Design of WSNs Sensor for River Water Quality Monitoring System for Neolissochillus thienemanni sumateranus Lifes (Pandumean, Bonan Dolok Balige-Toba)

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***Abstract*— In order to raise fish and provide them with healthy habitat, proper water quality is essential. This article outlines the creation of a river flow monitoring system that uses wireless sensor networks to track the number of important characteristics (WSNs). The WSNs-MS devices are deployed at three distinct sites in the same river, far from the monitoring station, and use solar panels as a source of recharging the battery. Each WSNs-MS will gather information, store it, and send it to the WSNs-MS sink node, which is a web server running on a Raspberry Pi and acts as a local database for information and monitoring systems. These WSNs-MS were developed and tested, and the outcomes demonstrate that each WSNs-MS is reliable.**

Keywords—wireless sensor networks, WSN multi-sensors, web server, grafana dashboard, android monitoring.

I. INTRODUCTION

There are seven districts around Lake Toba, and each of those districts has a stream that drains into the lake. The Batak ihan or "ihan" (Neolissochilus thienemanni sumateranus) is found in the streams and lakes of Toba. Due to overfishing (Over Fishing), habitat loss from river pollution, river silting, and trash disposal in the upstream area, which prevents fish reproduction, Ihan has been classified as an endangered species. Fish are likewise becoming smaller, and less visible, and their distribution is also dwindling as a result of habitat loss [1].

Ihan can flourish in waters that are transparent (clean), have a water discharge of fewer than 6 liters per second, are slightly acidic (pH) (less than 6), and have an appropriate level of dissolved oxygen (DO) a good breeder[2]. It is within the group of fish that are virtually extinct; thus it is important to pay attention to the norms for endemic species so that the breeding cycle can resume. Our earlier studies had to do with raising fish seedlings in aquariums. The parameters that we consider include making sure that the water content matches the environment where the fish are located [2], creating tools, and creating monitoring software using Arduino and Raspberry Pi.

In the next research, we conducted multi-parameter testing based on WSNs. The monitoring system is specially designed for the ability to monitor temperature, dissolved oxygen (DO), pH, river water level, and river water flow rate. The WSNs-MS device will accommodate and collect information from multiple sensors and forward it to the WSNs sink node which is embedded in memory and the Raspberry Pi as a local database, a web server that holds information and can also perform monitoring. Monitoring results show important information that can be monitored by users or local authorities. WSNs-MS monitoring is designed with the Django framework, grafana dashboard, and control using the Message Queue Telemetry Transport (MQTT) application [3][4], which functions to ensure energy-efficient data transfer for WSNs-MS devices is activated because each WSNs-MS monitoring on the base is powered by a small battery source, so it requires recharging. WSNs-MS are placed in different locations around the Sampuran Pandumean in Bonan Dolok Balige at coordinates (2° 18' 26" N 9906' 58") and a distance of 2.14 km from Balige.

II. LITERATURE REVIEW

The quality of clean water is good for the life around, which must be considered is the water that is tasteless, odorless, colorless, and does not contain heavy metals[5][6]. Clean water resources are currently being handled by governments around the world, only 2% of the world's water is good for consumption, the other 98% is in the oceans, groundwater, rivers, and lakes, water in rivers and seas cannot be consumed commercially. Directly but water from the source can be processed and consumed [7][8].

Laboratory monitoring of the Pandumean river flow's water quality has been done, although the measurement is limited to one location. Additionally, additional samples might need to be collected each day for laboratory-based tests to get appropriate findings, and for some parameters, the results may not be as accurate as the actual sample of the water's changes during the test.

The application of WSNs technology that can perform real-time sensor monitoring can be adopted in various types of applications [9][10], the monitoring system is designed based on WSNs, which are capable of conducting related reviews of water quality monitoring and identifying any drastic changes in it. Water pollution is also widely formed, especially in coastal areas, so the supply of safe drinking water quality must be considered progressively. They display strategies for observing water quality, sensors, and data dissemination methods, data storage in the Sensor Cloud and the data collected consists of several parameters, namely pH, turbidity, and temperature based on IoT (Internet of Things)[11][12]. Multi-parameter sensor data can be transmitted using WSNs technology in real time to obtain observational information to check the status of rivers and ecosystems and determine specific relationships with event detection [13][14].

