Research Article

Sistem Pemantauan Kualiti Air (PeKA)

Ahmad Haziq Mohd Zin[1,*], Suhaila Ismail[2], Nurhafizah Moziyana Mohd Yusop[3], and Siti Rohaidah Ahmad[4]

1 National Defence University Malaysia; haziq.zin06@gmail.com
2 National Defence University Malaysia; suhaila@upnm.edu.my; ORCID ID 0000-0003-4236-2758
3 National Defence University Malaysia; moziyana@upnm.edu.my; ORCID ID 0000-0003-0394-7710
4 National Defence University Malaysia; sitirohaidah@upnm.edu.my; ORCID ID 0000-0001-5045-9803
* Correspondence: haziq.zin06@gmail.com; 011-10732799.

Abstract: *Water is a fundamental element of life and a critical resource for ecosystems, agriculture, industry, and human consumption. Most of the water sources on this earth are not safe to use. A group of researchers from the Faculty of Civil Engineering have taken the initiative to treat water in Bukit Gemilang. Treated water is stored in a clean water storage tank before being distributed for use. However, there is still no system or device to ensure that the water stored in the storage tank is safe for use. Therefore, the Sistem Pemantauan Kualiti Air (PeKA) was developed to monitor and measure the quality of water stored in storage tanks. The PeKA system is based on IoT devices and the PeKA web. This IoT device is equipped with three types of sensors, namely TDS Sensor, pH Sensor, and Turbidity Sensor as a tool to measure the level of water quality that has been treated. The PeKA system is developed based on HTML and PHP for system interface development. C++ programming language is used to develop IoT devices while MySQL is used as a database for data storage. The prototype methodology is used for the development of the PeKA System. This is because IoT device prototypes need to be built first to make the system evaluation phase. This system can make it easier for users who are water treatment researchers to monitor and measure the level of water quality that has been treated. Among the advantages of this system is in terms of the administration of the system which is self-administered by the water treatment researchers, the web-based implementation of the PeKA System allows the system to be accessed online. Subsequently, users will receive a warning notification of extreme changes in water quality.*

Keywords: Water; Monitoring System; Internet of Things (IoT); Prototype; database.

DOI: 10.5281/zenodo.10921754

1. INTRODUCTION

Water is a basic need for life. The safety and quality of clean water are fundamental to human development and well-being. Providing access to clean and quality water is one of the most effective aspects of promoting health and well-being (World Health Organization, 2023). According to Ban Ki-moon in 2010, more people died from unsafe water than the number of war victims (United Nations, 2010). To improve water quality, lecturers from the Faculty of Civil Engineering have taken the initiative to treat water in Bukit Gemilang. The source of water in Bukit Gemilang is a source of water from rock cracks, and then this water is stored. This water is treated using iron removal system methods and the concept of Fiber-Reinforced Plastic (FRP) and combined with Ultrafiltration Membrane. This treated water is taken as a sample to be tested in the laboratory to ensure that the treated water is safe to use. Among the test results of the treated water samples are, the total dissolved solids (TDS) 36.8ppm, the pH of the water is 6.5pH indicating that the treated water is neutral, and the Turbidity value is 15NTU. The results of testing water samples found that the water that has been treated is safe to use based on Water Quality Standards from the United States Environmental Protection Agency (EPA) (U.S. Environmental Protection Agency, 2007). This treated water is stored in a clean water storage tank before being distributed for use. Therefore, this Sistem Pemantauan Kualiti Air (PeKA) was developed to facilitate users such as lecturers or researchers to monitor and measure water quality levels.

2. METHOD & MATERIAL

The Sistem Pemantauan Kualiti Air (PeKA) was developed to facilitate users to monitor and measure water quality levels to ensure safe water for use. The scope of this system is as follows:

a. **Administrator**

i) Head of the Water Research Project

ii) View the current and previous readings of TDS, Turbidity, and pH of the water.

iii) Register users of the PeKA System.

b. **User**

i) Water Researcher

ii) View the current and previous readings of TDS, Turbidity, and pH of the water.

iii) Receive notification of extreme changes in water quality. Extreme changes are when the TDS value exceeds 40ppm the Turbidity value exceeds 20NTU or the pH value is less than pH 6 or above pH 8.

c. **Hardware**

i) Total Dissolved Solids (TDS) Sensor – Measures the amount of dissolved solids in water (Neurafarm, 2021).

ii) Potential of Hydrogen (pH) Sensor – Measures the level of acidity or alkalinity of water (Chuzaini Et.Al., 2022).

iii) Turbidity Sensor – Measures water clarity by detecting the amount of suspended particles in the liquid (Darmana, 2022).

iv) Arduino Uno – Controls the output from the Sensors displays the readings on the LCD screen and sends the readings to the ESP8266 microcontroller (Arduino. Cc, 2021).

v) Microcontroller- ESP8266 sends the readings of the sensors to the database (Espressif, 2023).

vi) LCD screen – Displays readings from all three sensors (Arduino. Cc, 2021).

vii) Power bank – Power source to Arduino Uno and ESP8266.

d. **Software**

i) MySQL is used as a database to store data from sensor readings.

ii) Use of PHP and HTML for system interface development.

iii) C++ programming language is used to develop IoT devices.

For the development of the PeKA System, a prototype methodology was chosen to launch the development process of this system. The prototype methodology was chosen because it is appropriate and is a process in the development of models for system design in collaboration with system users, namely water research researchers to modify the PeKA System until their needs are met. Figure 1 displays the Prototype Model which consists of six main phases which are discussed as follows, from the first phase to the last phase. (Rajkumarupadhyay, 2022).

