Hindawi
Wireless Communications and Mobile Computing
Volume 2023, Article ID 9768271, 1 page
https://doi.org/10.1155/2023/9768271

Retraction

Retracted: Design of Ecological Environment Monitoring System Based on Internet of Things Technology

Wireless Communications and Mobile Computing

Received 26 September 2023; Accepted 26 September 2023; Published 27 September 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] L. Chen and L. Zhang, "Design of Ecological Environment Monitoring System Based on Internet of Things Technology," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 2531425, 7 pages, 2022.

Hindawi
Wireless Communications and Mobile Computing
Volume 2022, Article ID 2531425, 7 pages
https://doi.org/10.1155/2022/2531425

Research Article

Design of Ecological Environment Monitoring System Based on Internet of Things Technology

Limin Chen [1] and Lei Zhang [2]

[1]Jinhua Polytechnic, Jinhua Zhejiang 321000, China
[2]Jinhua Polytechnic Normal School, Jinhua Zhejiang 321000, China

Correspondence should be addressed to Limin Chen; 20121014@jhc.edu.cn

Received 7 May 2022; Revised 24 June 2022; Accepted 28 June 2022; Published 7 July 2022

Academic Editor: Kalidoss Rajakani

Because of its high availability, Internet of Things technology is widely used in multipoint ecological environment monitoring and other related fields, which greatly improves the scientificity and accuracy of ecological environment monitoring results. The Internet of Things technology can realize multilevel and omnidirectional environmental monitoring functions by combining GPS systems and GIS systems and, at the same time, can significantly increase the monitoring range of environmental monitoring. On the basis of the Internet of Things monitoring technology, the use of electronic sensors can track and monitor the content and composition of various elements in the environment in real time, thereby reducing the work intensity of environmental monitoring personnel and effectively improving the environment reliability of monitoring results. In this study, we introduce the actual application and direction of the Internet of Things technology in multisite environmental monitoring systems. A water quality pH and temperature sensor monitoring system based on wireless data transmission is designed. Experimental analysis shows that the communication stability of the designed sensor system is relatively good. The average packet loss rate of the network is only 0.87%. The value measured by the designed sensor is very close to the reference value measured by the standard instrument. The average relative error of pH and temperature is 1.56% and 0.77%, respectively, which meets the water quality environmental monitoring standards. It is believed that the use of Internet of Things technology in ecological environment monitoring can effectively solve the problems of low efficiency and low rationality in traditional environmental monitoring methods, thereby fully improving the quality and level of monitoring in ecological environment monitoring.

1. Introduction

In recent years, the environmental degradation and pollution problems in China have become more and more serious. Environmental pollution not only destroys the ecosystem but also threatens human survival [1]. The air pollution in China is serious. The sulfur dioxide emissions have ranked first in the world. In addition, the pollution of water resources is more obvious. 70% of the rivers in the country have pollution problems [2]. There are serious polluting companies within 1 kilometer of 110 million residential houses, including oil, coke, and thermal power generation. In addition, waste pollution in China is also very prominent. The average annual output of industrial solid waste is 8.2×10^8 t, and domestic waste is 1.4×10^8 t. In this case, pollution monitoring is particularly important. In the context of increasingly serious environmental pollution, conventional ecological pollution data monitoring methods cannot meet the needs of ecological pollution data monitoring and management [3]. The use of online monitoring technology to monitor ecological pollutant data not only improves the monitoring efficiency and reduces the monitoring cost but also further improves the accuracy and efficiency of the monitoring data. It recognizes that the continuous monitoring of pollutants can monitor the pollution data timely and accurately [4].

In the early 1990s, many countries automatically established stable multiecological monitoring systems for online environmental monitoring and developed geographic information systems (GIS), remote sensing technologies (RS), and global satellite positioning (GPS) satellite positioning systems [5]. These technologies were used to check the air pollution and the changes in the ecological environment and predict the future environmental quality. The application of these technologies has expanded the scope of environmental monitoring and the ability to acquire, process, transmit, and apply monitoring data [6]. With the continuous development of science and technology, the application of the Internet of Things technology in the actual ecological environment monitoring has been able to better realize the networking, informationization, real-time, and intelligentization of environmental monitoring, greatly improving the reliability and validity of the Internet of Things technology in environmental monitoring. Therefore, for the current stage, the research on the multisite ecological environment monitoring of Internet technology is of certain value [7].

