



# Implementation of IoT Platform Analytics for Monitoring Coastal Water Conditions

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**Abstract** In 2018, the level of damage to mangrove forests reached 5.9 million hectares or around 68.8%. As the damage increases, some action must be taken to maintain sea water quality by researching and monitoring water quality. The research can be done conventionally but will have several obstacles including research time, consistency of research time, distance traveled, and recap of research data. Therefore, will be made a platform that can handle these problems based on the Internet of Things (IoT). By utilizing IoT, monitoring can be carried out more efficiently by detecting temperature, salinity, dissolved oxygen, pH, water turbidity, and water levels using sensors. The sensor is implanted on Arduino and then sent using ESP32 to MQTT and then will be visualized using ELK-Stack and analyzed using the Water Pollution Index (IP) method which is calibrated with the Support Vector Machine (SVM) method. If an anomaly occurs, a notification will be sent to Telegram. The research of monitoring water quality and application functionality has been successfully carried out with scenarios of testing applications that are connected to devices and sensors on the coast of mangrove forests. The result of this study indicates that the sensor device can transmit data according to sea water quality conditions in real time. The data was successfully displayed in the form of tables and graphs on the website using ELK-Stack. Besides that, the testing using SVM method gives result 95% for accuracy, 94% for average precision, 95% for average recall, and 94% for average f1-score. It has been successful sending notification to user's telegram if there were an anomaly.

**Keyword:** IoT, MQTT, ELK-Stack, SVM, Water Monitoring

## 1. INTRODUCTION

Indonesia has 17,499 islands with a total area of around 7.81 million km<sup>2</sup>. Of the total area of the area, 3.25 million km<sup>2</sup> is ocean and 2.55 million km<sup>2</sup> is the Exclusive Economic Zone. Only about 2.01 million km<sup>2</sup> is land [1]. With the abundance of the sea area, people often make it a livelihood. The livelihoods generated will also vary according to the level of compatibility of each region with the environment.

A healthy and well-functioning mangrove forest can store large amounts of organic carbon (removing carbon dioxide from the atmosphere), protecting the shoreline and inland against natural hazards like hurricanes [2], [3], improve water quality, protect coastal communities from flood and storm impacts, and support fish species, migratory birds, and other biodiversity [4].

The current level of damage to mangrove forests is 5.9 million hectares or about 68.8%, where what happened in forest areas reached 1.7 million hectares or around 44.73%. Meanwhile, the damage that occurred outside the forest area reached 4.2 million hectares or 87.5%. This damage is caused by several factors, including ineffective management, weak law enforcement, and differences in perceptions of mangroves, as well as damage caused by economic pressures such as pollution and sedimentation. The natural factors are landslides, floods, and tsunamis [5]. Mangrove forests have also been cleared to make way for rice paddies, rubber trees and palm oil plantations. Human encroachment, including

building hotels and marinas; unsustainable tourism, and lumber industries [6]. Water pollution has become one of the most serious problems in many countries especially in developing countries like Indonesia [7]. Over time, it is possible that the environment will change. These environmental changes will affect the survival of marine life, especially mangroves.

Today's technology is much more developed than before, especially the role of the Internet of Things (IoT) which makes all human work easier. IoT is often used by humans in the fields of health, environment, transportation, smart home, business, etc. IoT is created using a program designed by the developer where the system applies several elements, namely artificial intelligence (AI), connections between networks, sensors, and communication between two devices to create automation.

Monitoring water conditions in real-time is a critical mission to preserve the water ecosystem in maritime and archipelagic developing countries, including Indonesia that is relying on the wealth of water resources [8]. The application of technology to monitor seawater conditions in mangroves is one of the prevention and early treatment steps to keep mangroves to survive and live longer and benefit the surrounding environment. Improving monitoring performance by utilizing IoT is one of the efforts to advance Indonesia in the environmental field. IoT provides convenience in automation so that researchers do not need more effort in conducting research.