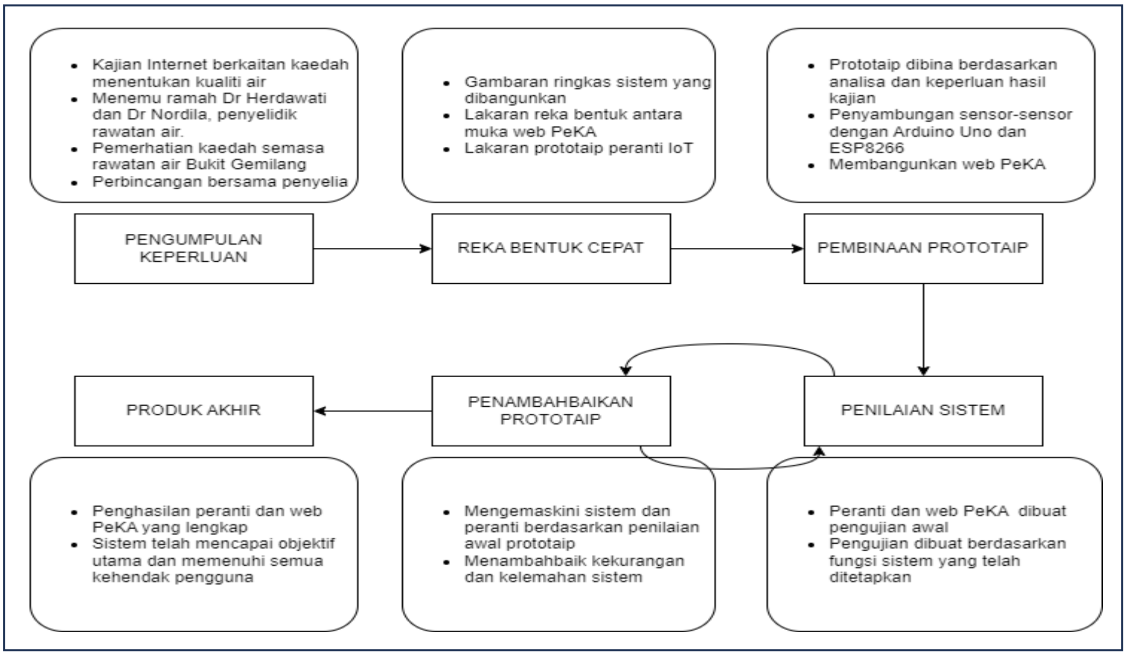


Figure 1: Prototype Model of PeKA System

The first phase is the requirement-gathering phase. This phase is carried out to collect information related to the project to be developed. Interview with Dr. Herdawati who is the head of the Nanohybrid Water Treatment project and Dr. Nordila, who is the head of the Water Treatment project at UPNM's Gemilang Hill, was conducted to collect information related to the system during the water treatment process.

Next is a quick design. At this phase, a preliminary sketch of the design of the IoT device and the PeKA web interface was carried out. This is to give early exposure to users of this system. Figure 2 shows the Preliminary sketch of the PeKA System.

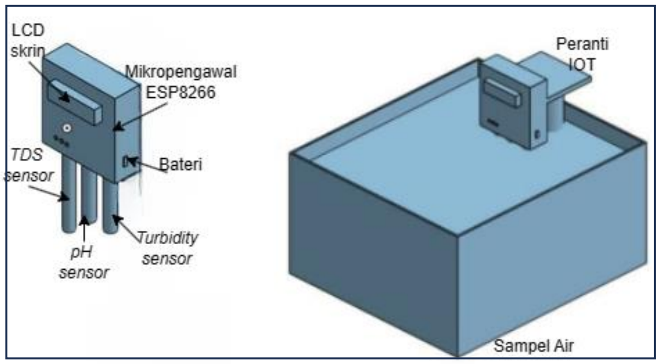


Figure 2: Preliminary sketch of the PeKA System

The Next phase is, the construction of a prototype, the PeKA System is developed based on the objectives of the system that have been set in. Among the steps used in this phase is developing prototypes of IoT devices and the PeKA web using software and system hardware that have been set. The connection of electronic hardware is carried out to form an IoT device.

Once the IoT device and PeKA web prototypes have been completed, they will undergo a system evaluation phase to ensure that the system functions smoothly. PeKA's IoT and web device prototypes are evaluated against the requirements that have been determined in the information-gathering phase. After the prototype has worked according to the system objectives that have been set, then the complete version of the PeKA System will be given to the system administrator. The intended system administrator is the Chief Water Treatment Researcher.

Next is the prototype improvement phase. This phase involves modifications to improve the prototype after the initial evaluation is done. This improvement considers all system tests that have been tested. This aims to ensure that all functions of the PeKA System work according to user needs.

Lastly is the final product phase. This phase is the last in the prototype model where the final product is produced. Based on the improvement of the prototype from the first phase to the last phase, a complete system is developed for use by users. The PeKA system will be tested and evaluated by users themselves after the renewal is made after the initial evaluation phase of the system is made. The final product is a complete and well-functioning PeKA system to achieve the project's objectives.

3. FINDINGS

The comparison results on this equivalent system comparison table show some differences between the developed system and the selected equivalent systems. The developed PeKA system is based on IoT devices and the PeKA web as the main platform. The developed system is designed to monitor water quality using sensors and send notifications of extreme changes in water quality to users. The system consists of specialized sensors that collect data, which is then sent to the ESP8266 microcontroller. The pH sensor is used to measure the pH content in the water while the TDS sensor is used to measure the amount of dissolved solids (TDS) in the water. In addition, the Turbidity Sensor is used to monitor and measure water clarity. The read reading will also be displayed on the LCD screen of the developed IoT device. The proposed system is expected to improve water quality, reduce the need for manual monitoring, prevent water pollution, and provide real-time data on the PeKA website. Overall, this system automates water quality monitoring and provides warning notifications to ensure water is safe to use.

