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*by* Bety Etikasari

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## Wireless sensor network development in unmanned aerial vehicle (uav) for water quality monitoring system

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**Abstract.** Based on the results of monitoring data by Badan Pengendalian Lingkungan Hidup (BPLHD) on 13 rivers that crossed Jakarta area in 2010 showed that both river water and ground water have high organic and inorganic pollutants. To tackle the pollution, government take a river water sample at waste disposal location periodically to examine its water content. The industrial waste disposal location point is not always easy to reach. At the certain condition, officers must ride raft boat or walk down the river to access that location. Besides taking a longer time, human safety factors are also become consideration. Based on these problems, in this research a wireless sensor network was developed in an Unmanned Aerial Vehicle (UAV / drone) using 912 MHz radio frequency. UAV in this research is equipped with various sensors to determine water quality, namely: PH, temperature, turbidity, Dissolved Oxygen (DO), and carbon dioxide. All sensors are integrated and monitored wirelessly using Universal Asynchronous Receiver Transmitter (UART) on the ground station. The telemetry system is designed to be able to send and receive data up to 1 KM distance in real-time. There are three general stages in this research, namely configuration design, manufacturing, and UAV flight test.

### 1. Introduction

Based on the results of monitoring data by Badan Pengendalian Lingkungan Hidup (BPLHD) on 13 rivers that crossed Jakarta area in 2010 showed that both river water and ground water have high organic and inorganic pollutants [1]. As an effect, river water in the DKI Jakarta region is no longer in accordance with its quality standard designation, namely drinking water, fisheries, agriculture and other urban businesses. Nationally, based on data from Kementerian Lingkungan Hidup dan Kehutanan (KLKH), in 2017 there were 73.24% of rivers in Indonesia that were in a heavy polluted status, while 2.01% were in grade II water quality standards. Nearly 60-80%. Industrial waste disposal into rivers without going through processing first provides an important role in the destruction of aquatic ecosystems, especially rivers. In some cases, dead fish was founded or agricultural products was damaged because of irrigation waters have been polluted by industrial waste. To tackle the pollution, Dinas Lingkungan Hidup of city government or regency government take a river water sample at waste disposal location periodically to examine its water content.

The industrial waste disposal location point is not always easy to reach. At the certain condition, officers must ride raft boat or walk down the river to access that location. Besides taking a longer time, human safety factors are also become consideration [2]. Based on these problems, in this research a wireless sensor network was developed in an Unmanned Aerial Vehicle (UAV / drone) using 912 MHz radio frequency. UAV[3] in this research is equipped with various sensors to determine water quality, namely: PH, temperature, turbidity, Dissolved Oxygen (DO), and carbon dioxide[4][5]. All sensors are integrated and monitored wirelessly using Universal Asynchronous Receiver Transmitter (UART) on the ground station. The telemetry system is designed to be able to send and receive data up to 1 KM distance in real-time. Based on the prototype, the water analysis test can later be carried out using unmanned aircraft. Users only need to be in the mainland and control the UAV to the certain point for



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 collecting water quality data. In addition to simplifying and speeding up the analysis process, this prototype can minimize occupational accidents in humans. UAV also be equipped with an automatic water sampling system to take water samples at a certain point. Water sampling is done if clinical laboratory testing is needed.

## 2. Research Methods

Wireless sensor network is a wireless network[6][7] that consists of many sensors so it can be used to monitor an environment. Each sensor will measure and monitor an environment so it can be sent to the coordinator. The function of the coordinator at WSN is to regulate and coordinate all sensors so they can be processed and the results of the data from the sensors will be sent to the recipient [8]. Research in WSN field by [9] entitled "Structural Health Monitoring Systems Using Wireless Sensor Networks" is one of the WSN developments in the field of system testing that focuses on SHM (System Health Monitoring) to detect damage and characteristic strategies for manipulation structure. In SHM, researchers observe the system using sample measurement periodically from various sensors, then extraction the damage, this damage feature is measured to determine the current state of system health. This research is the implementation of WSN into SHM, but the SHM system has several disadvantages including scalability, data accuracy, reliability and data precision [10]. This research method consists of several stages, such as literature review, data collection, parameter identification and data processing, application development, results and discussion, conclusions and recommendations.

### 2.1. Literature Review

The aim of literature review is gathering information from several references relating to the problem to be discussed. At this stage will be obtained where the research position to identify the problem, it is called State of The Art (research position). Literature review that has been done shows that there is a weakness that has not been achieved by displaying the research that become reference of this research. At this stage also identified and analyzed the system requirements to be used for research.