The Internet of Things actually refers to the connection of objects through the internet; thus, the Internet of Things technology can be understood as an information technology developed through the Internet. The Internet of Things is mainly composed of three architectural layers, which are network layer, perception layer, and application layer. The network center and communication signals in the system are the main system components in the network layer, which include the intelligent control and information collection and processing of the system in the system. The perception layer mainly includes hardware devices such as sensor devices, cameras, information recognition processors, and GPS in the system structure [8]. These devices have functions that can identify and capture the information released by each environmental object. The application layer is mainly composed of the actual application of technology content constitutes, such as cloud computing, application integration, and web services [9].

The Internet of Things technology can be used in many areas of ecological environmental monitoring to improve the quality and effectiveness of environmental monitoring. In this study, we use gas sensors to effectively monitor the content of various gases and particles in the atmosphere and the air through the Internet of Things technology and accurately transmit the monitored data to the Internet of Things control in real time. The computer terminal of the center realizes the application goal of monitoring the atmospheric environment [10]. It is verified that the use of sensors in the Internet of Things system in the actual water quality monitoring of the water environment can collect the water quality information and water quality content composition information existing in the studied water area in time, so as to achieve the system application goal of real-time monitoring of water quality [11]. The research results of this article provide reference for the application of Internet of Things technology in the field of ecological environment monitoring, such as its application in sewage, ocean, and other ecological environments.

2. Methods and Materials

2.1. Sensor Design. The sensor module is mainly composed of various sensors. The sensor module is designed with the most common water environment monitoring as an example. The pH composite electrode is used to measure the pH value [12]. The built-in thermistor can be used to measure temperature of the aqueous solution. The sensor module is mainly responsible for collecting various water quality index values and amplifying the analog signal. After that, the sensor module passes the analog signal to the processor module. The pH electrode has a high internal resistance, and the output signal is millivolt.

In the process of designing the circuit, because the signal is relatively weak, a three-stage amplification is formed by an operational amplifier [13]. The output of the first-stage amplifying pH electrode is connected to a voltage follower, so that the impedance can be matched in the circuit, and the back-EMF can be cut off for the first-stage amplification circuit interference [14]. The second level of amplification is to amplify the output signal of the pH electrode, and the third level of amplification is to adjust and amplify the signal to 0 ~ 3.3 V to meet the input range of the analog-digital converter. The pH value measurement circuit is shown in Figure 1. As shown, the output voltage of the circuit can be expressed as

$$V_{PH} = \frac{R_5}{R_4}\left(1 + \frac{R_3 + R_P}{R_2}\right)V_{\text{in}} - \frac{3R_6}{R_6 + R_7}\left(1 + \frac{R_5}{R_4}\right). \tag{1}$$

In the formula, V_{PH} is the output voltage, the output voltage is V_{in}, the adjustable resistance is R_P, the fixed resistance is R_{2-7}, the voltage stabilizer is D_1, the OP07 chip used in the first, second, and third stage amplifiers is U_1, U_2, and U_3, respectively, and filter capacitors are $C_1 - C_3$.

The pH electrode used in this system can measure the pH in the water environment. The composite electrode is composed of the reference calomel electrode and the indicator glass electrode. The glass electrode is only sensitive to hydrogen ions. When the hydrogen ion concentration in the environment changes, the electromotive force between the two electrodes also changes. According to the Nernst equation, the relationship between the electromotive force and the pH between the two electrodes is

$$E = E_0 + ST(pH - 7). \tag{2}$$

In the formula, the standard electric potential is expressed by E_0, the output electromotive force is expressed by E, the Nernst coefficient is expressed by S, and the absolute temperature is expressed by T.

The output voltage across the electrode V_{in} is

$$V_{\text{in}} = \frac{R_L}{R_S + R_L}E = BE, \tag{3}$$

In the formula, the equivalent resistance is represented by R_L, and the internal resistance of the electrode is represented byR_S.