At this time, several technologies have been applied to support mangrove life, especially in terms of monitoring. Therefore, this study proposes cloud based IoT technology as well as several new methods to monitor seawater conditions around mangroves. In this tool there are several sensors including temperature sensors, salinity, dissolved oxygen, pH, and water turbidity. It is hoped that this research can provide a solution so that mangroves can survive so that they provide many benefits for the surrounding environment.

## 2. RELATED WORKS

In carrying out this research, we were inspired and referenced a lot from previous studies related to the background of the same problem. The following is related research related to this study.

Valerio et al. [8] giving a concept of a wireless sensor network (WSN) for real time remote sea water quality monitoring. Each node is equipped by sensor temperature, ambient light, conductivity, dissolved oxygen, pH, dissolved ion, dan turbidity. They use ZigBee protocol to communicate between sensor and controller. Also using wireless using HTTP protocol to communicate between gateway and cloud. However, it doesn't have interface for user monitoring like website or something else.

Geetha et al. [9] provide a detailed survey of recent works carried out in the field of smart water quality monitoring. They suggested to use pH, turbidity, and conductivity sensors. Then to communicate with the internet using WiFi module. And they use ubidots website platform. However, it doesn't have telegram for sending a message if there were an anomaly.

Trevathan et al. [10] presents a simple and flexible open-source internet of things (IoT) electronics design for viable near real-time environmental measurements to rigors of aquatic settings. They use temperature, pH, DO, conductivity, light, and turbidity sensor. However, they don't have recap data in platform and checking if there were an anomaly.

Kamarul et al. [11] suggest and internet of things (IoT) based system implementation by embedding the radio frequency identification (RFID) and implement wireless sensor network (WSN) system that deployed in vegetation area. It measured water parameter using pH and temperature sensor. They use Digi Mesh protocol to surpass the signal attenuation. The data will be visualized in mobile application. However, it doesn't have machine learning, recap, and exporting data.

Eric et al. [12] aimed to design and developed a solar powered automated water management system for bio floc production using internet of things (IoT). They make a mobile application which has the following features: account management, fish/shrimp profile, water quality management, auto feeding and manual controls. It also using DO, pH, temperature to managing the system. However, they haven't machine learning method to analyze the data.

### 3. SYSTEM DESIGN

After carrying out the literature study and experiment stage, the next stage is making a design system. The picture below is a system design in this study which describes the system in outline. In the picture, there are the main components and the technology used in making this study.

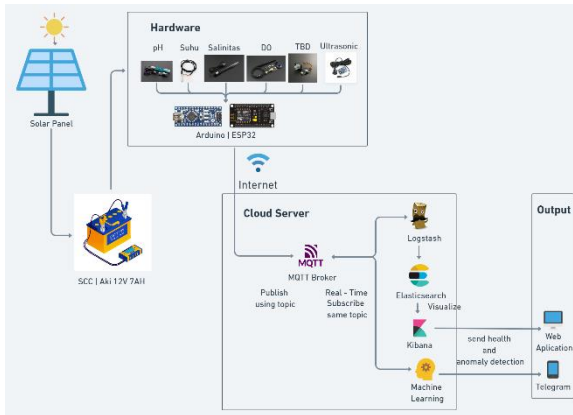


Fig. 1. System Design

Fig. 1 is an overview of the system that has been created. In the picture there are several parts including Solar Panel, solar charge controller (SCC), Hardware, Cloud Server, and Output. The parts are connected sequentially starting with the solar panel receiving power from the sun and sending the power to the battery via the SCC. The SCC also connects the battery to the hardware.

Hardware is a tool designed to detect and retrieve data from sensors in water. In that section there are Arduino, sensors, and ESP32. These sensors include pH, temperature, salinity, dissolved oxygen, water turbidity, and water level. The sensors will be applied under the water and Arduino will retrieve the data. And then ESP32 as publisher will send data into broker MQTT in cloud service.

The data that has been sent to the cloud server will be processed into information. The application that will be created will be packaged in a container on docker. That way, applications can be run simultaneously using different ports. In cloud service there were some microservice there are MQTT broker, ELK-Stack, and machine learning. MQTT save all data into some topic that is device/sensor/DSX0001/data.