The water pollution monitoring with the application of wireless sensor networks in production and distribution, and applications in the marketing chain [15][16] Unfortunately, with the enrichment of content that can be monitored by sensors, WSN will play an increasingly important role in social production [17][18]. Multiple sensors, but limited sensors that only cover basic water parameters, namely temperature and pH, as well as data stored locally make it incompatible with online remote monitoring [19]. An intelligent IoT-based water quality monitoring system linked to lakes is being used in rural areas; the structure uses pH, turbidity, and conductivity sensors to determine water quality parameters regarding hydrogen ions and total dissolved solvent in the water. Also, the calculation of K Means has been used to anticipate water properties, with the help of a collection of information prepared from various test glasses of water, and to calculate and compare water quality parameters with the predicted time the results displayed on the cloud server have been communicated to the water analyst via personal computer [20].

III. METHODS

A. *Study Area*

Monitoring of the river is carried out at the Bonandolok location, which is 2.14 km from the city of Balige, precisely at the Sampuran Pandumean River (2° 18' 26"N 99° 06'58"), which empties into Lake Toba.

(a) (b)

Fig. 1. (a) The flow of a river of the Sampuran Pandumean, (b) The life of the ihan Batak

Based on survey results (April 12, 2022 - May 23, 2022), Ihan is increasingly rare and breeding is very slow. The average depth/height of the river water is ± 40 – 70 cm and at what point in the river there are still ihan, where the habitat of the ihan is surrounded by large rocks and the water depth is ± 1 meter. Based on the observations in “Fig. 1b” and the analysis of the water, indicators of several river water quality parameters are very urgent and a monitoring system needs to be carried out including temperature, dissolved oxygen (DO), pH, river water level, river water flow rate. The monitoring to be carried out is shown in” Fig. 2”.

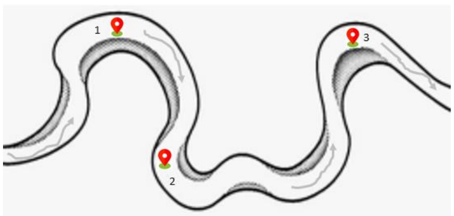
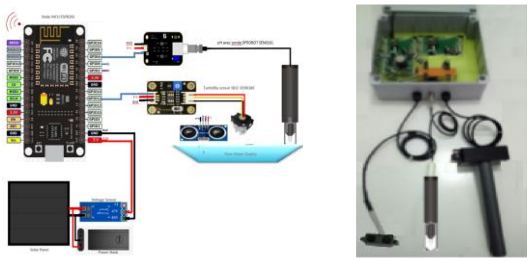


Fig. 2. River Flow Scheme

Monitoring with multiple sensors based on WSNs will be installed in three different locations, and the distance between devices ≤ 1 km, namely (1) Flow source stream A, (2) Flow source stream B; and (3) Flow source stream C. Each WSN-MS installed in three places will measure good or bad conditions with the parameter set [2].

B. *River Water Monitoring Devices*

The WSNs-MS device is shown in “Fig. 3b”, which has been packaged in the form of a module. Each sensor is connected to the MCU node or WSNs-MS using the ESP8233 microcontroller, shown in “Fig. 3a”, and is basically powered by a small battery source using a 12-volt DC power bank, thus requiring recharging from a solar panel.



(a) (b)

Fig.3. (a) Module node MCU ESP8233 in WSNs. (b) WSNs-MS devise for River Water Sensing.

The constant voltage source for the ESP8233 microcontroller (WSNs-MS) is 3 v dc, using a functional resistor circuit for the voltage divider, “Fig. 4”.

