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EARLY WARNING SYSTEM AND MONITORING OF RIVER WATER QUALITY BASED ON INTERNET OF THINGS

Vito Hafizh Cahaya Putra[1], Mokhamad Hendayun[2], Purnomo Yustianto[3]
Langlangbuana University[1,2 3]
[1] vitohafizhcputra@gmail.com, [2]mokh.hendayun@gmail.com, [3]yustianto@gmail.com

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ABSTRACT
River conditions in Bandung City are currently in critical condition. This study aims to create an early warning system and monitoring of river water quality based on the Internet of Things in the hope that early warnings sent through the telegram application belonging to the Bandung City DLHK officer and the Twitter social media website, can inform the Bandung City DLHK officer that a river is in a polluted condition and the officer can immediately go to the location of river water to carry out mitigation, and give warnings to the community. The research method used using the waterfall method which consists of: needs analysis, system design, implementation, testing, and maintenance with sequential implementation. Data collection methods were carried out in several ways, namely: interviews, giving questionnaires, and literature studies used in this study sourced from books, journals, seminar presentations, and the internet as references in the research conducted. Based on the research that has been carried out, the following test results are obtained: black box testing is carried out in accordance with those contained in the test plan with the results of each test having valid results. The results obtained from the user acceptance test which are calculated using the Likert scale have an average value of 86.94% which fall into the category of strongly agree, and there are three guidelines which are a follow-up to the output of the early warning system that can be carried out either by the Environmental Service. and Cleanliness (DLHK) of Bandung City and the community..

INTRODUCTION

Indonesia has many rivers with a variety of sizes, both with large and small river lengths, especially in the city of Bandung, West Java (MUHAMMAD, 2020). Bandung has a large number of rivers with a total of 46 rivers that have a variety of long sizes. Referring to ppid data of Bandung city for the longest size of river in The City of Bandung, namely Kali Cikapundung with a length of 15.50 KM, and the river with the shortest size cikahiayangan with a length of 1.60 KM. The river in Bandung is used by the community for various activities, such as: washing clothes, bathing, irrigation sources, fish livestock, children's playgrounds, and tourism. However, the condition of the river in Bandung is currently in critical condition, there are many rivers that are in bad condition (Rahayu, Juwana, & Marganingrum, 2018). This is due to the large amount of waste dumped by the community around the river, and aggravated by companies that dump their industrial waste directly into the river (Arsyandi, Pratama, & Apriyanti, 2019).

People can feel the quality of river water that decreases such as: discoloration of river water, has an unpleasant smell, there are bubbles, the amount of garbage floating, until there are family members of the community who have diseases such as diarrhea, skin diseases, cancer, and other diseases (Christiady & Mussadun, 2014). That's because it is directly active in river water and utilizes river water for various purposes (Yogafanny, 2015). DLHK Bandung conducts regular monitoring that is carried out twice a year on 24 rivers to know directly the quality of river water, especially river water whose existence is near the industry (Angkotasan & Warlina, 2014). The occurrence of a decrease in river water quality known by the community, certainly can not be detected quickly, which allows the time of occurrence of river water pollution has been long, which automatically the longer the occurrence of pollution in river water will certainly have a severe impact on river water conditions (Nugraha & Budi Heri Pirngadie, 2017).

If a river that has a decrease in river water quality caused by public waste and industrial waste can be detected early, and can be immediately investigated by DLHK Bandung to find the cause of river water pollution that results in decreased river water quality, then it can minimize the widespread problem of river water pollution. So another alternative is needed to give a warning quickly if there is a polluted river (Wahjono & Setiaji, 2018).

In today's modern era, various technologies have been used in various sectors to support the realization of Smart Environment (Suhendra, 2017) which aims to improve the quality of the environment such as air, river water quality, to better waste management and support environmentally friendly energy that utilizes solar cells by absorbing solar energy (Putri, Baiquni, & Cahyono, 2019).