There are two parallel system for visualizing and processing the data using machine learning. Logstash as subscriber pick up the data from MQTT broker and forward to Elasticsearch database NoSQL. Kibana will send the request to get the data from Elasticsearch and visualize into table and graph. The output of this system is website monitoring.

Besides that, the data will be taken and processing by SVM method, which calibrated with water pollution index. In SVM also known support vector classification) SVC and support vector regression (SVR). SVC used to classification the data into some class that calibrated with water pollution index. SVR will predict the data class in the future.

The data will be parsed into float type and every data income will be given a label using water pollution index formula. Dataset split into data training and testing. After getting that label, data will be training using SVM method and giving a conclusion that saved into *joblib* file. Testing data ready to be tested using *joblib* file. If there are anomalies, this method will send notification message into user's telegram.

### 3.1. Mangrove Standard Quality

Seawater quality standard is a measure of the limit or level of living things, substances, energy or components that exist or must exist and/or pollutant elements whose existence is tolerated in seawater [13]. After conducting a literature study, the parameter values for a good mangrove ecosystem were obtained.

**TABLE I.** SEAWATER QUALITY STANDARD OF THE MINISTER OF ENVIRONMENT NUMBER 51 of 2004 [13]

Parameter	Value
Temperature (°C)	28 - 32
pH (-)	7 – 8.5
Salinity (ppt)	< 34
DO (ppm)	> 5
Water Turbidity (NTU)	< 5

The table above is a range of sea water quality that is suitable for mangrove life. These parameters will be used to determine the water pollution index class in the SVM method. A good mangrove must have a good level of water quality that has a temperature ranging from 28-32 C, pH between 7-8.5, salinity or salinity level of less than 34 ppt, oxygen content of more than 5 ppm and less turbidity of water. of 5 NTU.

### 3.2. Water Pollution Index

$$PI_j = \sqrt{\frac{\left(\frac{C_i}{L_{ij}}\right)_{Max}^2 + \left(\frac{C_i}{L_{ij}}\right)_{Avg}^2}{2}} \quad (1)$$

$PI_j$  = Water Pollution Index  
 $C_i$  = Concentration of Water Quality Parameters  
 $L_{ij}$  = Concentration of Water Quality Standard Parameters

The formula above is a determination of the water pollution index and then the value will be classified into four classes.

**TABLE II.** Classification of Water Pollution Index

Class Index	Score	Conclusion
A	$0 \leq P_{ij} \leq 1$	Good
B	$1 < P_{ij} \leq 5$	Light Polluted
C	$5 < P_{ij} \leq 10$	Medium Polluted
D	$10 < P_{ij}$	Heavy Polluted

To determine the PI value, there are formula rules that need to be considered, including:

1. If the parameter concentration value decreases, the level of pollution increases, for example DO. Determine the theoretical value or the maximum value of  $C_{im}$  (eg for DO, then  $C_{im}$  is a saturated DO value). In this case the  $C_i/L_{ij}$  value of the measurement results is replaced by the calculated  $C_i/L_{ij}$  value.

$$\left(\frac{C_i}{L_{ij}}\right)_{new} = \frac{C_{im} - C_i(research)}{C_{im} - L_{ij}} \tag{2}$$

**TABLE III.** RELATIONSHIP BETWEEN DO AND TEMPERATURE [15]

Temp (°C)	DO (mg/l)	Suhu (°C)	DO (mg/l)	Suhu (°C)	DO (mg/l)
0	14.62	14	10.31	28	7.83
1	14.22	15	10.08	29	7.69
2	13.83	16	9.87	30	7.56
3	13.46	17	9.66	31	7.43
4	13.11	18	9.47	32	7.30
5	12.77	19	9.28	33	7.18
6	12.45	20	9.09	34	7.06
7	12.14	21	8.91	35	6.95
8	11.84	22	8.74	36	6.84
9	11.56	23	8.58	37	6.73
10	11.29	24	8.42	38	6.62
11	11.03	25	8.26	39	6.51
12	10.78	26	8.11	40	6.41
13	10.54	27	7.97	> 40	5.5

$C_{im}$  value is obtained from the relationship between saturated dissolved oxygen concentration and temperature at air pressure of 760 mmHg which is a study conducted by Gerald A Cole (1983) [15].

