Development of Low-Cost Autonomous Surface Vehicles (ASV) for Watershed Quality Monitoring

by Prawidya Destarianto

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***Abstract*— Water has always been an important part of human life, in the context of the global environment, water management and conservation is the focus because it impacts on human survival in a fundamental way. Current condition of the Kalibaru River Basin: (a) water use for agriculture, plantation and community needs is increasingly increasing, (b) unstable availability of water, (c) excessive utilization that does not pay attention to carrying capacity, (d) potentially for erosion and (e) high sources of water pollution that affect the quality of raw materials of drinking water, ecosystem, economy and human health and social security. This study aims to develop a system consisting of hardware and software capable of monitoring the quality of watersheds, in this research used Kalibaru's Watershed. This monitoring can be used by relevant agencies to conduct studies or even make policies related to quality watershed care.**

Keywords*— *Low-Cost Autonomous Surface Vehicles (ASV), Watershed Quality Monitoring, Wireless Sensor Network.

I. Introduction

River as a water drainage is at the lowest position in the earth's landscape, so that river conditions are strongly associated with watersheds, the quality of river water is influenced by the quality of the water supply coming from the catchment area while the quality of the water supply from the catchment area is related to human activities that is in it [1]. Changes in water quality conditions in river flows are the impact of discharges from land use that have an impact on the hydrological conditions of a watershed [1][2][3].

Current condition of the Kalibaru River Watershed: (a) water use for agriculture, plantation and community needs is increasingly increasing, (b) unstable availability of water, (c) excessive utilization that does not pay attention to carrying capacity, (d) potentially for erosion and (e) high sources of water pollution that affect the quality of raw materials of drinking water, ecosystem, economy and human health and social security. Pollutant material may cause harm, if (1) the amount exceeds the normal threshold; (2) existence at an improper time; and (3) existence in an inappropriate place. The nature of the pollutant is (1) destructive for a while and (2) destructive for a long time. Pollution resulting from household and industrial waste causes the quality or quality of water from the watershed to become less or no longer functioning according to its designation (UU Pokok Pengelolaan Lingkungan Hidup No. 4 Tahun 1982). This research uses IoT (Internet of Things) to monitor watershed waters [4].

IoT is a concept where an object has the ability to transfer data over a network on the Service [5]. The development of IoT is very fast, one of them in the field of water quality monitoring. In its application IoT intersect closely with WSN (Wireless Sensor Network) [6][7]. WSN is a network of connections between the sensor nodes on the router and the sink node. WSN contains components (a) Sensing (b) processing (c) communication and (d) power [8][9].

This study aims to develop a low-cost system [10] consisting of hardware and software capable of monitoring the quality of watersheds [11], in this research used Kalibaru's Watershed. This monitoring can be used by relevant agencies to conduct studies or even make policies related to quality watershed care.

II. Related Work

Water has always been an important part of human life, in the context of the global environment, water management and conservation is the focus because it impacts on human survival in a fundamental way. The study of the use of the Internet of Thing (IoT) is widely developed, especially in relation to its ability to support humans in all its activities, one of them in the context of the environment. Research conducted by [12] developed the design and implementation of Wireless Sensor Network (WSN) for in-situ Water Quality Monitoring (WQM), using ISFET Micro-sensors and mobile network communication, this research shows results as low-power,

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low-cost, easy-to-implement or developed systems. Slightly different research done by [6] developed a tool that can monitor the water level in the river in real time, this idea arises because the water level can be an important parameter to determine whether or not to be flooded. This research uses sensors that are used to detect high water, then the results will be sent automatically to social media such as Twitter. This study uses Cloud Server as data repository as well as analysis, then the measurement results are displayed on the Dashboard computer measurement. Research by [13] develops the same thing, that is automatic water quality monitoring, using the Brokerless Publisher-Subscriber Architecture (pub/sub) Framework. The system developed by Pranata, uses several parameters represented by several sensor, temperature sensor, pH, and Dissolved Oxygen Level (DO). All data collected by sensor then stored in the database, it aims to be used in water quality analysis using a computer device.

In an IoT environment, data gathering using WSN on WQM [14] is a global issue. Research [8] developed a suitable WSN design for the intelligent sensor interface of the WQM system in an IoT environment. This research uses Field Programmable Gate Array Field (FPGA), Sesor, ZibBee, and Personal Computer (PC). The FPGA Board is an important part of the tool developed by this study, diprogrammed by using Very High Spedd INtregreted Circuit Hardware Description Language (VHDL) and C ++ using Qsys Tool and Nios-II SBT for Eclipse on Quartus II Software. Being updated from the developed system is the ability of the system to collect data on Water Quality (WQ) such as, pH, water level, turbidity, CO2 on surface water, and surface temperatures, all sensors are distributed in parallel and real-time at high speed. The system developed has been tested/verified using computer simulations and laboratory experiments. The research was continued by [9], so that in his research Myint performed an implementation of the developed tool, then displayed on the Graphics installed on the PC to visualize the time series readings from the sensors using Python.