From the problem to know a river water in polluted conditions early on, it is necessary to build an early warning system based on the internet of things (Mahendra & Sukardi, 2021). Early warning system has been used for various purposes such as providing early warning from various natural disasters such as tsunami, mount merapi, to earthquake (Fitriawan, 2017). Early warning system is a series of communication systems between information and sensors, detecting events, and making decisions by the system (Nurdianto, 2018).

There is research that has been done on early warning systems to determine the quality of polluted river water, one of which is research conducted by (Ding, Zhang, Jiang, & Zhang, 2017) under the title Early Warning and Forecasting System of Water Quality Safety for Drinking Water Source Areas in Three Gorges Reservoir Area, China. The research focused on creating an early warning system and forecasting healthy water quality to drink, by providing early warning through the website in the form of a red box image on the parameters that the user or user wants to see. Although in the study has been done early warning delivery by the system if detected there is a poor water quality, but the delivery of early warning through the website in the form of a red box image can not be known quickly by the officer (Sianipar, 2020),because the officer must turn on the computer and access the website to see the image of the warning box.

Based on this, it is necessary to create an internet of things-based early warning system that can be sent through telegram applications and twitter social websites belonging to DLHK officers in Bandung. So by sending an early warning through telegram application and social media website Twitter is expected to inform dlhk officers of Bandung city directly that a river is polluted and the officer can immediately respond by heading to the location of river water to mitigate by examining business activities that dispose of wastewater directly into the river, and give warning to the community that a river is in polluted condition.

METHOD RESEARCH

The type of research method used in this study, using the type of applied research. Data collection is done in several ways, as follows:

a. The interview used in this study is a structured interview, in which the questions have been prepared, because the data/information needed has been designed. The interviewees were Industrial Analysts and Pollution Prevention from the Bandung City Environment and Hygiene Service which aims to obtain information about river water quality.

b. Giving Questionnaire, Questionnaires were given to get responses from respondents, namely DLHK Bandung City officers after accessing the system that had been built directly.

c. Sources of data used in this study are from books, journals, exposure to seminars, the internet and other literature that can be used as a reference in the research conducted.

The methodology used in developing the research system in this thesis uses the Software Development Life Cycle (SDLC) Waterfall Model. Waterfall Model is a process that is carried out step by step which must be passed waiting for the completion of the previous stage and runs sequentially. The methodology consists of five stages, namely: (1) Needs Analysis Phase, (2) System Design Phase, (3) Program Code Writing Phase, (4) Program Testing Phase, and (5) Program Implementation and Maintenance Phase, as in the following picture:

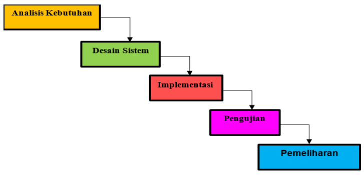


Figure 1 Waterfall Methodology

The system architecture is needed to describe the components that are needed as a whole in realizing the construction of a system. The following is a picture of the global architecture of the system to be built:

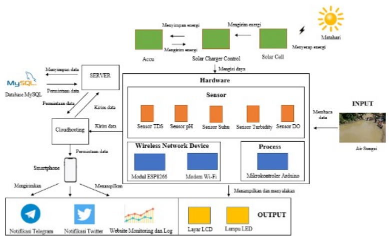
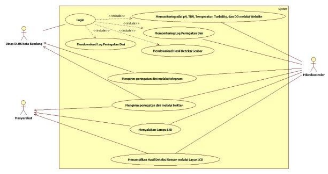


Figure 2 Architecture of an Internet of Things-Based Early Warning and Monitoring System for River Water Quality

The image use case diagram on the system built as follows:Figure 3 Use Case Diagram of an Early



Warning and Monitoring System for River Water Quality Based on the Internet of Things

The system workflow aims to describe the way the system runs from start to finish. The following is a flowchart of the system workflow:

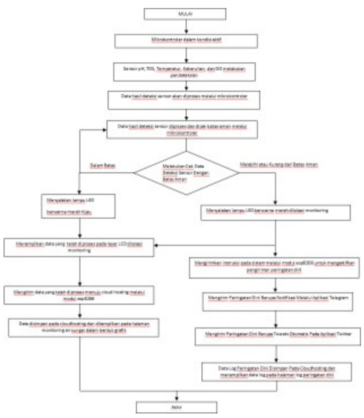


Figure 4 System Workflow.