2. If the standard  $L_{ij}$  value has a range, then the average  $L_{ij}$  value must first be found.

$$- \quad \left( \frac{C_i}{L_{ij}} \right)_{new} = \frac{C_i - L_{ij}(avg)}{L_{ij}(min) - L_{ij}(avg)} \quad (3)$$

$$- \quad \left( \frac{C_i}{L_{ij}} \right)_{new} = \frac{C_i - L_{ij}(avg)}{L_{ij}(max) - L_{ij}(avg)} \quad (4)$$

3. The doubts arise if two values ( $C_i/L_{ij}$ ) are close to the reference value of 1.0, for example  $C_1/L_{1j} = 0.9$  and  $C_2/L_{2j} = 1.1$  or the difference is very large, for example  $C_3/L_{3j} = 5.0$  and  $C_4/L_{4j} = 10.0$ . In this example the degree of damage to the water body is difficult to determine. The way to overcome this difficulty is

$$- \quad \left( \frac{C_i}{L_{ij}} \right)_{research} \leq 1$$

$$\left( \frac{C_i}{L_{ij}} \right)_{research} = \left( \frac{C_i}{L_{ij}} \right)_{research} \quad (5)$$

$$- \quad \left( \frac{C_i}{L_{ij}} \right)_{research} > 1$$

$$\left( \frac{C_i}{L_{ij}} \right)_{research} = 1 + 5 \log \left( \frac{C_i}{L_{ij}} \right)_{research} \quad (6)$$

4. After determining the new  $C_i/L_{ij}$  value, then determine the average value and maximum value of all these results.  
5. Then determine the price of  $P_{ij}$ .

### 3.3. SVM Method

Data that has received a label from IP, will be trained using the SVM method. To get the hyperplane line can use the formula:

$$\vec{w}\vec{x} + b = 0 \quad (7)$$

And to get the maximum margin between the two classes can use the formula:

$$\bar{w}\bar{x} + b \leq -1 \text{ dan } \bar{w}\bar{x} + b \geq 1 \tag{8}$$

SVM has a kernel that can provide convenience because in the process it is used to determine the supporting vector. In this study, we implemented an SVM module with a Gaussian Radial Basis Function (RBF) kernel.

$$K(\bar{x}_i, \bar{x}_j) = \exp\left(-\frac{\|\bar{x}_i - \bar{x}_j\|^2}{2\sigma^2}\right) \tag{9}$$

The output of this SVM is a classification class according to the water pollution index. After getting the IP class label from the SVC method, then the training data will be processed using the SVR method to get prediction class in the future. Then to perform the test, you can enter the desired date.

#### 4. EXPERIMENT RESULT AND ANALYSIS



Fig. 2. Implementation Stations Place

The experiment of this hardware was carried out at three stations on the coast of *Gunung Anyar Surabaya Mangrove*. The data obtained from this study are data taken from station 3 but in different locations. In fact, station 1 could not be tested because the waves that came on the beach were so high that made the hardware trouble. Then at station 2 an experiment has also been carried out, but at that location couldn't reach the signal so the



data that obtained by each sensor cannot be sent to the internet. Therefore, the data is taken from station 3 with different locations.

Some testing including hardware, application, calculation of water pollution index, and telegram bot has been done well. All the testing is aimed at making sure the system work well. Started from solar panel have charge the accu that shown in the SCC.



**Fig. 3.** Solar Charge Controller (SCC)

There are solar panel, accu, and hardware symbols in SCC with the arrow to link each other. It can control the power of sun from solar panel to fill the accu and then accu will give a voltage to the hardware. The implementation of testing hardware needs to connect with the SCC before solar panel get sunshine.