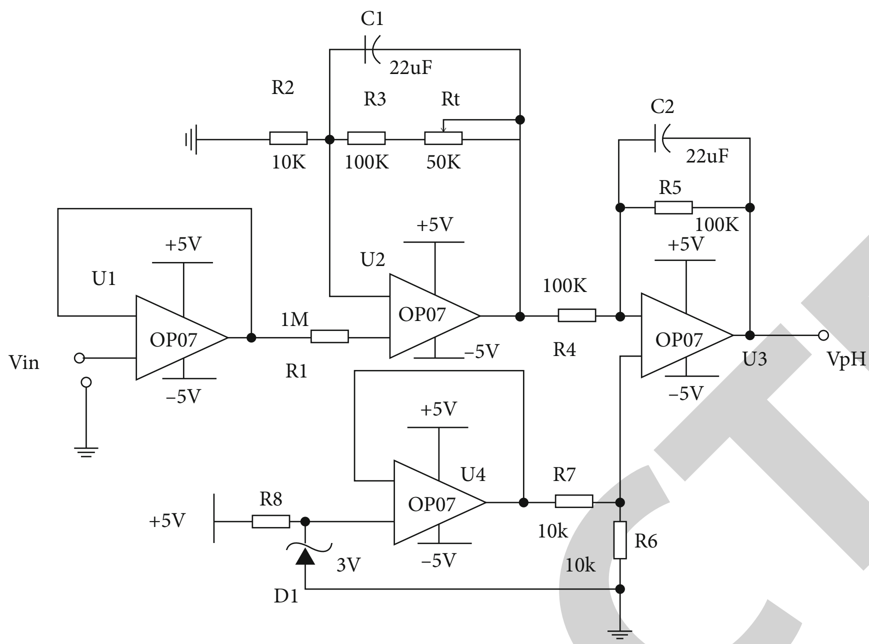

Figure 1: The pH sensor conditioning circuit diagram.

According to the above formula, the output voltage can be expressed as

$$V_{pH} = K_{pH}(T)(pH - 7) + V_0. \quad (4)$$

In the formula, the output voltage of the circuit when pH = 7 is expressed by V_0, and the Nernst coefficient is expressed by K_{pH}.

In order to reduce the development cost and complexity, the thermistor R_t in the pH composite electrode is used for temperature measurement. The working principle is to adjust the resistance of R_p to make the bridge reach a balanced state. The output voltage is

$$V_T = 5\left[\frac{R_T/R_P}{1 + R_T/R_P}\left(1 + \frac{R_2R_6 + R_3R_6}{R_2R_4 + R_2R_3 + R_3R_4}\right) - \frac{R_3R_6}{R_2R_4 + R_2R_3 + R_3R_4}\right]. \quad (5)$$

From the experiment, we can get

$$V_T = -4.593 * 10^{-3}T + 1.081(0 < T < 25), \quad (6)$$

$$V_T = -1.207 * 10^{-3}T + 1.257(25 < T < 50). \quad (7)$$

In equations (6) and (7), the centigrade temperature is expressed by T.

Figure 2 shows the temperature measurement circuit. Among them, the anode and cathode interfaces of the electrode are 1-2, the adjustable resistance is represented by R_P, the fixed resistance is represented by $R_{1\_}R_6$, the voltage stabilizer is represented by D_1, the built-in thermistor is represented by R_T, and the amplifier OP07 is represented by U_1. Figure 3 is a photograph of a sensor node.

2.2. Processor Module. The microcontroller chip MSP430F5638 is equipped with a high-performance 12-bit analog-to-digital converter, two universal serial communication interfaces, a comparator, a hardware multiplier, USB2.0, four 16-bit timers, DMA, and multiple I/O pin the microcontroller. The low power consumption of this single-chip microcomputer fully meets the requirements of this subject. The operating voltage is from 1.8 V to 3.6 V. The active mode (AM) is 8 MHz and 270 MHz at 3.0 V. The standby mode (LPM3) can wake up quickly. Different power-saving modes are also suitable for long-time working occasions with battery power supply [15]. The ultralow power consumption of the architecture and the high flexibility of the clock system can greatly extend the battery life. Because it is a FLASH type, it is possible to debug and download programs on the single-chip microcomputer online, and the processor module is converted into a digital quantity through analog-to-digital conversion.

