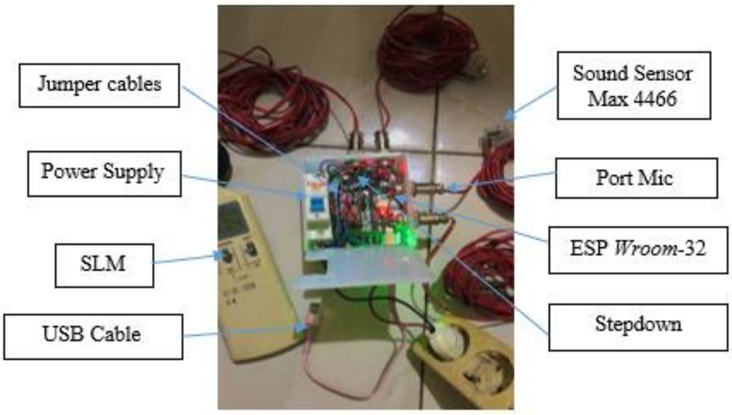


Figure 4. A Series of Monitoring tools

3.2 Gy Max 4466 Sensor Testing

The Gy Max 4466 sound sensor will be calibrated with a standard tool to determine the error value and accuracy of the sensor. The value can be known using the Arduino IDE software, and the value from the ADC Sensor will be converted to a dB value using the following programming.

```
void setup() {
  // put your setup code here, to run once:
pinMode(32, INPUT);
pinMode(34, INPUT);
pinMode(35, INPUT);
pinMode(33, INPUT);
Serial.begin(9600);
}
double mic1, mic2, mic3, mic4;

void loop() {
  // put your main code here, to run repeatedly:
mic1 = analogRead(32);
mic2 = analogRead(34);
mic3 = analogRead(35);
mic4 = analogRead(33);

nilaidB1 = (mic1-1473.3)/4.4599; //fix data mic1 pin d32
nilaidB2 = (mic3-536.98)/12.433; //FIX data mic2 pin d34
nilaidB3 = (mic2-206.43)/27.689; //fix data mic3 pin d35
nilaidB4 = (mic4-365.52)/7.1006; //fix data mic4 pin d33

Serial.println((String)"Mikrofon 1 ADC : " + mic1);
Serial.println((String)"Mikrofon 1 dB : " + nilaidB1+(String)" dB");
Serial.println((String)"Mikrofon 2 ADC: " + mic2);
Serial.println((String)"Mikrofon 2 dB : " + nilaidB2+(String)" dB");
Serial.println((String)"Mikrofon 3 ADC : " + mic3);
Serial.println((String)"Mikrofon 3 dB : " + nilaidB3+(String)" dB");
Serial.println((String)"Mikrofon 4 ADC: " + mic4);
Serial.println((String)"Mikrofon 4 dB : " + nilaidB4+(String)" dB");

delay(1000);
}
```

The above programming will convert the sensor's ADC value to a dB value. Then, the sensor's dB value will be compared with the calibrator's dB value to determine the sensor's error value and accuracy, as presented in **Table 1.**

Tabel 1. 1st Gy Max4466 Sound Sensor Measurement Data

No	SLM (dB)	sensor 1 (dB)	Accuraci %	Error%
1	38	37	97.37	2.63
2	39	37	94.87	5.13
3	42	43	97.62	2.38
4	45	47	95.56	4.44
5	49	49	100.00	0.00
6	51	50	98.04	1.96
7	55	55	100.00	0.00
8	58	56	96.55	3.45
9	63	62	98.41	1.59
10	68	69	98.53	1.47
Rata-rata			97.69	2.31

The sensor output data in **Table 1** shows the accuracy value and error value or measurement error on the 1st Gy Max 4466 sound sensor, with an average accuracy of 97.69% and an average error value of 2.31%. Equations 3.1 and 3.2 explain the formula for carrying out these calculations.

$$Accuracy\ (\%) = \left(1 - \left|\frac{Y - X_n}{Y}\right|\right) x\ 100\% \quad \textbf{(3.1)}$$

$$Error\ (\%) = \left|\frac{Y - X_n}{Y}\right| x\ 100\% \quad \textbf{(3.2)}$$

Y is the Reference/Standard Parameter Value, X_n is the Measured Parameter Value ($iteration - n$ on the sensor), and $\bar{X}_n$ is the Overall Average Value of n Parameters (Arkudanto, 2018).