#### 4.1. Hardware Testing

The experiment at station 3.1. has been carried out and the results are as shown in the table above. The table shows the values for each sensor from 10:00 to 1:00. The data has been lost at 1:00 – 09:00 because the accu has run out of power. Overall, data is suitable but in some conditions like at 1:00 the data income so high because accu in critical time of power.

The testing at station 3.2. has been done and the results are as shown in the table above. From that table, the data income at 10:00 until 20:00. Besides that, the accu has run out of power at 21:00 until 10:00 next day. The conductivity in that station was so low only reach around 11. Turbidity also gives a low value because the water very dirty.

**TABLE IV.** Data Sensor at ST 3.1

Timestamp	DO	EC	pH	TBD	Temp	WL
7/8/2022 10:00	5.18	3.46	3.14	4.97	30.6	20
7/8/2022 11:00	4.61	39.2	2.89	5	33.4	20
7/8/2022 12:00	4.93	39.9	7.95	2.27	32.1	20
7/8/2022 13:00	4.93	40.5	7.95	2	31.1	20
7/8/2022 14:00	4.93	40.5	7.95	2.8	31.5	20
7/8/2022 15:00	4.93	40.5	7.95	2.81	31.4	20
7/8/2022 16:00	4.96	40.5	7.92	2.85	31.3	20
7/8/2022 17:00	4.88	40.5	7.95	2.78	31	20
7/8/2022 18:00	5.09	41.2	7.92	2.82	30.4	20
7/8/2022 19:00	5.15	41.2	7.95	2.91	30.1	20
7/8/2022 20:00	5.38	41.9	7.95	4.29	29.9	20
7/8/2022 21:00	5.38	41.9	7.95	2.62	29.7	20
7/8/2022 22:00	5.41	41.9	7.95	2.59	29.4	20
7/8/2022 23:00	2.62	29.5	11.4	1.85	28.4	30.1
7/9/2022 0:00	5.38	41.9	7.95	0.53	29	20
7/9/2022 1:00	16	64.8	4.58	8.12	41.7	33

**TABLE V.** Data Sensor at ST 3.2

Timestamp	DO	EC	pH	TBD	Temp	WL
7/9/2022 10:00	6.68	11.1	7.95	0.43	27.6	20
7/9/2022 11:00	5.74	8.46	7.9	0.44	28.9	20
7/9/2022 12:00	5.6	10	7.76	0.32	29.4	20
7/9/2022 13:00	5.05	12.2	7.84	0.34	32.2	20
7/9/2022 14:00	5.3	11.5	7.76	0.34	31	20
7/9/2022 15:00	5.61	11.8	7.76	0.3	30	20
7/9/2022 16:00	5.75	12.1	7.95	0.26	29.3	20
7/9/2022 17:00	6	12	7.73	0.24	28.4	20
7/9/2022 18:00	6.06	13.2	7.95	0.34	27.9	20
7/9/2022 19:00	5.94	9.04	7.95	0.44	27.6	20
7/9/2022 20:00	5.97	9.25	7.81	0.46	27.4	20

The testing at station 3.3. has been done and the results are as shown in the table above. Previously, at 00:00 – 11:30 the data did not enter because the power in the battery ran out

and the placement of the solar panel did not get the sun. At 12:00 the solar panel got power from the sun. However, at that time the Arduino could not turn on because the voltage generated by the battery was still lacking so that only the timestamp and datetime were sent. The table shows the values for each sensor from 10:00 to 12:50. At 13:30 - 17:30 the data did not come because didn't get a signal, so at 17:00 the writers moved the tool to a place where there was a signal. Then at 21.30 and above the data does not enter because the power in the battery has run out.