RESULT AND DISCUSSION

A. Hardware Implementation

1. Connecting the pH Sensor with Arduino Mega

The pH sensor is used to detect pH parameters in river water. Below is a picture of the connection of the pH sensor device with the Arduino Mega microcontroller:

Figure 5 Installing a pH Sensor Device with Arduino Mega

2. Connecting TDS Sensor with Arduino Mega

TDS sensor (Total Dissolved Solid) is used to detect TDS parameters related to the amount of dissolved solids in river water. Below is an image of the connected TDS sensor device with a mega arduino microcontroller:

Figure 6 Installing a TDS Sensor Device with Arduino Mega

3. Connecting the Temperature Sensor with the Arduino Mega

Temperature sensors are used to detect heat or cold levels in a river water. Below is an image of the pairing of temperature sensor devices with mega arduino microcontrollers:

Figure 7 Installing a Temperature Sensor Device with a Mega Arduino

4. Connecting Turbidity Sensors with Arduino Mega

Turbidity sensors are used to detect turbidity levels in river water. Below is an image of the pairing of turbidity sensor devices with mega arduino microcontrollers:

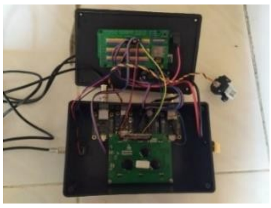


Figure 8 Installing a Turbidity Sensor Device with Arduino Mega

5. Connecting the DO Sensor with the Arduino Mega

Do sensor (Dissolved of Oxygen) has a function to detect the level of oxygen contained in river water. Below is an image of the connecting do sensor device with a mega arduino microcontroller:

Figure 9 Installing a DO Sensor Device with Arduino Mega

6. Connecting Solar Cell with Arduino Mega

The following is an image of the connection of solar cell, battery, solar charger control, and stepdown with mega arduino microcontroller:

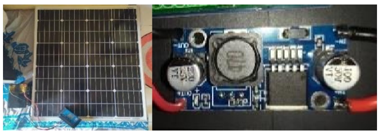


Figure 10 Installing a Solar Cell Device with Arduino Mega

7. Connecting esp8266 Module with Arduino Mega

Wi-Fi module (Wireless Fideality) esp8266 is used to transmit data that has been processed by microcontrollers on cloud hosting wirelessly over a Wi-Fi network. Below is the connecting Wi-Fi module esp8266 with a mega arduino microcontroller, as shown below:

Figure 11 Installing an ESP8266 Module Device with arduino Mega

8. Connecting led screen with Arduino Mega

LED light (Light Emitting Diode) is used as an indicator. Below is an image of the connected LED light device with a mega arduino microcontroller:

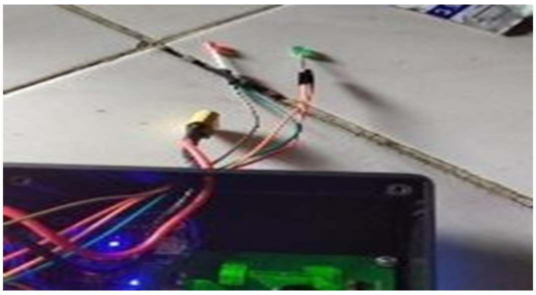


Figure 12 Installing led light device with Arduino Mega

B. Software Implementation

After configuring cloud hosting, river water monitoring website has been accessible online, with the website link http://dlhkbdgmonitoringairsungai.xyz/. River water monitoring website consists of 5 pages, namely: LoginPage, HomePage, About Page, River Water Monitoring Page, and Early Warning Log Page, as follows:

1. Login Page

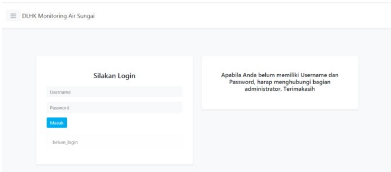


Figure 13 Login Page of DLHK River Water Monitoring Website

2. Home Page

Figure 14 Home Page Website DLHK Early Warning System and River Water Monitoring

3. About Page

Figure 15 Page About DLHK Website Early Warning System and River Water Monitoring

4. River Water Monitoring Page

Figure 16 Graphic Page Monitoring Website DLHK Early Warning System and River Water Monitoring

5. Early Warning Logs

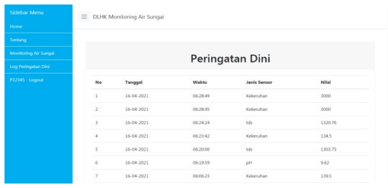


Figure 17 Page Early Warning Log Website Early Warning System and River Water Monitoring

6. Early Warning Logs

Figure 18 Sending Early Warning via Telegram

7. Early Warning On Twitter Website

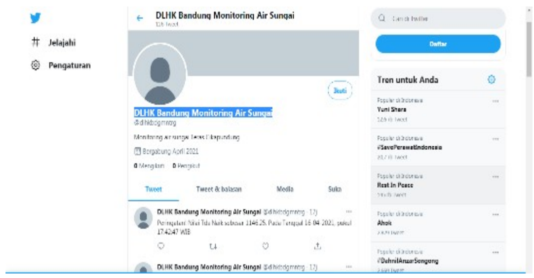


Figure 19 Sending Early Warning via Twitter

C. Testing

1. Black Box Testing
   Black box testing is a test used to see if the inputs and outputs on the system are appropriate or not.

2. System-Wide Testing
   The whole system test is a test conducted directly on the hardware and software used on this system as found in the review plan, as follows: pH sensors detrksi pH water, TDS sensors to detect total marine substances in water, temperature sensors to detect water temperature, turbidity sensors to detect water turbidity, DO sensors to detect water oxygen levels, led lights and lcd screens, send early warning through telegram applications and social media websites twitter, monitoringcharts, early warning logs, download early warning monitoring data and early warning logs, store data on cloud hosting,and manage users.

3. Bandwidth Consumption Testing
   From the calculation of bandwidth consumption, data quota usage for 3 days of testing is 220 MB, and for daily data quota of 73.44 MB. So for data quota that for 1 month or per 30 days for sending sensor detection data to niagahoster cloud hosting server is required by 2.2 GB.

4. Energy Consumption Testing
   Energy consumption testing is performed to determine if the solar cell can provide power to all hardware used such as mega microcontrollers, sensors, ESP8266 modules, LCD screens, and LED lights for the whole day.

Jumlah Hari	Tanggal	Waktu Pengisian Daya Melalui *Accumulator*	Waktu Pengisian Waktu efektif solar cell dalam mengisi daya accumulator	Total Waktu Keseluruhan Dalam Pengisian Daya	Kondisi Perangkat
3 hari	18 April 2021 - 21 April 2021	07.00 – 07.00	10.00 – 15.00	24 jam	Menyala Dengan Baik.