### 2.2. Design System

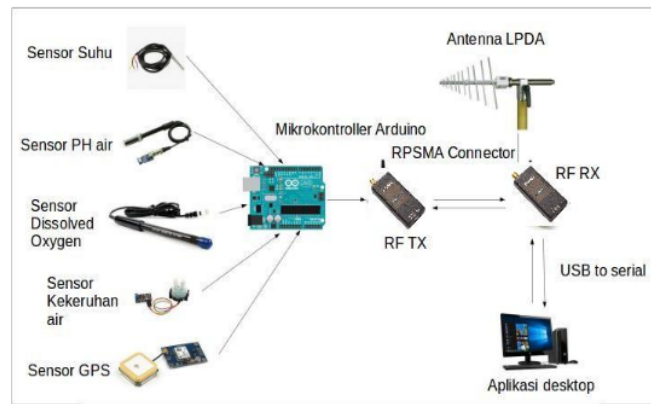


Figure 1. System Design

After analyzing the system requirements, then design the drone system with the ability to analyze water quality. In this research, use a four-propeller aircraft with a total load lift of 4 kg. JSN which install on the drone body includes a temperature sensor, turbidity sensor, Dissolved Oxygen sensor, and pH sensor. The GPS sensor on the controller is used for return to home mode, that is returns to the starting point automatically after finished the mission. Sensor reading data is sent to Ground Station using 922MHz wireless telemetry. Data is received by Ground Station via UART communication.

2.3. Application Development

Application develop using C#.net. The application function is receiving sensor data from drone and display it on the PC Ground Station screen. The application also storing the data from sensor readings on drone using an off-line database. Sensor data sent in one data packet form with protocol in transfer rate of 57600bps. Protocol data sent via telemetry device as shown in figure 2. Then, the protocol data parsing will be process into temperature, pH, turbidity, and dissolved oxygen data. The data from the GPS module is used to display the location of the map using the google map feature. Figure 2 is mock up application used in this research.

Sensor data is sent in the form of a data packet with a protocol with a data transfer rate of 57600bps. The protocol data sent via the telemetry device is shown in figure 2. Next, the protocol data parsing process will be carried out into temperature, pH, turbidity, and dissolved oxygen data. The data from the GPS module is used to display the location of the map using the google map feature. Figure 3 is a mock-up of the application used in this study.



Figure 2. Data Protocol

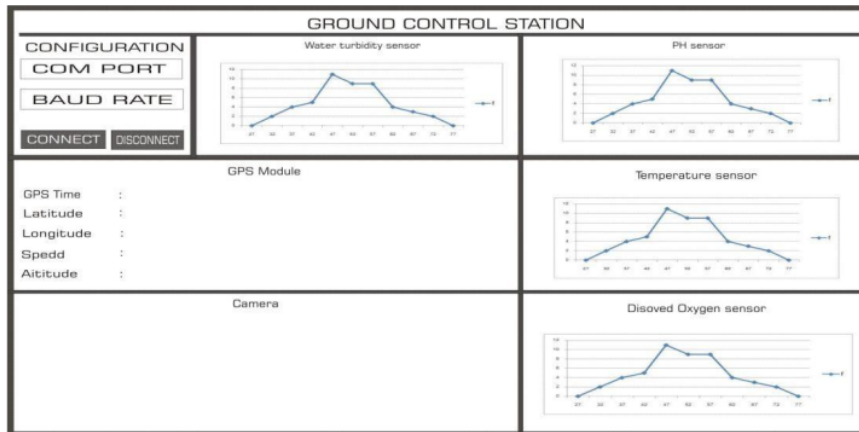


Figure 3. GUI display

2.4. Results and Discussion

After the system is successfully built, the system is tested in the field. The sensor readings were tested, the distance of delivery and success in completing the mission. The test was carried out in several locations, such as lakes, rivers, and ponds.

**5. Conclusions and Recommendations**

This stage is the final stage of the research that is draws conclusions from the results of analysis discussion and provides suggestions for further research. This stage reviews the implementation of related technology / research, this is carried out to ensure that the research has a novelty contribution to the research fields.