**TABLE VI.** Data Sensor at ST 3.3

<b>Timestamp</b>	<b>DO</b>	<b>EC</b>	<b>pH</b>	<b>TBD</b>	<b>Temp</b>	<b>WL</b>
7/10/2022 12:00	6.96	11.2	7.76	0.51	25.8	20
7/10/2022 13:00	5.79	7.09	7.73	2.36	27.4	20
7/10/2022 14:00						
7/10/2022 15:00						
7/10/2022 16:00						
7/10/2022 17:00						
7/10/2022 18:00	6.87	7.52	7.62	0.75	26.5	20
7/10/2022 19:00	6.32	6.7	7.68	4.96	26.6	21
7/10/2022 20:00	6.32	6.65	7.7	4.8	26.6	20
7/10/2022 21:00	6.32	6.91	7.73	4.92	26.6	20

## 4.2. Application

Data that is already in the MQTT broker will be retrieved by Logstash who acts as a subscriber. Before entering Elasticsearch, Logstash as a pipeline or connector to process the data structure, more over the output from the sensor is a string so it needs to be separated and specified type for each sensor. There are input, filter, and output inside the Logstash script. Input used to configurate the MQTT credential that coming to Elasticsearch. Filter is used to modify data structure. Output is used to determine the destination that is Elasticsearch.

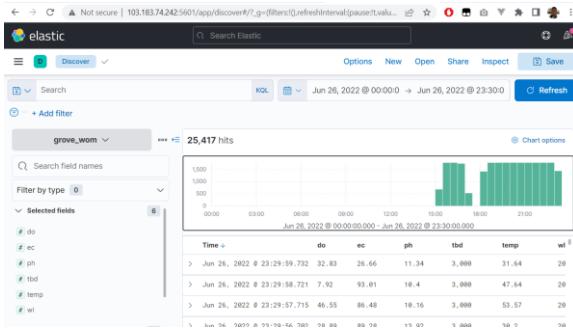


Fig. 4. Discover Menu

On the Kibana, data that incoming can be monitored in real-time on the discover menu. It shows the amount of data entered is one every second. There weren't always data that comes in every second, but also in the next second the incoming data will be a lot.

Besides that, Kibana also provides a dashboard menu to monitor incoming data in an attractive appearance that the user wants. After entering the dashboard, the user can create a card or section for the desired display.

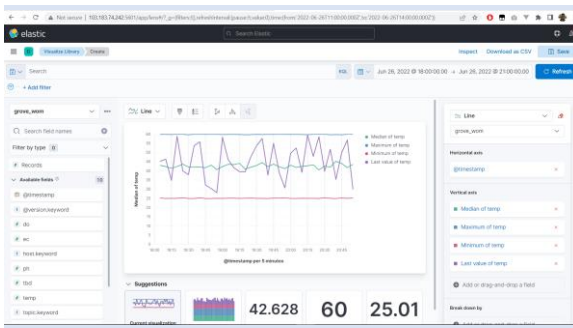


Fig. 5. Dashboard Menu

Users can adjust the contents of the dashboard to view monitoring graphs for all sensors or specific sensors they want. In the picture above, the temperature sensor enters every second with normal temperature testing, then transferred to hot water so that the temperature rises and then transferred to cold water so that the temperature drops drastically.

	A	B	C	D	E	F
1	@timestamp	Median of	Maximum	Minimum	Last value of temp	
2	18:05	43.085	59.92	25.27	45.23	
3	18:10	42.39	59.95	25.02	46.4	
4	18:15	41.465	59.85	25.12	34.92	
5	18:20	42.46	59.99	25.1	58.94	
6	18:25	43.723	59.97	25.41	40.04	
7	18:30	42.125	59.71	25.03	38.02	
8	18:35	42.143	59.99	25.04	53.68	
9	18:40	42.133	59.97	25.4	55.92	
10	18:45	41.78	59.9	25.01	32.33	
11	18:50	43.18	59.99	25.05	30.48	
12	18:55	40.779	59.95	25.1	28.22	
13	19:00	42.41	59.82	25.08	58.39	
14	19:05	43.62	59.93	25.2	46.17	
15	19:10	43.465	59.96	25.2	41.76	
16	19:15	44.19	59.87	25.07	39.64	
17	19:20	41.02	59.72	25.17	39.55	

Fig. 6. Result of Export Data

The dashboard also provides a export data from the dashboard card that has been created by pressing the three-dot button and selecting "Download as CSV". Kibana will generate automatically from the selected horizontal and vertical parameters.