This research uses GPS Sensor, Temperature Sensor, Camera, Turbidity Sensor, pH Sensor, DO Sensor and Motor Pump. All of the above components are controlled using Arduino Mega, while communication between devices with receivers using Wireless Telemetry 915MHz. By setting such a tool can be controlled up to a distance of 2 km from the control unit. This study uses more types of sensors, it aims to be able to provide a more complete picture of water quality. On the other hand this research uses a more affordable equipment, so it can be widely used.

III. WSN-Based Water Quality Monitoring on Watershed Monitoring

A. Device Architecture

The architecture of the tools developed in this study on the functionality and price of components. It is intended that tools can be developed easily and widely applied, there are two main objectives, the first is the mission of improving the water quality in the watershed, and the second is to create tools that can be developed and applied easily by the practitioners.

Ease of manufacture and low cost are the main objectives of this research, although research does not rule out the quality of the tools. Indonesia is a tropical country with a large watershed area, improving the quality of river flow that exist in Indonesia will also improve the quality of the world environment. Indonesia is one of the lungs of the world, but lately its existence is diminished due to the high environmental pollution that impact on the amount of environmental damage, marked by the number of floods, landslides, and others.

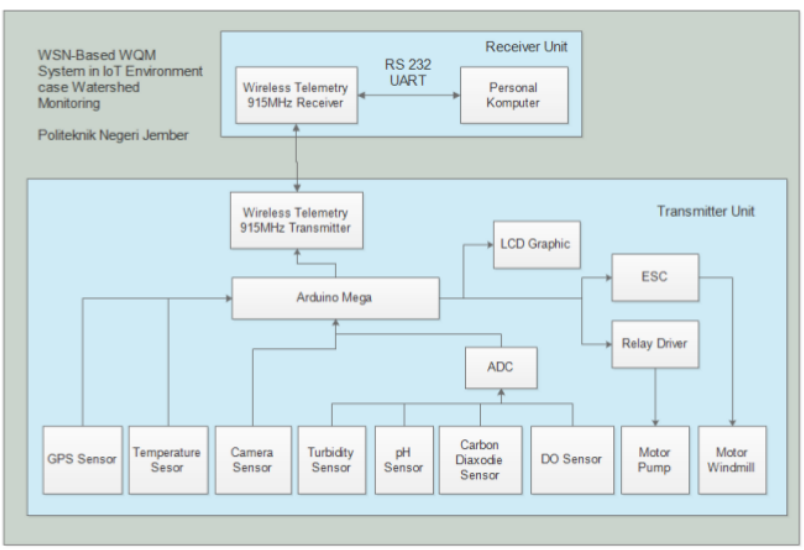

Fig. 1 Diagrams Block System

Using GPS Sensor, Temperature Sensor, Camera, Turbidity Sensor, pH Sensor, DO Sensor and Motor Pump. All of the above components are controlled using Arduino Mega, while communication between devices with receivers using Wireless Telemetry 915MHz. With this settings, tool can be controlled up to 2 km distance from the control unit. This distance will facilitate monitoring to the middle of the river, than provide a more detailed picture of the water quality of the watershed. This is based on the depth of river water that is shallower at the edge and deeper in the middle, shown by Figure 1.

As a propeller of the appliance, two propellers are placed behind the tool. The motor of the propeller is controlled by using a control unit. This tool can be freely moved to model water quality from the watershed.

In addition to having the ability to move freely, this developed tool has a GPS sensor, this tool on advanced mining can be used to monitor from multiple points at once, then processed and produced a better picture of water quality.

B. Hardware Component

There are nine sensors used in the development of this tool, the sensors used in this tool aims to provide a complete picture, as well as multi-function for many activities related to water quality, shown by Figure 3. So in the application can be used for monitoring fish or shrimp as example. Here are the sensors used in this study: GPS Sensor, Temperature Sensor, Camera, Turbidity Sensor, pH Sensor, DO Sensor, and Motor Pump.

1) GPS Sensor

The GPS sensor (NEO-M8) is used to provide the coordinates of the recording location of the device, information regarding the location of the tool will be useful for future development, the continuation of this research will be added to the GIS capability, so as to provide an overview of the water quality sectorally. This GPS is also used to provide the ability to the tool, in case of loose signal the tool will be able to return itself to the docking of departure.