2.3. Wireless Communication Module. The wireless communication module adopts the Zig Bee low-power and high-performance CC2530 microcontroller introduced by TI. The CC2530 sends the collected data through the wireless radio module. Moreover, this design method of integrating MCU and radio frequency transceiver module has many advantages, which makes the node miniaturization and lower power consumption. It contains an 8051 single-chip microcomputer and a high-performance RF transceiver, with a communication distance of up to 1000 m. An 8051 microprocessor and a high-performance RF transceiver are integrated inside, with a communication distance of up to 1000 m. A large flash memory which is up to 256 KB of storage space is the ideal professional chip for Zig Bee. It works in the global 2.4 GHz frequency band. The radio frequency

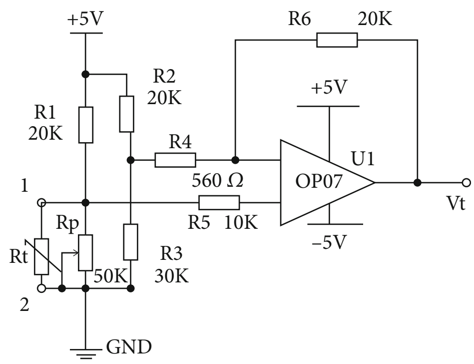

Figure 2: Temperature sensor conditioning circuit.

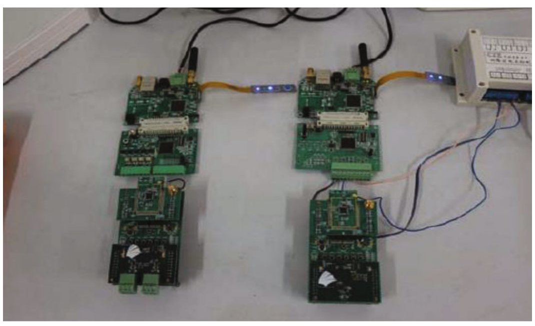

Figure 3: Physical map of sensor node.

transceiver complies with relevant standards, has stable performance and low power consumption, and can achieve fast multipoint-to-multipoint networking. Figure 4 shows the function pin diagram of CC2530. CC2530 was chosen for the following reasons:

(1) According to the actual needs of the project, Zig Bee has smaller data flow, lower cost, and lower power consumption

(2) CC2530 integrates ADC, microprocessor, and communication module to improve reliability while miniaturizing the node

(3) CC2530 can use the latest ZigBee protocol, namely, ZigBee 2007, while chips such as CC2430 or CC2431 do not support ZigBee 2007 protocol. ZigBee 2007 has improved interoperability and other aspects. Using CC2530 as a processor node can communicate over longer distances and has more stable networking performance

(4) CC2530 has better performance and lower price

2.4. Power Module. The power management module provides energy to each module of the sensor node. Since the sensor node must have the characteristics of convenient power supply and strong continuous working ability, the wireless sensor node power supply system designed in this paper uses 2 AA batteries as the main power supply [16]. The circuit design only needs to add four at the input and output ends. The filter capacitor is sufficient, which has the advantages of low power supply cost and convenient battery replacement [17].

2.5. Internet of Things Technology Gateway Design. For the design of the gateway, the OMAP3730 chip from TI Company is used. The OMAP3730 processor uses the advanced 45 nm process technology from TI Company. This architecture design provides better ARM and graphics card performance, while ensuring low power consumption.

OMAO3730 integrates a DSP subsystem and an ARM subsystem. The DSP subsystem uses a TMS320CC64 DSP processor. The heterogeneous dual-core OMAP3730 processor integrates a TMS320CC64 processor. The operating frequency can reach up to 800 MHz, and there are 64 32-bit general registers. There are 8 independent functional units, including 6 arithmetic logic units and 2 multipliers. 8 functional units are with a word length of 256 bits. At a clock frequency of 800 MHz, when 8 processing units are running at the same time, the maximum processing capacity is 6400MIPS. The TMS320CC64 core adds free power saving areas, variable length instructions, and parallel expansion mechanism. In addition, the core of TMS320CC64 has added a hardware accelerator to enable it to play a role in occasions that require large data volume floating point operations or where real-time performance is required.