### 4.3. Calculation of Water Pollution

TABLE VII. Example Data

#	DO	EC	pH	TBD	Temp	WP Index
1	3.59	66.56	9.25	2.8	26.08	2.22
2	21.69	53.28	13.98	2.81	34.49	6.06
3	14.95	67.72	11.08	2.78	51.7	8.05
4	30.73	49.06	13.11	2.82	51.19	8.13
5	40.36	67.02	5.08	2.91	58.37	10.25

This calculation uses dummy data in order to obtain varied class results. Table above, is a sample that will be used for calculations and will later be tested for telegram bots.

TABLE VIII. Example of Water Pollution Index Calculation

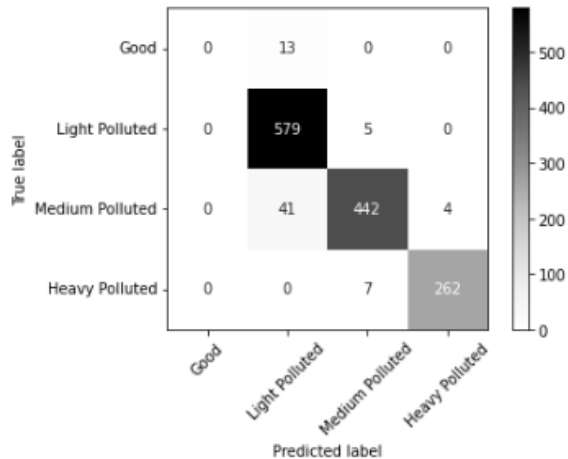
Calculation of number 1				
	Ci	Li	Calculation	Ci/Lij
DO	3.59	5	$\left(\frac{C_i}{L_{ij}}\right)$ $= \frac{8.11 - 3.59}{8.11 - 5}$	1.45
EC	66.56	34	$\left(\frac{C_i}{L_{ij}}\right)$ $= 1 + 5 \log(1.96)$	2.45
pH	9.25	7 - 8.5	$\left(\frac{C_i}{L_{ij}}\right)$ $= \frac{9.25 - 7.75}{8.5 - 7.75}$	2
Temp	26.08	28 - 32	$\left(\frac{C_i}{L_{ij}}\right)$ $= \frac{26.08 - 30}{28 - 30}$	1.96
TBD	2.8	5	$\left(\frac{C_i}{L_{ij}}\right) = \frac{2.8}{5}$	0.56
Ci/Lij Max	2.45			
Ci/Lij Avg	1.7			
PI	$PI_j = \sqrt{\frac{(2.45)^2 + (1.7)^2}{2}}$			2.11 (Light Polluted)

The table above is a calculation of the water pollution index at number 1 and the maximum Ci/Lij value is 2.45, the Ci/Lij average is 1.7 and the IP is 2.11, which means it is included in class B, which is lightly polluted. The calculation is entered in the program so that with the aim of getting a class that will later be used as a label on the SVC. And then the SVC will be training and giving a precision label classification.

#### 4.4. SVM Method

SVM Method has been testing using sample data from publisher MQTT in python script with various labels on every data income. The total of sample data is 5354. It splitted into 4000 training and 1354 testing data. Training data will be train using SVC and SVR method

with rbf as a default kernel from sklearn. The result of training will predict the classification of the current and future of class index.