The following is a graph of the 1st Gy Max4466 sound sensor measurement results with a standard measuring instrument (SLM) shown in **Figure 5.**

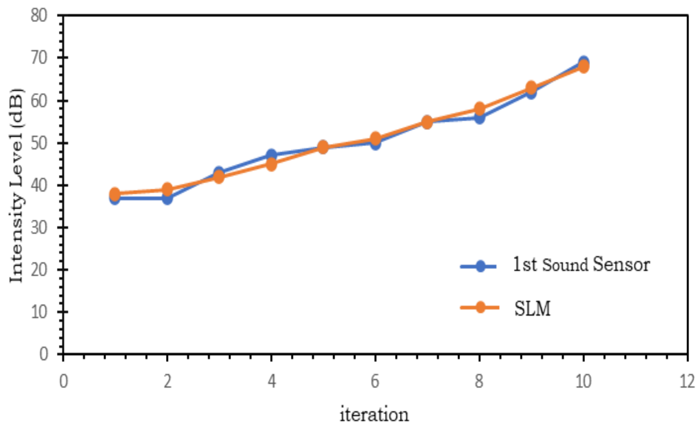


Figure 5. Graph of Intensity Level Value (dB) of the first sensor.

The exact measurement will be done on the second sensor, determining the dB value from the second sensor and the accuracy and error values listed in **Table 2**.

Tabel 2. 2nd Gy Max4466 Sound Sensor Measurement Data

No	SLM (dB)	sensor 2 (dB)	Accuraci %	Error%
1	38	36	94.74	5.26
2	39	37	94.87	5.13
3	42	44	95.24	4.76
4	45	44	97.78	2.22
5	49	49	100.00	0.00
6	51	49	96.08	3.92
7	55	56	98.18	1.82
8	58	56	96.55	3.45
9	63	60	95.24	4.76
10	68	67	98.53	1.47
Rata-rata			96.72	3.28

Table 2 produces an average accuracy value of 96.72% and an error value of 3.28%. The data above shows a curve or graph like **Figure 6**.

Subsequent measurements will be made on the third sound sensor by measuring the dB level and determining its accuracy and error values . The data from the third sensor measurement results are in **Table 3**.

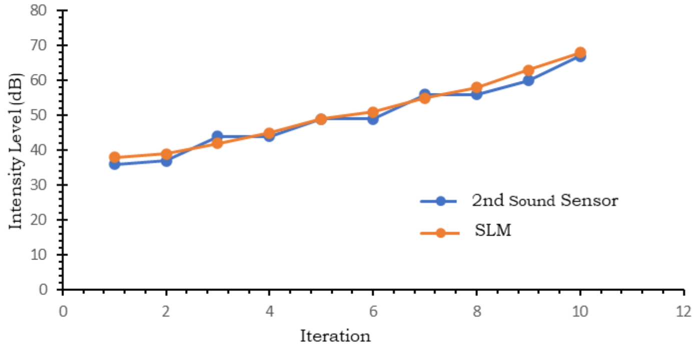


Figure 6. Graph of Intensity level (dB) value of the second sensor.

Tabel 3. Data from the 3rd Gy Max4466 Sound Sensor Measurements

No	SLM (dB)	sensor 3 (dB)	Accuracy %	Error%
1	38	35	92.11	7.89
2	39	35	89.74	10.26
3	42	41	97.62	2.38
4	45	44	97.78	2.22
5	49	49	100.00	0.00
6	51	53	96.08	3.92
7	55	54	98.18	1.82
8	58	56	96.55	3.45
9	63	61	96.83	3.17
10	68	66	97.06	2.94
Rata-rata			96.19	3.81

Table 3 produces an average accuracy value of 96.19% and an error value of 3.81%; from the table above, the curve obtained is shown in **Figure 7**.