Figure 20 Energy Consumption Testing

5. Live Testing On River
   In this section will be conducted testing the device directly on the water of the Cikapundung river to detect pH, TDS (Total Dissolved Solid), temperature, turbidity, and DO (Dissolved of Oxygen). The location of the river that is done for testing is the river located in Teras Cikapundung Bandung. The following is a picture of the entire device that has been prepared on the side of the river:

Figure 21 Overall River Water Testing Devices All sensors perform detection, as shown below:

Figure 22 Overall pH, TDS, Temperature, Turbidity, and DO Sensors Detecting River Water

The detection results of all sensors can be seen on the monitoring page website in the form of graphs, as shown below:

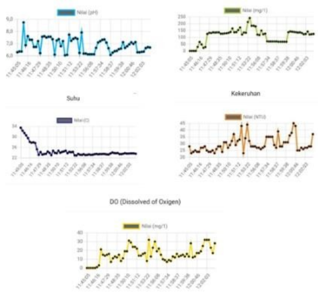


Figure 23 Sensor Overall Detection Monitoring Graph

6. Black Box Testing Results
   The results of black box testing that has been conducted based on the test plan, have a validoverall result.
7. User Acceptance Test
   User acceptance test was conducted at the Office of Environment and Hygiene (DLHK) Bandung. Below is an image of the installation of all hardware for testing in DLHK Bandung:

Figure 24 Entire Device for User Acceptance Test

After setting up the hardware and software, the system is turned on. Furthermore, each sensor, namely pH, TDS, temperature, turbidity, and DO perform detection on several containers that have been filled with water with different solutions. Data that has been stored on cloud hosting, can be seen on the water quality monitoring website with the link http: //dlhkbdgmonitoringairsungai.xyz/. Below is a picture of DLHK officers who access the website monitoring river water quality through the website and smartphone:

Figure 25 DLHK Officers Bandung access DLHK website monitoring river water

After the DLHK officer accesses the system, the next step is to fill out the questionnaire. The questionnaire distribution aims to get a response from the user or DLHK officer regarding the early warning system and monitoring of the quality of river water based on the internet of things that has been accessed by the DLHK officer. Questionnaires contained in the google docs link that has been answered by all respoden contained in DLHK Bandung, it will be continued to be calculated using the likert scale. Below is the result of the calculation of the likert scale in the respondent's answer to all questionnaire questions contained as follows:

No.	Pertanyaan	Indeks %	Skor Interval
1	Sistem peringatan dini menggunakan notifikasi telegram dapat membantu untuk memberitahukan anda seandainya disuatu sungai terdapat parameter yang kurang atau melebihi batas aman	88 %	Sangat Setuju
2	Grafik hasil deteksi sensor pada website monitoring dapat dipahami dengan mudah	86,6 %	Sangat Setuju
3	*Log* peringatan dini pada website *monitoring* dapat dipahami dengan mudah	88 %	Sangat Setuju
4	Peringatan dini berupa pengiriman notifikasi kepada telegram anda dapat diterima dengan cepat	81,3 %	Sangat Setuju
5	Peringatan dini berupa tweets secara otomatis pada sosial media twitter dapat diterima dengan cepat	86,6 %	Sangat Setuju
6	Mendownload data hasil monitoring deteksi sensor dalam bentuk excel dapat dilakukan dengan mudah dan cepat	88 %	Sangat Setuju
7	Mendownload data log peringatan dini dalam bentuk excel dapat dilakukan dengan mudah dan cepat	86,6 %	Sangat Setuju
8	Antarmuka atau *user interface* website *monitoring* nyaman untuk dilihat	86,6 %	Sangat Setuju
9	Layar LCD yang menampilkan parameter hasil pendeteksian dapat dipahami dengan mudah	93,3 %	Sangat Setuju
10	Anda merasa bahwa untuk mengakses sistem ini mudah untuk digunakan	85,3 %	Sangat Setuju
11	Anda merasa sangat puas menggunakan sistem ini	84 %	Sangat Setuju
Total		**86,94 %**	**Sangat Setuju**

Figure 26 Results of Likert Scale Calculation on All Respondents' Answers

Based on the table above which is the respondent's response, that the average value obtained is 86.94%. The figure is at intervals of 80 % - 100% and belongs to the category of strongly agreed, so it can be concluded that the existence of an early warning system and monitoring of river water based on the internet of things in the context of the Department of Environment and Hygiene (DLHK) Bandung is classified as very agreeable.