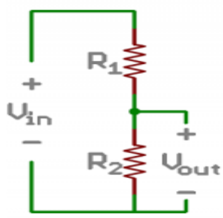


Fig. 4. Voltage divider circuit

Circuit for dividing voltage In “Fig. 4”, the power bank's constant (Vin) 12 volt DC input voltage will result in a constant (Vout) 3.16 volt DC output. The above circuit may be modified with R1 = 42 Mohm and R2 = 15 Mohm, according to the following formula, to provide a Vout value that can be adjusted for voltage:

$$Vout = [R1 / (R1+R2)] \times Vin \quad (1)$$

Fundamental monitoring WSNs-MS is powered by a source, WSNs-MS monitoring is designed with the Django framework, Graphana dashboard, and control using the Message Queue Telemetry Transport (MQTT) application. This ensures that energy-efficient data transfer for WSNs-MS devices is enabled. The little battery has to be recharged. To make water quality monitoring easier, the WSNs-MS system will take measurements of the given parameters every 71 minutes and send data regularly to a web server using a Raspberry Pi. Users can also retrieve the data using an application on a smartphone.

IV. PROPOSED SYSTEM

Based on data analysis and the findings of the first survey in the actual environment, the suggested design of WSNs multi sensors utilizing the ESP8233 microcontroller (WSNs-MS), used as a monitoring system for river water conditions, in three separate sites, was developed. The WSNs-MS system uses solar panels to recharge the power bank or battery, which is an individual power source input for the system.

Monitoring parameters may be flexibly organized in term of information measure, configuration, and there the distance of the transmitter/receiver antenna, so as to be ready to work with sensible performance, WSNs-MS devices may be abundant deeper. If the trick is to activate all the nodes contained in the ESP8233, it needs an influence consumption of 160 - 260 mA, therefore it's necessary to activate mode (deep sleep and light sleep) [21] [22] [23], in order that MCU node is active every 71 minutes.

The ESP8233 microcontroller module utilizes power-saving modes (modem-sleep, light-sleep, and deep-sleep) with current consumption of 14.25 mA, 0.87 – 0.89 mA and 9.87 A, respectively [24]. The need for large/small energy power will have an impact on sending/receiving data from the system. This time span is done so that the system does not work continuously and extends the life of the device. System mode settings will be made to the WiFi modem module; the system clock and CPU are all turned off, while only a real-time clock (RTC) is left to enable user-defined periodic wakes. Active deep-sleep mode with long time intervals between readings of WSNs-Ms. WSNs-Ms reads sensor data every 4,294,967,296 s (approximately 71 minutes) and process, and distribute that data to the database using node-sink.

In general, the MCU nodes and other devices can sleep for basically two hours or more, with the exception of the CPU. The CPU cannot be completely shut down; it is recommended that the MCU node must always be active. The WiFi modem sleep mode and the system clock are both turned off and the CPU is delayed (or suspended) while the RTC is active [2][20][26]. The CPU can only be woken up via the active high on the external general purpose (GPIO) output/input pin which can send/receive data from/to the Server to function as local data storage. For example, Monitoring Node A, Monitoring Node B, and Monitoring Node C monitoring sensor performance in the event of an unexpected intrusion into a restricted area can be operated in light sleep mode. The WSNs-Ms device wakes up when an intruder is detected instantly, gives a notification to the admin, and then the system returns to light sleep mode, but the multi-sensor is always on.

Application layer protocols do not use HTTP, because the application is not optimized for MCU nodes. But Constrained Application Protocol (CoAP), Message Queue Telemetry Transport (MQTT), or MQ Rabbit applications are widely used because application layer protocols are lightweight and can set restrictions, and resources for data transfer [3][4][25][26]. Power-saving data transfer can be ensured by enabling Tx/Rx mode, IoT-based MCU nodes and IoT monitoring nodes are generally powered by small battery sources; there is a need for developers to be able to estimate how long this small battery can continue to serve the MCU node without the need for replacement or charging repeat.

The focus of this work is we monitor data transfer from each WSNs-MS with the grafana dashboard and android applications, also monitor the charging of power banks or batteries sourced from solar panels, which will continuously provide power supply to time-based monitoring systems and multi-sensor monitoring events that enabled ESP8233. Nodes before that will require replacement or recharging. However, the model assumes that only the current drawn by the node component affects the capacity of the power bank/battery.