Figure 3 shows the architectural diagram of the PeKA System. The user will turn on the IoT device by using the power bank as a power source to activate the Arduino Uno and the ESP8266 microcontroller. The Arduino Uno will control the data and readings from the TDS Sensor, pH Sensor, and Turbidity Sensor. The reading will also be displayed on the IoT device's LCD screen. Next, this data will be sent to the ESP8266 microcontroller that has been connected to the Arduino Uno. This ESP8266 microcontroller will send all the readings from the sensors to the database. Next, this reading will be displayed to users via the PeKA website. Users will get direct notifications about extreme changes in water quality levels.

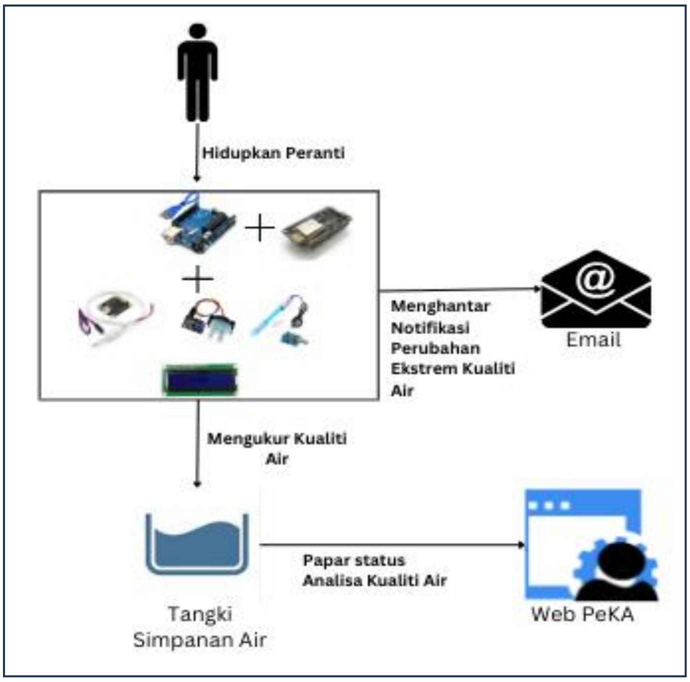


Figure 3: Architecture Diagram of PeKA System

The analysis phase describes the overall process of the PeKA System. The analysis phase has four important phases to implement. The phases are requirements modeling, data modeling, object modeling, and transition to system design. Figure 4 shows the analysis phase of the PeKA System.

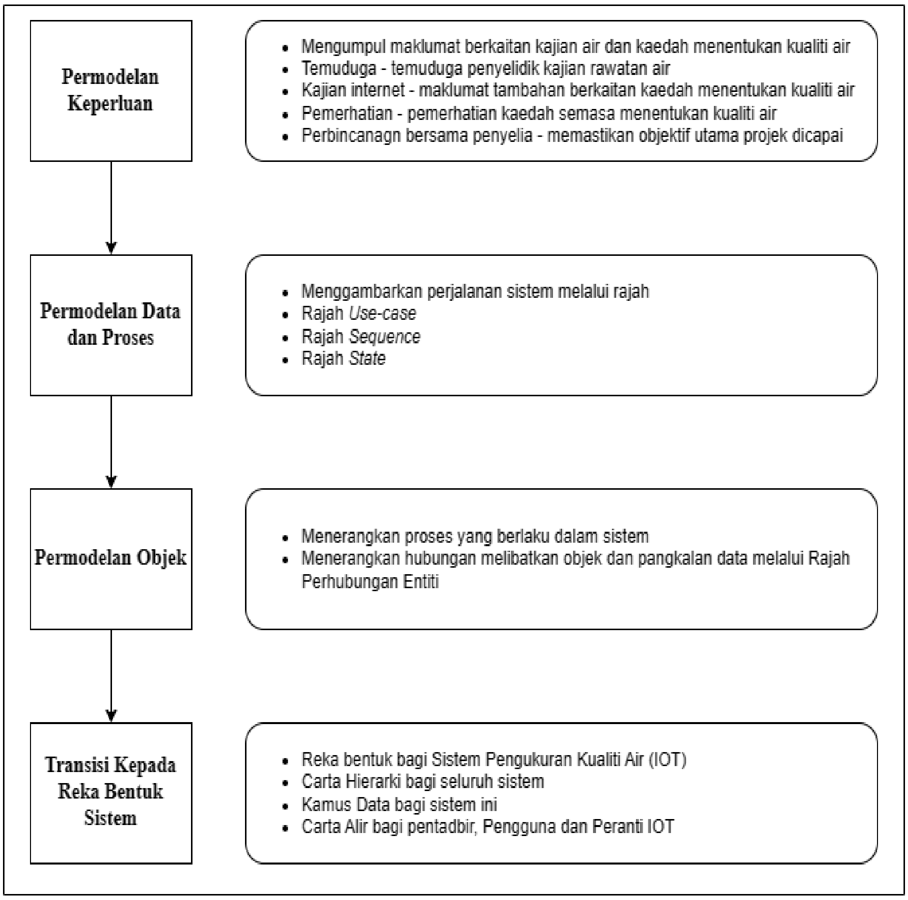


Figure 4: Analysis Phase of System PeKA

Figure 5 is a Use Case Diagram for the PeKA System. The Use Case diagram illustrates how administrators, users, and IoT devices interact with the system to be developed. The actors involved are administrators, users, and IoT devices. In general, the administrator is the head of the water treatment researcher while the user who is the water treatment researcher will use this system assisted by IoT devices to determine the water quality.