The ARM subsystem uses the ARM Coretex-A8 processor with a frequency of up to 1000 MHz. As shown in Figure 5, the gateway still uses the CC2530 chip for reception, and the unified transmission protocol ensures reliable transmission. There are no sensors in the gateway node designed in this paper, and it is only responsible for processing and sending and receiving data. A Wi-Fi module is used to complete remote data transmission.

3. Results and Analysis

In this study, we achieve the wireless connection of monitoring the whole process, which can be used in different environments flexibly and can realize the functions of real-time collection, wireless transmission, and remote monitoring of environmental parameters [18]. In addition, Niagara is used as the host computer development environment for secondary development. This software is the first time to be used in a system based on the Internet of Things technology. The data collected by the sensors can be monitored and controlled in the host computer in real time. The environment can be monitored at anytime and anywhere [19]. The corresponding control is very flexible. The following takes the measurement of the water environment as an example to verify the wireless environment monitoring system based on the Internet of Things technology. For the current water quality monitoring, the water temperature and pH value are selected according to the types of sensors commonly used in the current market to monitor water quality.

3.1. Network Packet Loss Rate Test. During the experiment, 6 sensor nodes, 1 gateway node, and 6 routing nodes were placed in different positions of the pool. The routing node

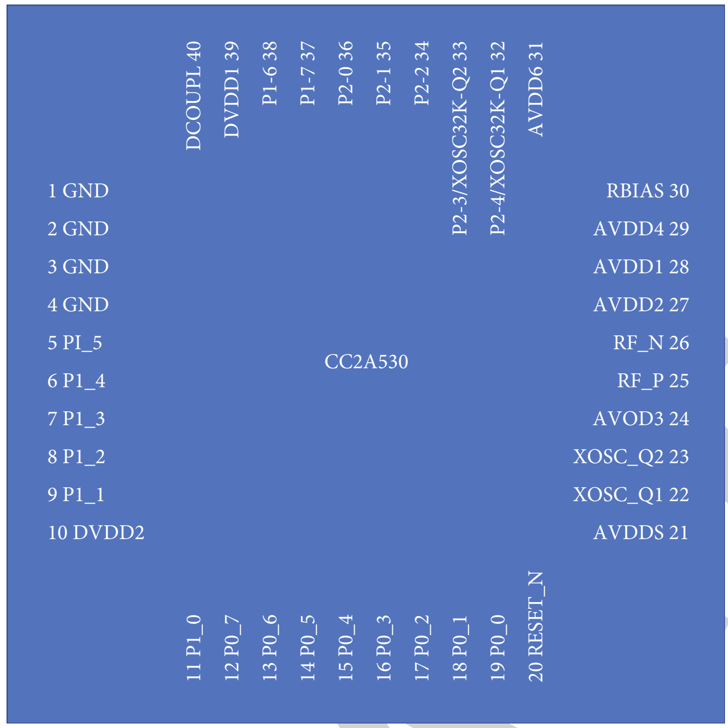

Figure 4: CC2530 function pin diagram.

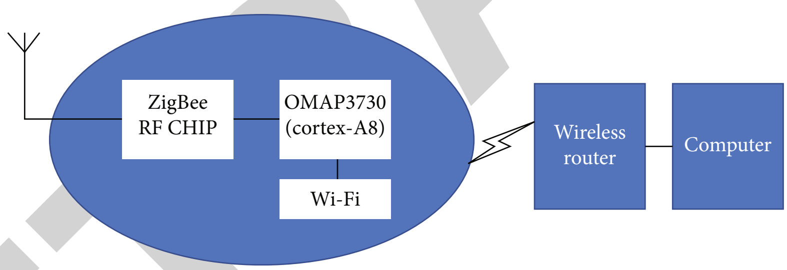

Figure 5: Block diagram of the hardware structure of the gateway.

was between the sensor node and the gateway node, and the data collected by the sensor was forwarded to the gateway node. During every 30 s, the sensor node collects and sends data once, and then the node enters the receiving mode. Table 1 shows the result of continuous monitoring. The stability of system communication is relatively good, and the average packet loss rate of the network is only 0.87%.