A. *WSNs-MS for River Water Sensing*

Complete monitoring system to all sensors to detect how many points of river flow to get real river flow data. As shown in "Fig. 4" depicts, the sensor node is mounted on the Riverside, with individual power systems being solar panels. Sensor nodes are usually installed very far from the monitoring site, so in this case, electricity supply from normal public services is not available. So in this system, utilizing a solar power system as a backup battery recharge becomes very useful. A large amount of detection data for each sensor is collected from one of the sensor systems and then contributed in large amounts because the sensor node has limited data storage; large data results in low feedback when sending data to the sink node. Multi-sensor WSNs-MS will affect the performance of the sensor nodes and also the response speed. Thus, a smart sensor node is proposed to be designed to get a fast response if abnormal detection in river water monitoring is introduced. The introduction of algorithms for sensor nodes and filtering some data makes sensor nodes smarter in detecting and determining river water pollution. The complete WSNs-MS sensing system for detection of water conditions with all parameters is shown in "Fig. 4". The system is designed to be integrated with all parameters including battery recharging and power supply with individual solar panel systems.

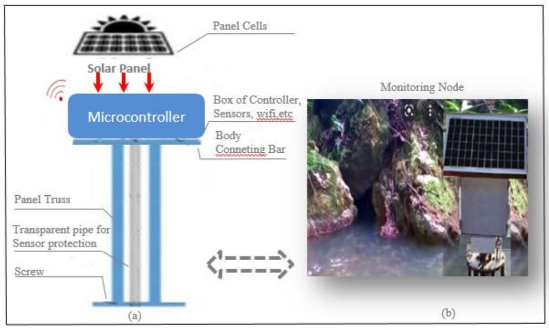


Fig. 4. (a) WSNs-MS node installed (b) WSNs-MS application.

B. *WSNs-MS Sink Node Communication*

WSNs (MCU nodes) were installed in three different locations with an average distance of 1 km. Internet connection facilities are available on-site using wifi. id, and the addition of an access point device as a base station or sink. Based on initial data collection with geographic information and surveys from three river points. In addition, people in villages and activities have contributed to river water pollution; in order to achieve more accurate data, the average node distance should be installed at 700 m as possible with the base station. "Fig. 5" shows a network topology scenario for a sensor system with a number of sensor nodes; each sensor node has a sink node to the base station for the data collection on a local host using an RPI-Web server and can be accessed using smartphones.

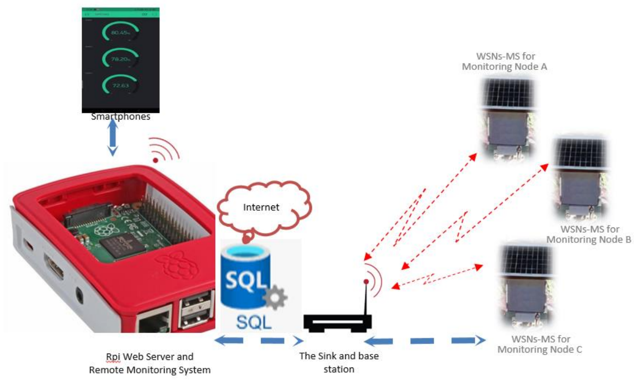


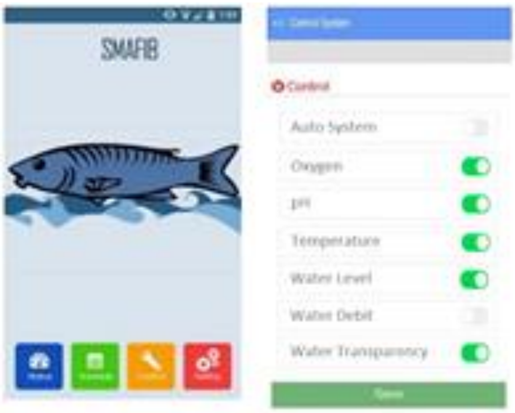
Fig. 5. Communication of **WSNs-MS** to the sink base station system.

C. *Software Development*

The ESP8233 MCU node microcontroller is used in the development of the software part of the WSNs-MS system, which accommodates the data signal from each sensor measurement result, and the data signal will be converted to digital data. Data from each WSNs-MS is forwarded to the WSNs sink node, which is embedded into memory, and the Raspberry Pi as a local database, a web server that holds the information. The local web server uses the Grafana dashboard embedded on the Raspberry Pi device. Menus that can be monitored on the web server are temperature, humidity, pH, water level, water discharge, and water transparency. The monitoring of each WSNs-MS activity is shown in "Fig. 5" and can also be performed in real-time monitoring using the SMAFIB v2 application.