**Fig. 7.** Confusion Matrix of SVC Method

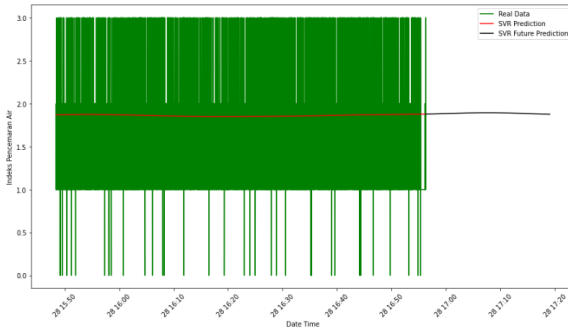
Confusion matrix will provide information on the comparison of the classification results performed by the system (predicted label) with the actual classification result (true label). The image above describes the true data from good class is 0, for light polluted class is 579, medium polluted class is 442, and heavy polluted class that is 262. The false data from good class is 13, light polluted class is 59, medium polluted class is 57, and heavy polluted class is 11. Overall, the true data is greater than false data. It means that the classification work well.

**TABLE IX.** Report Classification of Confusion Matrix

#	Precision	Recall	F1 - Score	Support
Good	0	0	0	13
Light Polluted	0.91	0.99	0.95	584
Medium Polluted	0.97	0.91	0.94	487
Heavy Polluted	0.98	0.97	0.98	269
Acc			0.95	1353

Macro Avg	0.72	0.72	0.72	1353
Weighted Avg	0.94	0.95	0.94	1353

Sklearn also provides report classification of confusion matrix to measure the performance of model that made like the table above. Every index class will be detailed into Boolean model and calculated of the True Positive (TP), False Positive (FP), False Negative (FN), and True Negative (TN). From that parameter will be scored and be calculated to measure precision, recall, f1-score, and accuracy. Every class have a good score except first index because the results are only a few data obtained on the index. The weighted average (averaging the support-weighted mean per label) precision, recall, f1- score, and accuracy of all the data reach around 90% that indicates that the SVC method can provide excellent classification results.

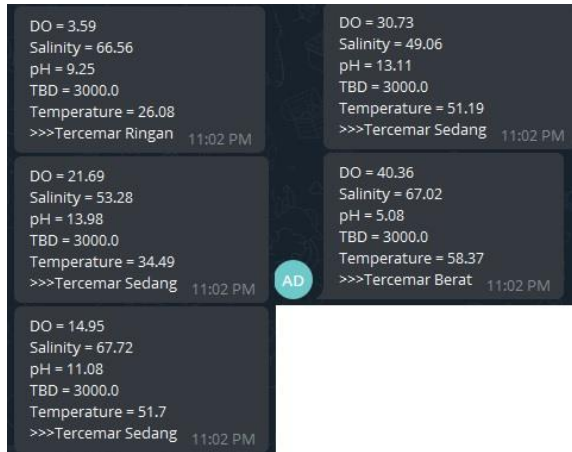


**Fig. 8.** Predict Class of SVR Method

The results of the application of the SVR method to predict index classes in the future which looks like the picture above. In the picture there is a green line which means the class index of the original data, while red is the index of the training prediction class and for black is the class index in the future.

#### 4.5. Telegram Bot





**Fig. 9.** Result of Anomalies in User's Telegram

The data that has been tested by the SVM method will produce a class output that is in accordance with the water conditions at that time. After that the message is sent to Telegram using a registered bot. The message consists of the value of each sensor and a conclusion on water pollution. Delivery is done by sending a GET request on the Telegram API where the parameters and tokens obtained match the bot's identity.

## CONCLUSION

This study aims to build an application platform that can be used as a smart system based on IoT technology for monitoring the condition of mangrove coastal waters. In its implementation, a tool and application were developed to help the related parties or the surrounding community in monitoring the condition of coastal water quality in real-time. The sensor can work properly and the ESP32 can send data to the internet using the MQTT communication protocol. On the cloud server, the data was successfully retrieved by Logstash and sent to the Elasticsearch database and then visualized using Kibana. The application of machine learning for classification and prediction has also been successfully carried out by taking data from MQTT and processing it in a python script. On the kibana, the user can adjust the visual appearance of the sensors that have been installed, making it easier for the user to control or monitor the state of coastal water conditions in real-time. However, for the application have a stuck that is ELK-Stack is difficult to be modified and

the main problem is signal to communicate with the internet very hard to reach at that station. So, for the next research, the author hope it can solve the problems.

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