**Figure 4.** UAV for water monitoring

**3. Result and Discussion**

UAV is driven by 4 propellers. The battery used is the 4S lithium-polymer battery. UAV robot consists of a transmitter device consisting of the ATmega 2560 microcontroller, water turbidity sensor, water ph sensor, dissolved oxygen sensor, temperature sensor, GPS sensor, and 3DR radio telemetry transmitter. Table 1 is a schematic of the transmitter device. The power supply used by the Arduino Mega microcontroller is 12 VDC and the supply used by the five sensors is 5 VDC. The five sensors are connected to the Arduino Mega microcontroller port to see that it works properly. All the five sensor ports connected to the arduino mega microcontroller is shown in Table 1. 2 plastic bottle with 4bar pressurized installed at bottom of the robot[11]. This function is to keep the drone float when landing on water.

**Table 1.** ATmega 2560 Microcontroller Transmitter System Port Configuration

Microcontroller port	Output
A1	Water Turbidity Sensor Output
A2	Water PH Sensor Output
A3	Dissolved Oxygen Sensor Output
A4	Right Brushless motor output
A7	Left Brushless motor output
D2	Temperature Sensor Output
RX3	GPS Sensor data communication
TX3	GPS Sensor data communication
RX1	Radio telemetry data communication
TX1	Radio telemetry data communication



The application used at Ground Station which can display sensor data reading into numeric and graphic displays *real-time* [12]. The data also stored in a local database for further analysis. Figure 5 shows the application when it is running. Data is received by the Ground Station every 500mS. At the time of testing, distance the drone with the ground station was 1 km away.

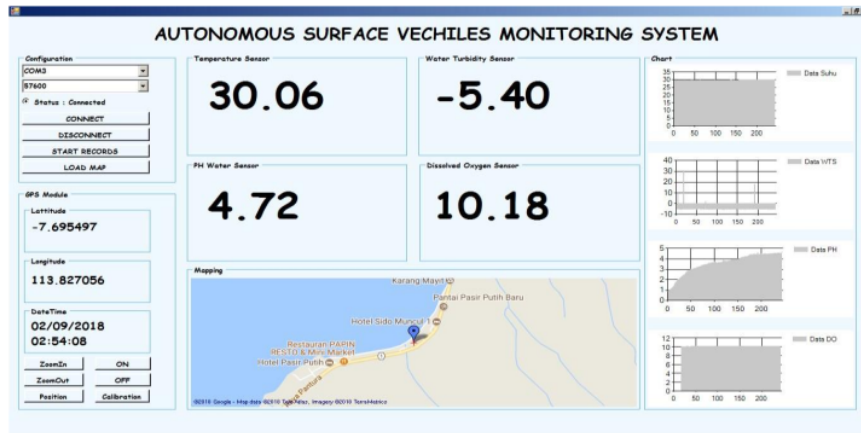


Figure 5. Real-time monitoring system

Table 2. Data record

No.	Sensor Temperature (^C)	Sensor Turbidity (NTU)	Sensor PH (pH)	Sensor Dissolved Oxygen (mg/L)	Sensor GPS (Latitude, Longitude)
1.	28,19	19.60	7.44	36.55	-7.695497, 113.827056
2.	28,19	30.16	6.38	36.55	-7.695497, 113.827056
3.	28,19	29.34	5.86	36.55	-7.695497, 113.827056
4.	28,19	20.77	5.52	36.55	-7.695497, 113.827056
5.	28,19	21.24	5.52	36.55	-7.695497, 113.827056
6.	28,19	31.57	5.86	36.55	-7.695497, 113.827056
7.	28,19	31.10	6.27	36.55	-7.695497, 113.827056
8.	28,19	31.69	6.04	36.55	-7.695497, 113.827056
9.	28,19	30.98	5.69	36.55	-7.695497, 113.827056
10.	28,19	31.92	6.61	36.55	-7.695497, 113.827056
11.	28,19	31.34	5.78	36.55	-7.695497, 113.827056
12.	28,19	32.16	5.92	36.55	-7.695497, 113.827056
13.	28,19	32.04	7.42	36.55	-7.695497, 113.827056
14.	28,19	32.74	6.78	36.55	-7.695497, 113.827056
15.	28,19	32.39	6.3	36.55	-7.695497, 113.827056





#### 4. Conclusion

Based on the research that has been conducted, it can be concluded several things. UAV makes it easy to monitor water quality with sensor arrays wirelessly. The UAV monitoring system is carried out with various data transmission distances. Based on test results, data can be sent and received by the ground station in real-time. Testing receiving data from the receiver device, data received by the receiver device can read simultaneously with data accuracy 99,8% of data sent.

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