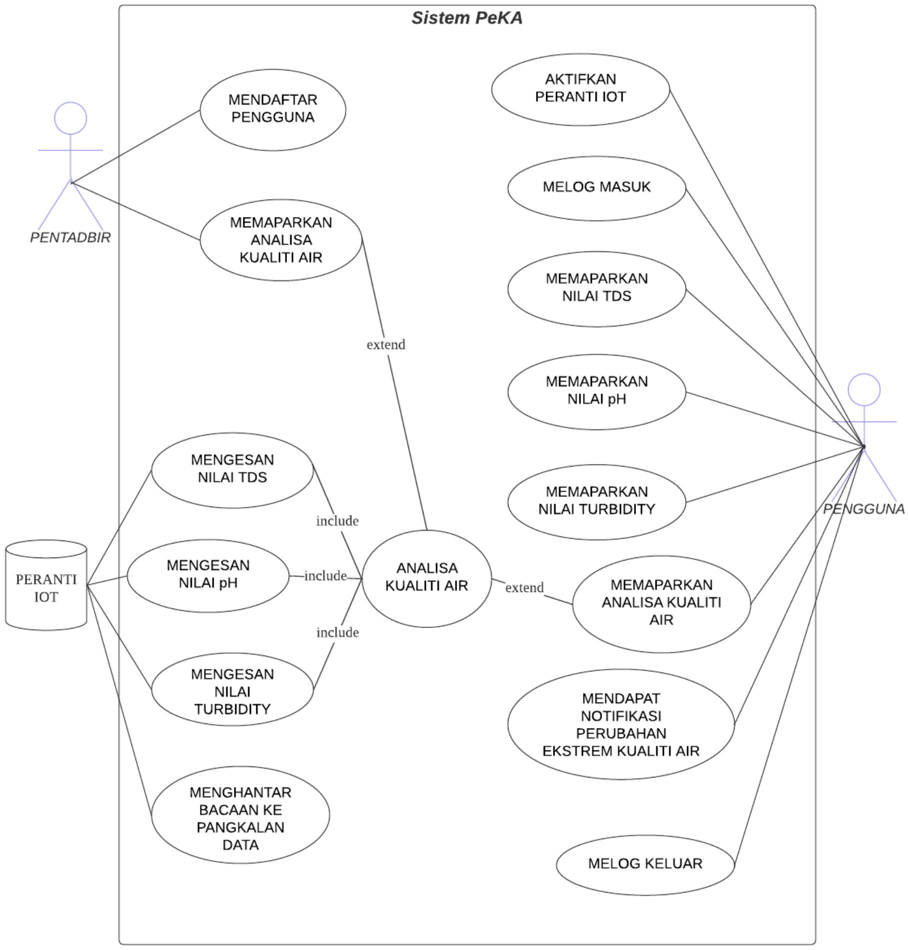


Figure 5: Use Case Diagram of PeKA System

Figure 6 shows the sequence diagram for the developed PeKA System. Administrators can register users and can also monitor the status of water quality analysis. Users who have been registered by the administrator can access the system after logging in. Users will access the system interface by entering their user ID and password. The system interface is connected to the ESP8266 microcontroller which is connected to the sensor. The sensors will detect total marine solids (TDS), pH, and turbidity values in the water. Users can see all readings and water analysis values displayed in the developed system interface. Users will also get direct notifications about extreme changes in water quality. Extreme changes occur when the sensor reading value exceeds the value for normal water quality. For the TDS Sensor the normal value is not more than 250ppm, for normal pH value is between 6-8pH, while for turbidity is not more than 20NTU. The reading value will be stored in the server for future analysis purposes.

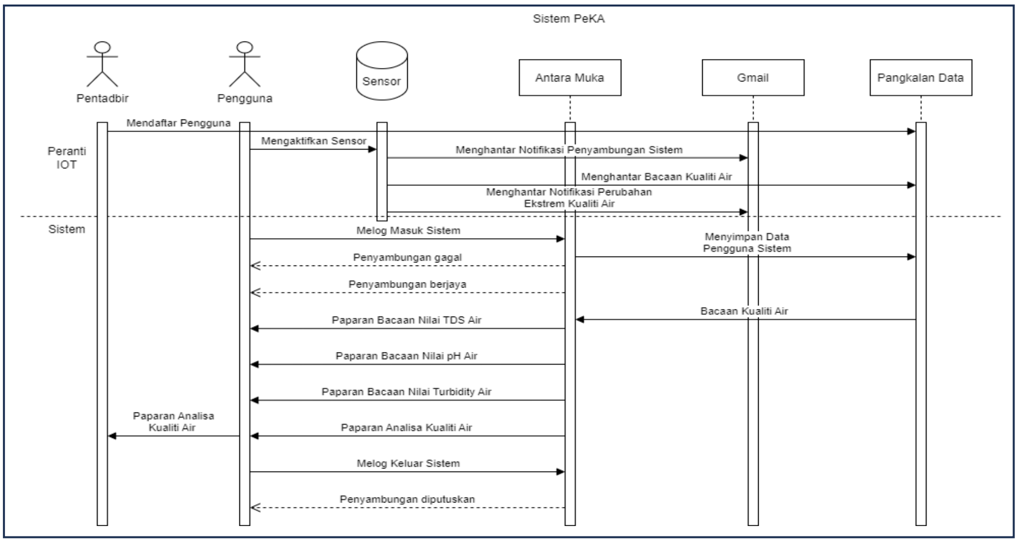


Figure 6: Sequence Diagram of PeKA System

Generally, a hierarchy chart is built to show the modules displayed in the system to be developed. Figure 7 shows a hierarchy chart that displays the overall PeKA System. The admin module, user module, and IoT device module are the main modules. Administrator module to register users and administrators can also monitor water quality analysis. The user module is to access the system to see all reading values from the Sensor and analyze the water quality. Users will also get direct notifications about extreme changes in water quality. The IOT device module measures and detects total dissolved solids (TDS), pH value, and Turbidity value in water, and then the reading is sent directly to the interface.