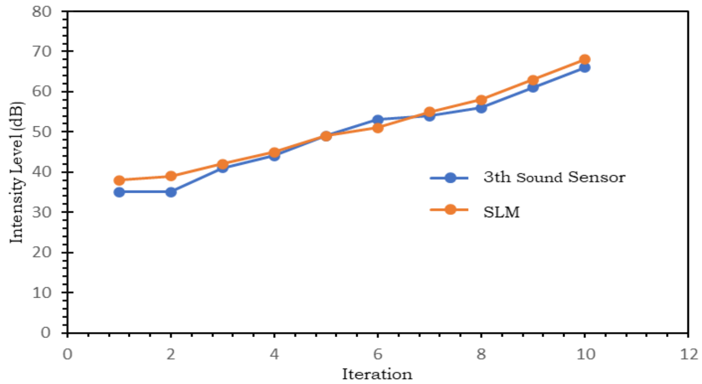


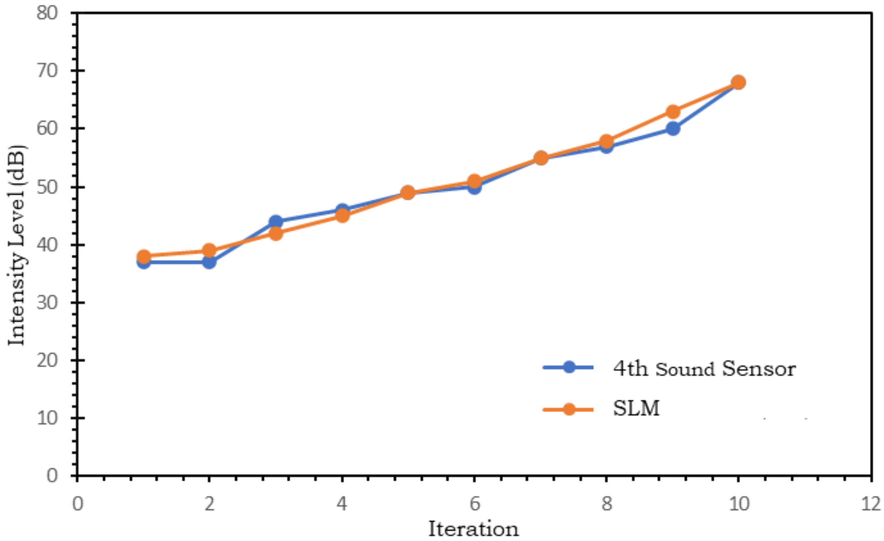
Figure 7. Graph of the third sensor's intensity level (dB) value.

Subsequent measurements were carried out on the fourth sensor, looking for dB values, accuracy, and error values , which can be seen in **Table 4**.

Table 4. 4th Gy Max4466 Sound Sensor Measurement Data

No	SLM (dB)	sensor 4 (dB)	Accuracy %	Error%
1	38	37	97.37	2.63
2	39	37	94.87	5.13
3	42	44	95.24	4.76
4	45	46	97.78	2.22
5	49	49	100.00	0.00
6	51	50	98.04	1.96
7	55	55	100.00	0.00
8	58	57	98.28	1.72
9	63	60	95.24	4.76
10	68	68	100.00	0.00
Rata-rata			97.68	2.32

Table 4 shows an average accuracy value of 97.68% and an error value of 2.32%. The results of the table above are shown as a curve or graph, which can be seen in **Figure 8**.



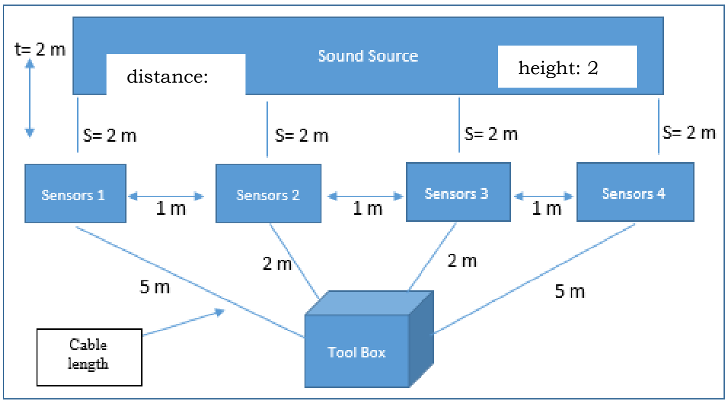
Gambar 8. Grafik Nilai Tingkat Intensitas (dB) sensor ke-4.