The NEO-M8 series of concurrent GNSS modules is built on the high performing u-blox M8 GNSS engine in the industry proven NEO form factor. The NEO-M8 series utilizes concurrent reception of up to three GNSS systems (GPS/Galileo together with BeiDou or GLONASS), recognizes multiple constellations simultaneously and provides outstanding positioning accuracy in scenarios where urban canyon or weak signals are involved. For even better and faster positioning improvement, the NEO-M8 series supports augmentation of QZSS, GAGAN and IMES together with WAAS, EGNOS, MSAS. The NEO-M8 series also supports message integrity protection, geofencing, and spoofing detection with configurable interface settings to easily fit to customer applications. The NEO form factor allows easy migration from previous NEO generations [15].

The NEO-M8M is optimized for cost sensitive applications, while NEO-M8N/M8Q provides best performance and easier RF integration. The NEO-M8N offers high performance also at low power consumption levels. The future-proof NEO-M8N includes an internal Flash that allows future firmware updates. This makes NEO-M8N perfectly suited to industrial and automotive applications.

2) Temperature Sensor

This sensor (DS18B20) will describe the temperature level of water in a watershed. This temperature is important to provide a picture of the feasibility of water for a particular ecosystem. The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has an alarm function with nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central micro-processor. In addition, the DS18B20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply [16].

3) Turbidity Sensor

This turbidity (analog) sensor is used to provide an image of water density, analog sensors used based on the ease of getting the sensor and the cheap price, consequently the research must convert Voltage output to NTU units. This sensor is related to the ability of water to penetrate for sunlight. This sunlight is an important component for some biota or even ecosystem.

4) pH Sensor

This pH (analog) sensor will give an idea of the acidity level of a water. This acidity level is also related to the viability of biota or ecosystem. pH is also an important component for example if the watershed is used for the location of a particular commodity cultivation. The calibration of the pH sensor in the study using Natrium Hidroksida (NaOH), NaOH is used directly to control the level of acidity or pH at the water treatment facility.

5) DO Sensor

This DO (Analog Dissolved Oxygen Sensor) sensor is an important component in water quality analysis, in some DO calculation methods is an important variable in water quality analysis. This is a dissolved oxygen sensor kit, which is compatible with Arduino microcontrollers. This product is used to measure the dissolved oxygen in water, to reflect the water quality. It is widely applied in many water quality applications, such as aquaculture, environment monitoring and natural Science [17], shown by Figure 2.

Fig. 2 Analog Dissolved Oxygen Sensor [17]

Dissolved oxygen is one of the important parameters to reflect the water quality. Low dissolved oxygen in water will lead to difficulty in breathing for aquatic organisms, which may threaten their lives. So with the use of DOS sensors in the tool, it is expected to be widely used for studies or studies related to water quality.

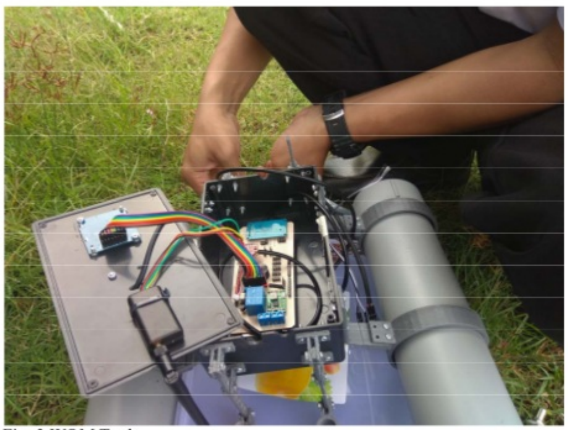

Fig. 3 WQM Tools

6) Motor Pump

This propulsion motor is used to drive water into the test tubes owned by the appliance. This mechanism is important to standardize the location of sensor readings. Differences of illumination, depth, and other factors are reduced by using a water-testing confinement mechanism driven by this motor.

IV. Result and Discussion

The results of the experiments conducted on shrimp ponds, the selection of ponds assume that the pond requires strict control of water quality, so that when tested directly in the pond, the tool will be tested with a comprehensive. This is done with regard to the purpose of the development of this tool, which not only provides a picture of water quality, but more than that aims to provide broad benefits for watersheds, humans, ecosystems, biota and contained therein.