Fig. 5. Monitoring WSNs-MS using Grafana Dashboard

The SMAFIB v2 application was developed using Android Studio, which was designed with the Django framework. The menu of the SMAFIB v2 application has four menus that users can use to carry out monitoring activities. Menu "Status" serves to display all data. The "Schedule" menu is used to select the sensor to be active and to set the period for which the sensor will operate. The "Control" menu serves to select how breeding activities will be carried out manually or automatically. The "Settings" menu is used to manage applications. In this menu, the user can change the appearance of the application, change the shape of the icon, explore the "Help" for using the SMAFIB v2 application, and adjust the time or date, as shown in "Fig. 6a". The GUI on the control menu is shown in "Fig. 5b", which is able to activate and deactivate several features of WSNs-MS. Features in the control menu consist of an "auto system" which functions to activate all sensors. However, if we choose several sensors that will be active, including oxygen, pH, humidity, temperature, water level, water discharge, and water transparency.



(a) (b)

Fig. 6. (a) Menu (b) Control Sistem

V. RESULT AND DISCUSSION

Monitoring the life of Neolissochillus thienemanni sumateranus in the Pandumean river flow is carried out from June - July 2022 using WSNs multi-sensor (WSNs-MS) and the ESP8233 controller and each WSNs-MS will accommodate and collect information from WSNs-MS and forward it to nodes WSNs-MS sinks are embedded into memory and the web server uses a raspberry Pi as a local database that holds information and a monitoring system. Real-time monitoring is carried out with the grafana dashboard and the SMAFIB v2 application [12]. The measurement data obtained from WSNs-MS installed in three different locations are in "Table 1".

TABLE I. MONITORING NODES

Parameter	Monitoring Node			
	A	B	C	Average
DO-Oksigen (mg/l)	8,72	8,57	8,40	8,56
pH (ml)	7,58	7,24	7,72	7,51
Temperature (°C)	23	24	24	23,6
C02 (mg/l)	3,2	3,1	3,2	3,16
Humidity (%H)	23	24	24	23,6
BOD5 (mg/l)	3,23	2,74	3,81	3,26
Water Debit (m/s) l/s)	1,13	1,27	1,20	1,2
Water transparency (m)	1,15	2,23	1,68	1,68

The data obtained in the test are used as initial parameters before the actual test is carried out and the sensors are installed. In this scenario, initial testing yields invaluable information to adjust whether the sensor node proposed as the model is relevant to be applied based on the defined design parameters. Some data are compared with other sensor data sets [2][13]. The results obtained from the tested temperature sensor are compared with conventional measurements, namely thermometers, "Fig. 5". Measurement of water discharge parameters, temperature, pH of the main factor, and measurement of pH are very important indicators for measuring water quality.

The sensor applied for pH measurements uses a glass electrode, where the sensor is first calibrated by adjusting the previous measurement results from the laboratory. The pH sensor design is in special specifications and precision, such as a minimum pH of 0.4. There are two classifications of tests carried out to observe the accuracy of the installed water pH sensor. Table 1 shows the results of water pH sensor measurements for three measurement points in the same river flow and measurements in a laboratory environment versus theoretical analysis obtained based on simulation and mathematical modeling. Both results give a good response and agreement, and in this measurement, it can be determined that the pH sensor is working well. Monitoring the life of Neolissochillus thienemanni sumatranus can grow at an average temperature of 23.6 °C and a pH of 7.51ml and a water flow rate of 1.2 liters/second. The data of WSNs-Ms measurement results which were distributed to the database showed that the measurement results for one day with time intervals of 71, 142, 213, and 284 minutes were the same.

VI.CONCLUSIONS

The proposed intelligent sensor node design for WSNs has been carried out with WSNs-MS to measure all parameters in the river flow. Initial tests in the laboratory gave a good response and several sample tests were carried out on river flows because many parameters of river water would be monitored, and various water sensors were used. Measurements were carried out for one month (June – July 2022) and were carried out showing good results and achievements compared to the analysis and theoretical for all sensors. Thus, WSNs-MS can be deployed and ready to be deployed to the actual location.

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