3.3 Overall Data Analysis

Field data collection was carried out at PDAM Way Rilau for one day within four hours from 08.00 to 12.00. It was carried out in April after all the tools were ready and the sensors were calibrated and ready for monitoring. Data collection was carried out in a pump room, which the agency mentioned as the IPA 1 Lab, which can be seen in Figure 9.

(a) Looks Outsite

(b) Deep Look



(c) Sound Source Plan and Equipment Placement

Figure 9. Research Room Area (a) Outer View (b) Inside View (c) Sound Source Plan and Equipment Placement

Figure 9 shows the IPA 1 pump room as seen from the outside in Figure (a) with a room area of 15x10 m, in Figure (b) is the placement of the tool above with a height of 2 m to the sound source, and in Figure (c) is a plan for the location of the sound source below and the placement of the equipment with a height of 2 m, and the distance between the tools is 2 m from the sound source. This sound source is the author's research this time, and the author has obtained monitoring of the noise meter shown in **Figure 10**.

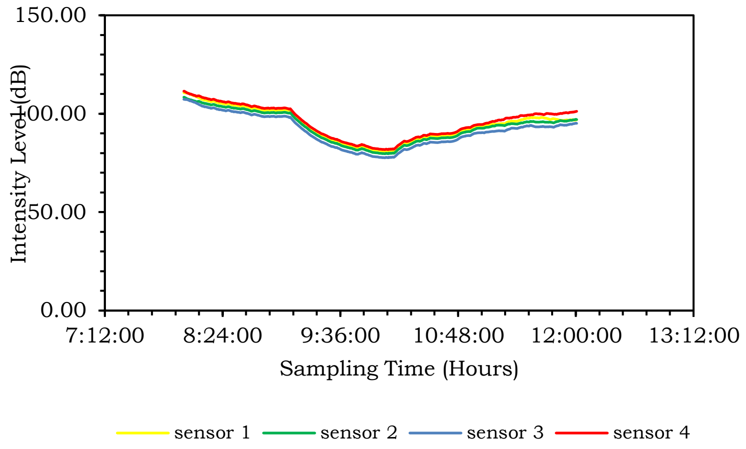


Figure 10. Graph of 1st-4th sensor result data (dB) against time (s)

Figure 10 is a noise monitoring graph that was carried out from 08.00-12.00 WIB. The results of measuring the noise level generated through the 1st sensor, 2nd sensor, 3rd sensor, and 4th sensor have been processed using exponential smoothing data analysis. Exponential smoothing is the exponential smoothing of data using the moving average method, which gives exponential or multilevel weight to the latest data so that it will receive more significant weight. The monitoring results of noise measurements at PDAM Way Rilau on the first sound sensor produced the lowest noise level in the pump room of 69.60 dB at 09:40:46 WIB, and the highest was 116.17 dB at 11:32:02 WIB, on the second sound sensor generates the sensor noise level

the lowest was 68.35 dB at 09:40:46 WIB and the highest was 113.12 dB at 08.57:17 WIB and 11:11:03 WIB, on the third sensor the lowest noise level was 66.32 dB, and the highest noise level is 111.09 dB. The fourth sensor produces the lowest noise level of 70.45 dB at 09:40:46 WIB and the highest noise level of 115.92 dB at 11:56:02 WIB. Based on the measurement results, the sound generated in the pump room is different every hour. The noise level generated from sensors 1-4 shows an average noise value of 92.10 dB. This value can be considered high/dangerous if workers are continuously exposed to noise for 8 hours without taking turns because, based on Permenaker No. 13 of 2011 concerning the threshold value in the workplace, the maximum noise is 70 dB. The solution to this problem is that workers should use earplugs and personal protective equipment to prevent health problems due to noise or take turns on guard and not be exposed to more than 8 hours a day. Noise monitoring is carried out via the website in real-time. The following is a display of the noise monitoring website in **Figure 11**.

Figure 11. Display of the noise monitoring Webserver

4. Conclusions

Noise monitoring tools have been designed to detect noise with an average accuracy rate of 97.07% and an average error value of 2.93%. This system can monitor noise levels with one server in the work environment and can be measured in real-time. The noise level generated from the PDAM Way Rilau pump room is classified as high/dangerous because it has exceeded the noise threshold value of 70 dB.

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