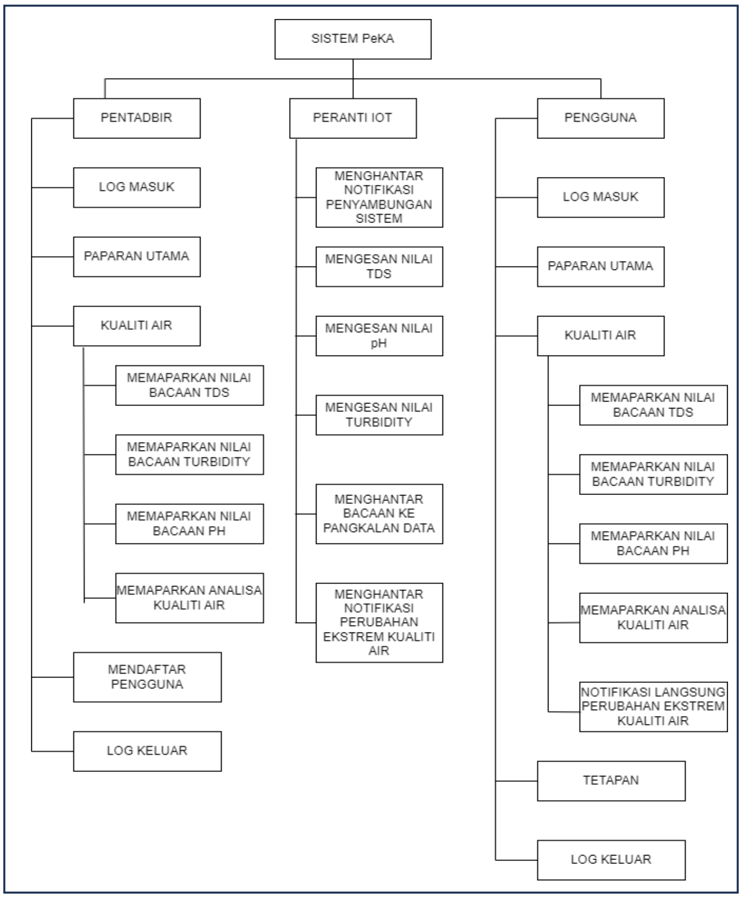


Figure 7: Hierarchy Chart of PeKA System

Architectural design is central to this project. This system will not be able to work if there is no connection between the electronic equipment. This connection forms a complete circuit to ensure this project works. Figure 8 shows the Electronic Circuit of the PeKA System.

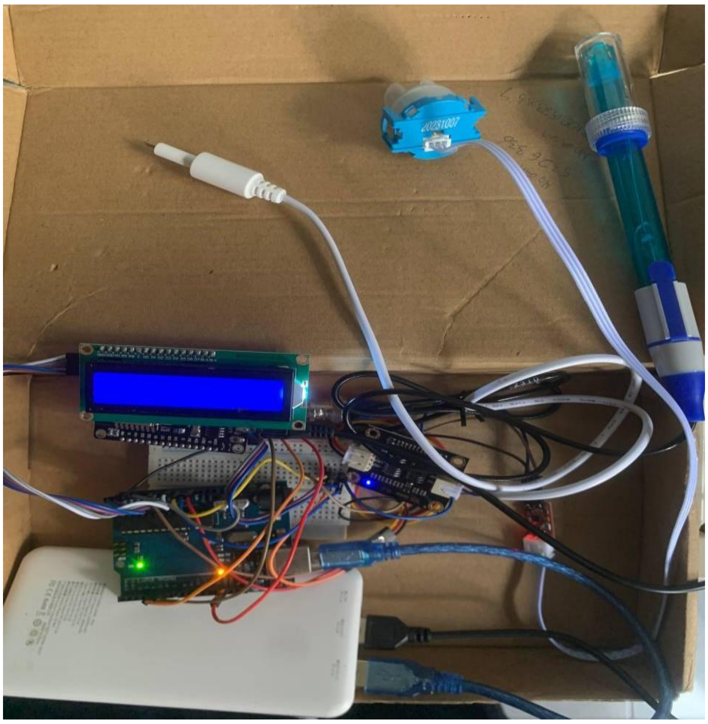


Figure 8: Electronic Circuit of PeKA System

Figure 9 shows the main display on the front page of the system which is the Welcome to PeKA main page. Two buttons are placed, the Admin Login button serves as a link to the display of the Administrator Login interface and the User Login button serves as a link to the display of the User Login interface.