In the test, the whole sensor is immersed into the water, except the GPS sensor. The tool is designed to have a buoy on the right and left side, this buoy is used to ensure the device remains floating on the surface of the water. Then the movement of the tool will be controlled from the computer receiver/control, communication between this tool using Wireless Telemetry 915MHz. The average results (100 test) of the sensor readings show pH 7, Turbidity 65.75119 NTU, DO 6.618 ppm and Temperature 27.563°C, shown by Table 1. These results differ slightly from the results of manual measurements, showing differences in pH (7), Turbidity (60 NTU), DO (7.3 ppm) and Temperature 27.563°C. This result will then become a reference in the development of the next tool, by re-calibrating the Volt to the appropriate units (pH, NTU, DO and Temperature).

TABLE I. TESTING RESULT (PATHEK BEACH, SITUBONDO, EAST JAVA)

No.	pH	Turbi-dity (NTU)	DO (ppm)	Temp (°C)	GPS La	GPS Log
1	7	66	6.8	27.5	-7,644,360	113,989,336
2	7	64	6.7	27.5	-7,644,375	113,989,336
3	7	62	6.8	27.5	-7,644,360	113,989,336
4	7	62	6.8	27.5	-7,644,360	113,989,336
5	7	62	6.8	27.5	-7,644,360	113,989,321
6	7	62	6.8	27.6	-7,644,360	113,989,321
7	7	64	6.7	27.6	-7,644,375	113,989,321
8	7	64	6.7	27.7	-7,644,375	113,989,321
9	7	64	6.7	27.7	-7,644,375	113,989,321
10	7	66	6.6	27.7	-7,644,390	113,989,321
11	7	66	6.6	27.7	-7,644,390	113,989,321
12	7	66	6.6	27.5	-7,644,390	113,989,336
13	7	64	6.7	27.5	-7,644,375	113,989,336
14	7	64	6.7	27.5	-7,644,375	113,989,336
15	7	64	6.7	27.5	-7,644,375	113,989,351
16	7	65	6.7	27.5	-7,644,375	113,989,351
17	7	66	6.7	27.5	-7,644,375	113,989,351
18	7	66	6.7	27.6	-7,644,375	113,989,351
19	7	66	6.7	27.6	-7,644,375	113,989,351
20	7	66	6.7	27.8	-7,644,375	113,989,351
21	7	67	6.6	27.8	-7,644,390	113,989,351
22	7	67	6.6	27.8	-7,644,390	113,989,351
23	7	67	6.6	27.8	-7,644,390	113,989,321
24	7	64	6.6	27.8	-7,644,390	113,989,321
25	7	64	6.6	27.8	-7,644,390	113,989,321
26	7	64	6.6	27.8	-7,644,390	113,989,321
27	7	66	6.6	27.9	-7,644,390	113,989,321
28	7	66	6.7	27.9	-7,644,375	113,989,321
29	7	66	6.7	27.9	-7,644,375	113,989,321
30	7	66	6.7	27.9	-7,644,375	113,989,351
31	7	66	6.8	27.9	-7,644,360	113,989,351
32	7	66	6.8	27.9	-7,644,360	113,989,351
33	7	66	6.8	27.7	-7,644,360	113,989,351
34	7	64	6.8	27.7	-7,644,360	113,989,336
35	7	64	6.8	27.7	-7,644,360	113,989,336
36	7	64	6.8	27.7	-7,644,360	113,989,336
37	7	65	6.8	27.7	-7,644,360	113,989,321
38	7	65	6.8	27.7	-7,644,360	113,989,321
39	7	65	6.6	27.7	-7,644,390	113,989,321
40	7	65	6.6	27.6	-7,644,390	113,989,336