Table 1: Test results of packet loss rate.

Sensor node	Packet sent	Data packet received by the gateway node	Packet loss rate
01	1000	994	0.60%
02	1000	998	0.20%
03	1000	987	1.3%
04	1000	991	0.9%
05	1000	984	1.6%
06	1000	992	0.8%
Average	1000	991	0.90%

3.2. Water Quality Parameter Collection Test. Before the pH test, it is necessary to calibrate the pH electrode with pH 6.86 and 9.18 solutions to avoid errors affecting the authenticity of the experimental data. Then, under the condition of 25°C, we prepare different pH solutions and then use this system for testing. The measurement result is compared with the value measured by the PHSCAN30 acidity meter. The accuracy of the PHSCAN30 acidity meter is ±0.05 pH, and the experimental data is shown in Table 2. The water temperature is taken from pool water for cooling and heating tests. The test data is shown in Table 3. By comparing the results of the test, the value measured by the system is very close to the reference value measured by the standard instrument. The average relative errors of pH and temperature are 1.56% and 0.77%, respectively. The errors are within the allowable range, and the measurement accuracy is relatively high which is able to meet the requirements of data collection.

Table 2: The pH test results.

PHSCAN30	Measured value of this system	Relative error
5.0	4.87	-2.60%
5.5	5.35	-2.72%
6.0	5.89	-1.83%
6.5	6.42	-1.23%
7.0	6.94	-0.86%
7.5	7.40	-1.33%
8.0	7.93	-0.88%
8.5	8.38	-1.41%
9.0	8.89	-1.22%
Average	/	-1.56%

Table 3: Temperature test results.

Standard instrument	Measured value of this system	Relative error
4.9	4.97	1.43%
10.1	10.19	0.89%
15.2	15.31	0.72%
19.8	19.88	0.40%
25.1	25.20	0.39%
30.3	30.43	0.43%
34.8	35.20	1.15%
40.1	41.40	3.24%
Average	/	1.08%

3.3. Discussion on the Application of Internet of Things Technology in Environmental Monitoring

(1) Ecological environment monitoring

In ecological environment monitoring, when using the Internet of Things technology, the monitoring area can be divided, and then, the ecological environment in the target area can be monitored separately by using sensors. The main function of the sensor in the actual ecological monitoring process is to collect information and then transmit the actually monitored information to the monitoring center through the Internet of Things transmission mode, so that environmental monitors can fully understand the ecological environment of the area, thereby helping it to carry out better management [20]. In addition, the Internet of Things technology can also realize the functions of sending, receiving, and processing information of the ecological environment information system in the actual environment. After the monitoring center receives the information and data signals sent by the sensors, the display can clearly show the environmental conditions in the area to achieve the purpose of collecting information effectively for ecological monitoring.

(2) Marine environment monitoring

In the application of the Internet of Things technology in marine ecological environment monitoring, sensor network devices are placed at the corresponding monitoring area points in the ocean, thereby transmitting the actual ecological environment status at the bottom of the ocean to the monitoring center on the ground through wireless communication data transmission [21]. In this way, the environmental management personnel on the ground can grasp the ecological environment of the seabed in time, so as to solve problems such as the more frequent seawater pollution (chemical pollution), heavy metal pollution, oil pollution, the problem of rich oxidation in seawater, and the timing of rising and falling tides. The application of the Internet of Things technology to the improvement of marine ecological environment monitoring has also provided more scientific and specific value information for the marine environmental monitoring work in China, which can further improve the quality of marine ecological environment monitoring (Figure 6).

Figure 6: The application of the Internet of Things in ocean monitoring.