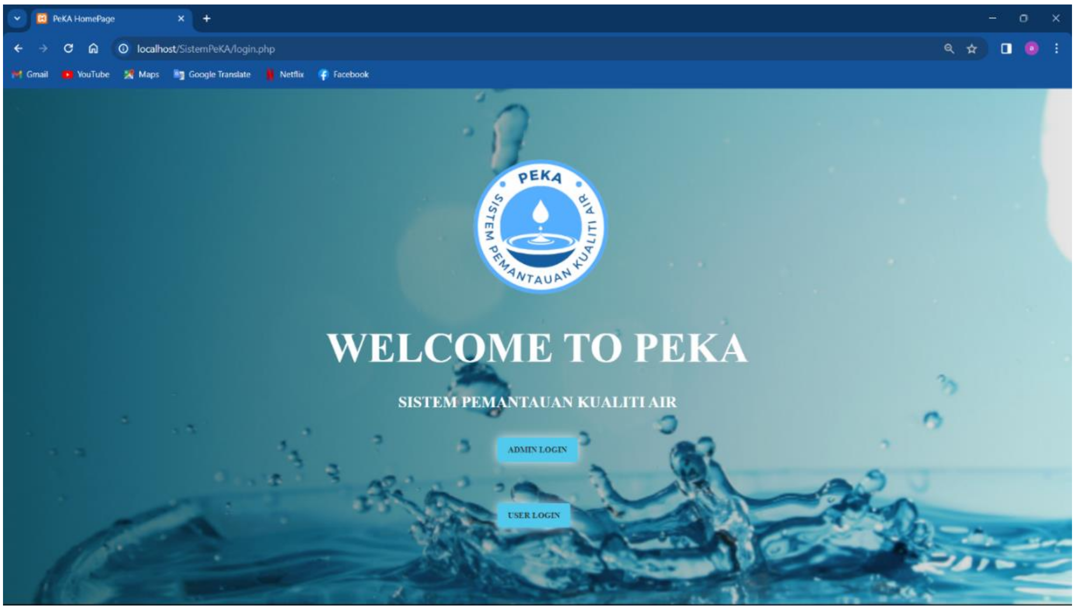


Figure 9: Main page of PeKA System

Next when the user has finished logging in. The user will be taken to the user's home page. Figure 10 shows the display of the user's home page interface. Users can view information related to the developed PeKA System. All information related to the sensors used is displayed on the main page. In addition, there are markers for all sensor readings to determine the water quality that has been measured.

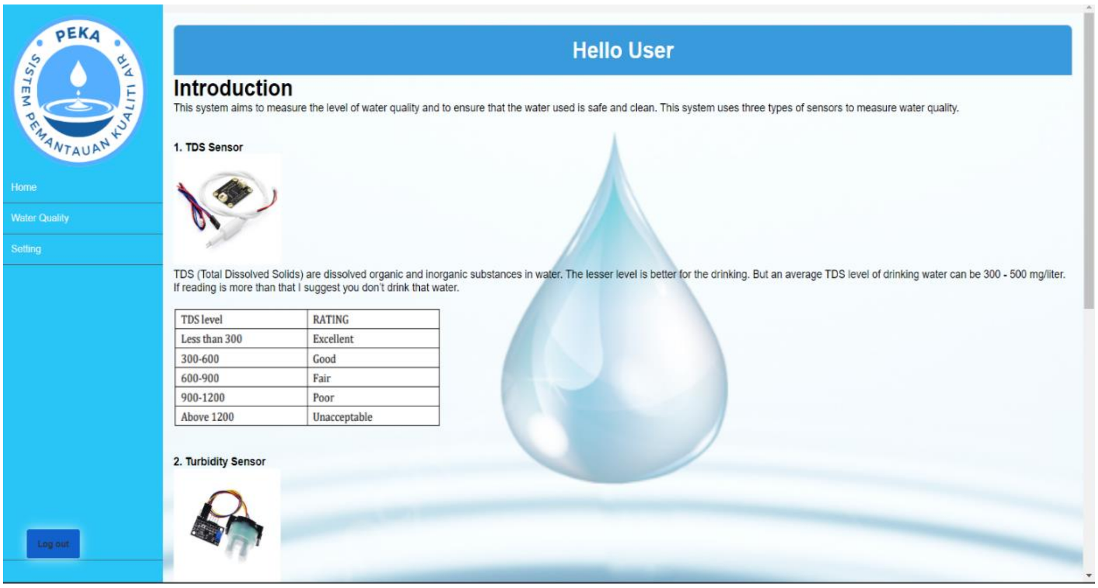


Figure 10: Home Page of PeKA System

Figure 11 shows the System Connection Notification Interface Display. When the IoT device is connected to the Wi-Fi network, the user will receive a system connection notification from the IoT device.

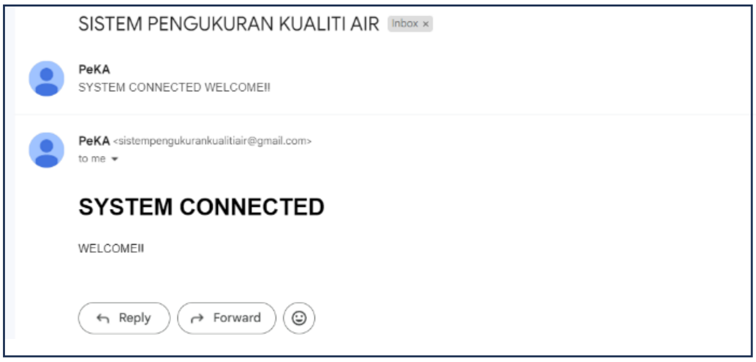


Figure 11: System Connection Notification

After the IoT device is turned on and put in water, administrators and users can monitor water quality through this display. All water quality readings from the sensors used are displayed in this interface Figure 12 shows the Water Quality Interface View.