D. System Maintenance

The following are maintenance that can be performed on hardware and software:

1. Make regular payments for availability of access to niagahoster cloud hosting. The fee to be paid for niagahoster cloudhosing package named baby with nominal cost rp. 369.000,- / year.
2. Fix bugs immediately if there are problems in the system, both from the front end and back end.
3. Fill the internet quota for the modem used for a period of 30 days or 1 month of 3 GB, so that the data that has been processed by the arduino uno microcontroller can be sent on the niagahoster cloud hosting server through the esp8266 module.
4. Check the condition of all input, process and output devices, namely microcontrollers, esp8266 modules, LCD screens, LED lights, all sensors i.e. pH sensors, TDS (Total Dissolved Solid),temperature, turbidity,and DO (Dissolved of Oxygen), solar cell, solar charger control,step down, and battery, as well as jumper and PV cables regularly every 2 weeks. This is to ensure the device can do its job properly. If any device is damaged, it must be replaced immediately.

E. Guidance

In this section there are three guidance or guidance which is a follow-up of the output that can be done both by the Department of Environment and Hygiene (DLHK) Bandung city and the community, with each guidance as follows:

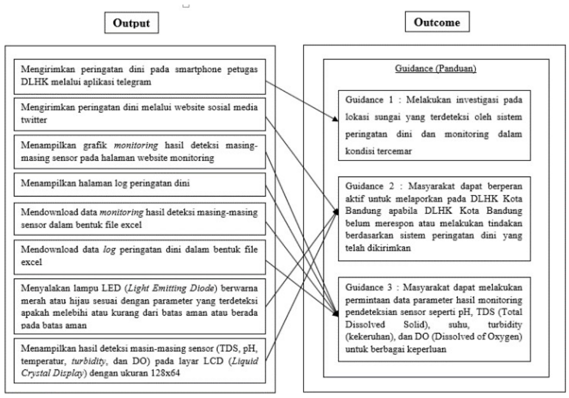


Figure 27 Guidance Early Warning System and Internet of Things-Based River Water Monitoring

From each guidance is explained about the output related to guidance, description, and steps.

CONCLUSION

Based on the research that has been done, the results of the system design and prototype are obtained. The design form is described by the system architecture built, UML (Unified Modeling Language), and system workflow. The prototype form has been built which consists of hardware and software implementation based on the system design form. Hardware implementation in the form of installation of each component such as sensors (pH (Power of Hydrogen), TDS (Total Dissolved Solid), temperature, turbidity, and DO (Dissolved of Oxygen), ESP8266 module, lcd screen, LED (Light Emitting) lamp Diode), and a solar cell with an arduino mega 2560 microcontroller. The software implementation is in the form of coding to create an early warning and river water monitoring website, as well as configuring the niagahoster cloud hosting, telegram application, and the twitter website.

After the system prototype is built based on the design form, it is necessary to test using blackbox testing in accordance with the test design that has been made in advance with the overall test results that are valid including sending early warnings on the telegram application and the Twitter social media website. After doing black box testing, user acceptance test can be done to find out the response from the user, namely DLHK Bandung City after using the system directly, and all responses that have been collected are calculated using the Likert Scale 5 method which has an average value of 86.94%.

This figure is in the 80% - 100% interval and is included in the category of strongly agree, so it can be concluded that the existence of an internet of things-based early warning and monitoring system for river water in the Bandung City Environment and Hygiene Service (DLHK) is classified as strongly agree. . And there is a guidance consisting of three guidelines which are a follow-up to the outputs or early warnings that can be carried out by both the Bandung City Environment and Hygiene Service (DLHK) and the community.

For future development, it is possible to use an all-in-one sensor or all sensors are combined into one unit, so that they have good resistance and are easier to use. The recommended sensor is the YSI-600R multiparameter sonde water quality sensor with the advantage of detecting many parameters at one time and increasing the number of river water locations to implement an early warning and monitoring system. The recommended location is in river water which is located near the factory area.

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