41	7	65	6.6	27.6	-7,644,390	113,989,336
42	7	66	6.6	27.5	-7,644,390	113,989,336
43	7	66	6.6	27.5	-7,644,390	113,989,336
44	7	66	6.6	27.5	-7,644,390	113,989,336
45	7	66	6.6	27.5	-7,644,390	113,989,336
46	7	66	6.6	27.5	-7,644,390	113,989,321
47	7	66	6.5	27.5	-7,644,405	113,989,321
48	7	68	6.5	27.5	-7,644,405	113,989,321
49	7	68	6.5	27.5	-7,644,405	113,989,321
50	7	68	6.5	27.5	-7,644,405	113,989,321
51	7	68	6.3	27.4	-7,644,435	113,989,306
52	7	66	6.3	27.4	-7,644,435	113,989,306
53	7	66	6.3	27.4	-7,644,435	113,989,306
54	7	66	6.3	27.4	-7,644,435	113,989,306
55	7	66	6.3	27.4	-7,644,435	113,989,306
56	7	68	6.3	27.4	-7,644,435	113,989,306
57	7	66	6.3	27.4	-7,644,435	113,989,291
58	7	66	6.5	27.4	-7,644,405	113,989,291
59	7	66	6.5	27.5	-7,644,405	113,989,321
60	7	66	6.5	27.5	-7,644,405	113,989,321
61	7	68	6.5	27.5	-7,644,405	113,989,321
62	7	68	6.5	27.5	-7,644,405	113,989,321
63	7	68	6.5	27.5	-7,644,405	113,989,321
64	7	68	6.5	27.5	-7,644,405	113,989,336
65	7	65	6.6	27.5	-7,644,390	113,989,321
66	7	65	6.6	27.5	-7,644,390	113,989,321
67	7	65	6.6	27.5	-7,644,390	113,989,321
68	7	65	6.7	27.5	-7,644,375	113,989,336
69	7	65	6.7	27.4	-7,644,375	113,989,336
70	7	65	6.7	27.4	-7,644,375	113,989,336
71	7	65	6.8	27.4	-7,644,360	113,989,351
72	7	65	6.8	27.4	-7,644,360	113,989,351
73	7	65	6.8	27.4	-7,644,360	113,989,351
74	7	68	6.8	27.4	-7,644,360	113,989,351
75	7	68	6.7	27.3	-7,644,375	113,989,336
76	7	68	6.7	27.3	-7,644,375	113,989,336
78	7	65	6.7	27.3	-7,644,375	113,989,336
79	7	65	6.7	27.5	-7,644,375	113,989,336
80	7	65	6.7	27.5	-7,644,375	113,989,336
81	7	68	6.7	27.5	-7,644,375	113,989,336
82	7	65	6.7	27.5	-7,644,375	113,989,336
83	7	65	6.6	27.5	-7,644,390	113,989,321
84	7	65	6.6	27.5	-7,644,390	113,989,321
85	7	68	6.6	27.5	-7,644,390	113,989,321
86	7	68	6.6	27.5	-7,644,390	113,989,321
87	7	68	6.6	27.5	-7,644,390	113,989,321
88	7	65	6.5	27.6	-7,644,405	113,989,321
89	7	65	6.5	27.6	-7,644,405	113,989,321
90	7	65	6.5	27.6	-7,644,405	113,989,321
91	7	65	6.5	27.6	-7,644,405	113,989,321
92	7	66	6.5	27.6	-7,644,405	113,989,306
93	7	65	6.5	27.7	-7,644,405	113,989,306
94	7	66	6.4	27.7	-7,644,420	113,989,306
95	7	65	6.4	27.6	-7,644,420	113,989,306
96	7	65	6.6	27.7	-7,644,390	113,989,306
97	7	65	6.6	27.5	-7,644,390	113,989,306
98	7	68	6.6	27.5	-7,644,390	113,989,291
99	7	68	6.6	27.5	-7,644,390	113,989,291
100	7	68	6.6	27.4	-7,644,390	113,989,321
	7	**65.75119**	**6.618**	**27.563**	**Average Tool**	
	7	**60**	**7,3**	**27.5**	**Manual Test**	

With the control of water quality in the watershed, it will directly or indirectly provide broad benefits for communities and ecosystems [18][19]. For example, when water quality is maintained, the watershed can be used to perform various kinds of cultivation, or at least can be used directly, such as for water consumption.

Monitoring generated by the tool can also be used for environmental agencies, but it can also be used by regional or central authorities in making informed decisions that are aligned to the quality of the environment/ecosystem [20][21]. The tool tested the success of providing water quality in ponds. Visible tools are able to provide near-figure measurement value manually. The tool test is shown in Figure 4 and Table 1.

Fig. 4 WQM Tools

V. Conclusion

Current condition of the Kalibaru River Basin: (a) water use for agriculture, plantation and community needs is increasingly increasing, (b) unstable availability of water, (c) excessive utilization that does not pay attention to carrying capacity, (d) potentially for erosion and (e) high sources of water pollution that affect the quality of raw materials of drinking water, ecosystem, economy and human health and social security. This study resulted a system consisting of hardware and software capable of monitoring the quality of watersheds, in this research used Kalibaru's Watershed. As a propeller of the appliance, two propellers are placed behind the tool. The motor of the propeller is controlled by using a control unit. This tool can be freely moved to model water quality from the watershed.

Using GPS Sensor, Temperature Sensor, Camera, Turbidity Sensor, pH Sensor, DO Sensor and Motor Pump. All of the above components are controlled using Arduino Mega, while communication between devices with receivers using Wireless Telemetry 915MHz. Monitoring generated by the tool can also be used for environmental agencies, but it can also be used by regional or central authorities in making informed decisions that are aligned to the quality of the environment/ecosystem. This monitoring can be used by relevant agencies to conduct studies or even make policies related to quality watershed care.

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