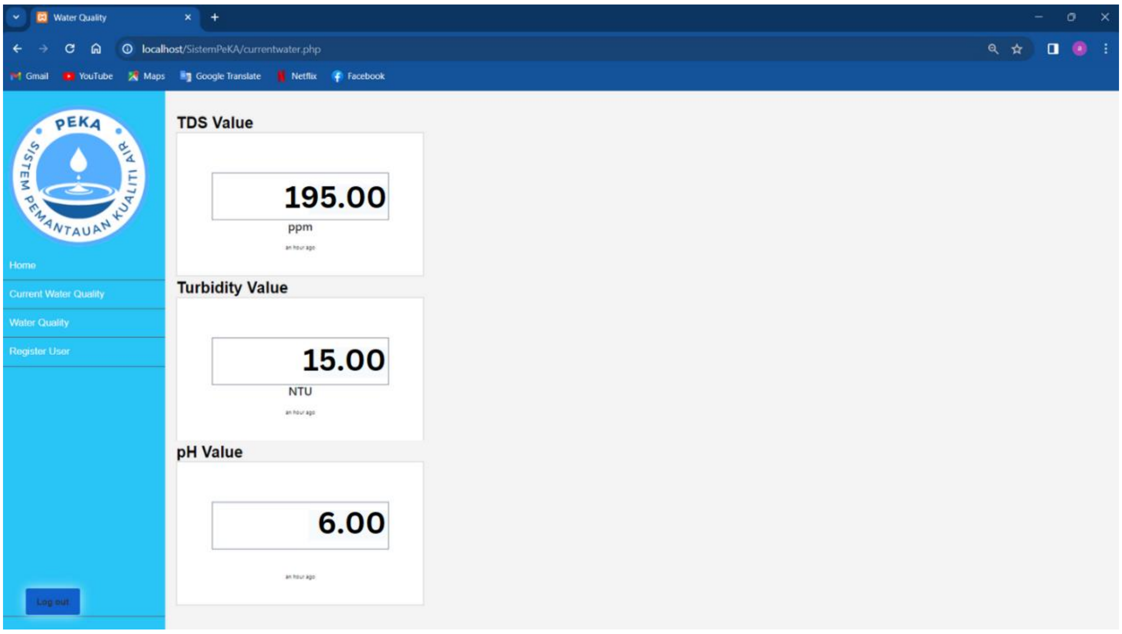
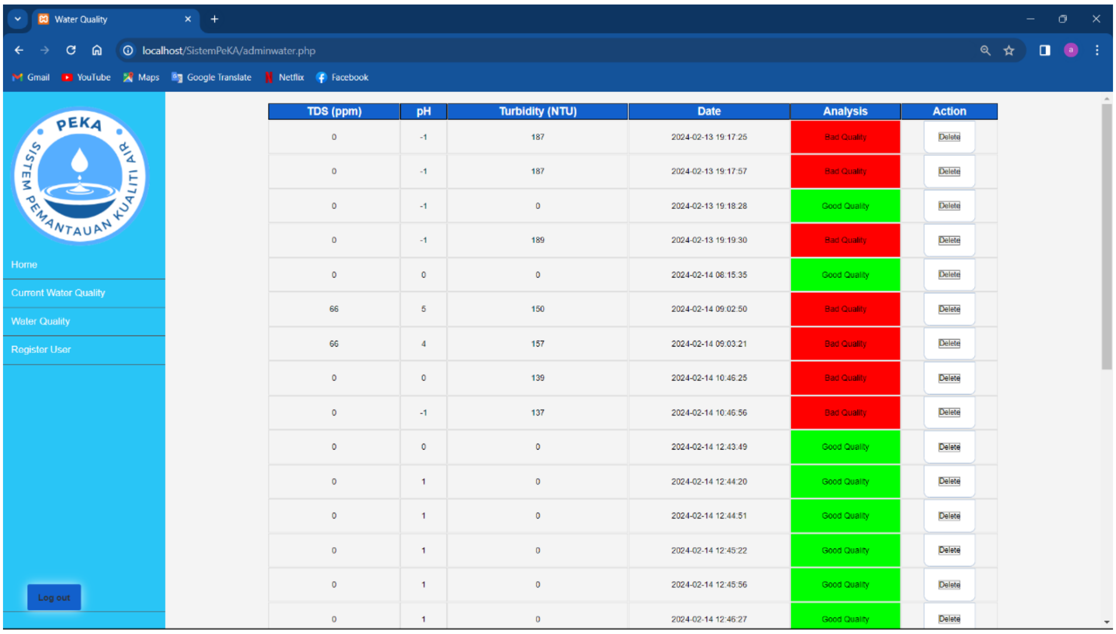


Figure 12: Water Quality Interface View

Administrators and users can also view water quality analysis through the sensitive system interface. When the water quality exceeds the normal level that has been set TDS>250ppm, water pH between pH6 and pH 8 while Turbidity>20NTU it will display bad quality while when the water quality reading is normal it will display good quality. In addition, users will receive an email notification informing them that water quality is bad. Figure 13 shows the Analysis of Water Quality Interface View.



TDS (ppm)	pH	Turbidity (NTU)	Date	Analysis	Action
0	-1	187	2024-02-13 19:17:25	Bad Quality	Delete
0	-1	187	2024-02-13 19:17:57	Bad Quality	Delete
0	-1	0	2024-02-13 19:18:28	Good Quality	Delete
0	-1	189	2024-02-13 19:19:30	Bad Quality	Delete
0	0	0	2024-02-14 08:15:35	Good Quality	Delete
66	5	150	2024-02-14 09:02:50	Bad Quality	Delete
66	4	157	2024-02-14 09:03:21	Bad Quality	Delete
0	0	139	2024-02-14 10:46:25	Bad Quality	Delete
0	-1	137	2024-02-14 10:46:56	Bad Quality	Delete
0	0	0	2024-02-14 12:43:49	Good Quality	Delete
0	1	0	2024-02-14 12:44:20	Good Quality	Delete
0	1	0	2024-02-14 12:44:51	Good Quality	Delete
0	1	0	2024-02-14 12:45:22	Good Quality	Delete
0	1	0	2024-02-14 12:45:56	Good Quality	Delete
0	1	0	2024-02-14 12:46:27	Good Quality	Delete

Figure 13: Analysis of Water Quality Interface View

Figure 14 shows the water quality warning notification display. When the water quality exceeds the normal level that has been set, ie TDS>250ppm, water pH is between pH6 and pH 8 while Turbidity>20NTU, users will receive an email notification regarding water quality. With this notification, users can act as soon as possible to treat the water again to ensure that the water is safe to use.

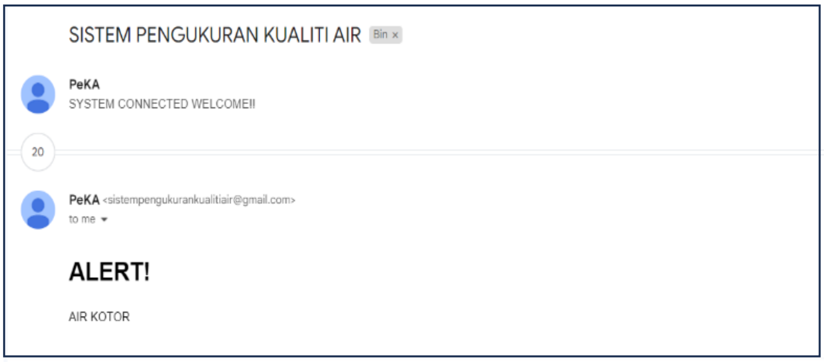


Figure 14: Water Quality Warning Notification Message

4. Discussion

This system can make it easier for users, especially water treatment researchers, to monitor and determine the level of water quality. This IoT device can help users monitor the quality level of water that has been treated in storage tanks. Through internet access, this system can be accessed in various places. Users can also monitor in real-time to ensure the water is safe for use. In addition, users can also see the water quality level data that has been read by the sensor and stored in the database for analysis and the process of improving water.

The PeKA system has criteria that can provide convenience to users who are water nurses in measuring and ensuring the quality of water that has been treated is not contaminated. Therefore, achievements in the development of this system are measured through the project objectives that have been stated. The objectives of this system are achieved if:

a) Analyze the requirements needed in establishing a Water Quality Monitoring System (PeKA) to measure and monitor water quality.

   Three main parameters in determining water quality have been identified, the amount of dissolved solids in the water, the level of clarity or turbidity of the water, and the level of acidity or alkalinity of the water. Therefore, this IoT device is developed with three types of sensors to measure the water quality parameters.

b) Designing a mobile IoT device to measure water quality levels by measuring total dissolved solids (TDS), the potential of hydrogen (pH), and water turbidity values.

   The PeKA system is developed with the PeKA web and mobile IOT devices equipped with three types of Sensors, namely TDS Sensor, Turbidity Sensor, and pH Sensor. This device is intended to monitor and measure the level of water quality in clean water storage tanks.

c) Develop a Web-based PeKA System that can provide direct information and real monitoring and can store water quality level data.

   The developed system has a database that can store all administrator and user information as well as water quality readings for water quality analysis. Users will receive a warning notification if there is an extreme change in water quality.

The system developed has its advantages and attractiveness depending on the objectives and scope of the system development based on the needs of the targeted users. the following are the advantages of the PeKA system:

a) This system uses mobile IoT devices to monitor and measure the level of quality of treated water.

b) Water treatment researchers can monitor the status of water quality by simply using a laptop through the PeKA web.

c) The water treatment researchers will also receive a notification alert if the water stored in the tank is contaminated or the water quality is reduced.

5. CONCLUSION

Finally, it can be concluded that the development of the PeKa system has achieved the goal, objectives, and scope of the project, as outlined at the beginning of this project. Systematic and based a framework on a planned schedule that allows the system to develop as expected. The PeKA system is very highly desired by water nurses to implement and use because it can help in monitoring water quality in real-time. In the future, we have identified several improvements that can be made to improve and make this system work better.

a) Upgrade this system to be able to monitor water quality through Android devices and iOS devices.

b) Using dry cell batteries as a power source to make it easier for water users or nurses to use the device in various places.

c) Added functionality in the PeKA web to control the IOT device to turn the IOT device on or off.

The recommendations highlighted are important so that the system improvement process can be implemented comprehensively and from time to time. This allows the developed system to be used by users over a long period as system improvements are carried out regularly. This makes the system remain relevant and continue to be used.

Acknowledgments: The head project member acknowledges financial support from the Department of Computer Science, Faculty of Science and Defense Technology, and the Student Affairs Department of National Defense University Malaysia for financial support in the publication of this research in the journal and proceeding. Lastly, thank you very much to Dr. Norherdawati Binti Kasim and Dr. Nordila Binti Ahmad for sharing about their water treatment project.

References

Arduino. cc. (2021). *Liquid Crystal Displays (LCD) with Arduino | Arduino Documentation*. https://docs.arduino.cc/learn/electronics/lcd-displays/

Chuzaini, F., Studi Fisika, P., Fisika, J., & Negeri Surabaya, U. (2022). IoT MONITORING KUALITAS AIR DENGAN MENGGUNAKAN SENSOR SUHU, pH, DAN TOTAL DISSOLVED SOLIDS (TDS). In *Jurnal Inovasi Fisika Indonesia (IFI)* (Vol. 11).

Darmana, T., Muchammad;, Qosim, N., Hidayat, ; Syarif, Ariman, ;, & Pln, I. T. (2022). Sistem Deteksi Kejernihan Air dengan Menggunakan LoRa. In *Prosiding Seminar Nasional Energi* (Vol. 13). Kelistrikan.

ElectronicWings. (2023). *ESP8266 WiFi Module Interfacing with Arduino UNO | Arduino*. https://www.electronicwings.com/arduino/esp8266-wifi-module-interfacing-with-arduino-uno

ESP8266 - Wikipedia. (2023). https://en.wikipedia.org/wiki/ESP8266

Espressif. (2023). *ESP8266 Wi-Fi MCU*. https://www.espressif.com/en/products/socs/esp8266

NeuraFarm. (2021). *Mengenal TDS Meter dan EC Meter*. https://www.neurafarm.com/blog/InfoTania/Teknologi%20Pertanian/mengenal-tds-meter-dan-ec-meter

Rajkumarupadhyay. (2022). *Advantages and Disadvantages of Prototype model - GeeksforGeeks*. https://www.geeksforgeeks.org/advantages-and-disadvantages-of-prototype-model/

United Nations. (2010). *Unsafe water kills more people than war, Ban says on World Day | UN News*. https://news.un.org/en/story/2010/03/333182

U.S Environmental Protection Agency. (2007). *Quality Standards for Drinking Water*. https://www.researchgate.net/figure/US-Environmental-protection-agency-quality-standards-for-drinking-water_tbl1_309039699

Wikipedia. (2021). https://ms.wikipedia.org/wiki/Rawatan_air

World Health Organization. (2023). *Water Sanitation and Health*. https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/water-safety-and-quality