(3) Wastewater treatment monitoring

The monitoring of sewage treatment is carried out by using the monitoring method of Internet of Things sensors correctly. This highly intelligent monitoring method can reflect the water quality of regional water sources in a more real-time and comprehensive manner. At the same time, this method also has advantageous features such as low-cost and high-monitoring efficiency, which greatly improve the accuracy of regional sewage monitoring results. In addition, it can assist sewage monitoring and treatment workers in the form of auxiliary functions to analyze the pollution situation and pollution degree in the water body in time. The main process of water quality monitoring of the Internet of Things is to collect the content of various elements in the sewage water body at the outlet or entrance of the sewage discharge through the application of various sensors in the monitoring system or camera, video monitoring equipment, and so on. These data will be uploaded to the monitoring center. Then, the collected information can be sent to the management personnel or make an alarm and other reactions to remind the equipment management personnel.

4. Conclusion

(1) With the continuous development of human society in the fields of economy and technology, the Internet of Things technology integrates a close attitude into people's real life, improving people's quality of life and making people's life styles intelligent. Especially

in the construction of modern environmental monitoring systems, it has a huge positive force in promoting the development of an energy-saving society and environmental protection in the new social development period

(2) Taking the water environment pH and temperature monitoring as the application direction, a wireless environment monitoring system based on the Internet of Things technology, including sensor modules, processor modules, wireless communication modules, power modules, and gateway design, fully realizes the monitoring of the entire process wireless connection, real-time collection of water environment parameters, wireless transmission, and remote monitoring functions

(3) We test the designed monitoring system. The stability of system communication is relatively good. The average packet loss rate of the network is only 0.87%, which can achieve good data collection and transmission. The monitoring results are compared with those measured by standard instruments. The average relative errors of pH and temperature are 1.56% and 0.77%, respectively, which meets the water quality environmental monitoring standards

Data Availability

The figures and tables used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors would like to show sincere thanks to those techniques who have contributed to this research. This work was supported by the Zhejiang educational science planning project "research on the construction of personalized push model of normal students' teaching skills case based on video TAG" (gh2022290).

References

[1] X. Xu, Y. Zhang, M. Ji, and Y. Song, "Determination of effective transmission distances of wireless sensor network nodes for agro-ecological environment monitoring," *Transactions of the Chinese Society of Agricultural Engineering*, vol. 29, no. 14, pp. 164–170, 2013.

[2] Y. Z. Sun, L. P. Guo, W. Q. Zhu, L. Q. Huang, and Y. Z. Pan, "Remote sensing monitoring methods for medicinal plants resource in different types of ecological environment," *China Journal of Chinese Materia Medica*, vol. 32, no. 14, pp. 1490–1492, 2013.

[3] K. H. Nam, "A study on Yeong-san river ecological environment monitoring based on loT," *Journal of Ikeee*, vol. 10, no. 2, pp. 203–210, 2015.

[4] B. Tegler, M. Sharp, and M. A. Johnson, "Ecological monitoring and assessment network's proposed core monitoring variables: an early warning of environmental change," *Environmental Monitoring & Assessment*, vol. 67, no. 1/2, pp. 29–55, 2001.

[5] G. S. Zhang and R. Q. Wang, "Research on dynamic monitoring of ecological environment in modern Yellow River Delta," *China Environmental ence*, vol. 28, no. 4, pp. 380–384, 2008.

[6] J. P. Kimmins, "Monitoring the condition of the Canadian forest environment: the relevance of the concept of 'ecological indicators'," *Environmental Monitoring & Assessment*, vol. 15, no. 3, pp. 231–240, 1990.

[7] A. S. Danilov, U. D. Smirnov, and M. A. Pashkevich, "The system of the ecological monitoring of environment which is based on the usage of UAV," *Russian Journal of Ecology.*, vol. 46, no. 1, pp. 14–19, 2015.

[8] G. V. Belle and L. Fisher, "Monitoring the environment for ecological change," *Journal-Water Pollution Control Federation*, vol. 49, no. 7, pp. 1671–1679, 1977.

[9] Z. Yu, "Research on the distributed dynamic ecological environment monitoring system," *Journal of Anhui Agricultural ences*, vol. 36, no. 12, p. 5095, 2008.

[10] J. Y. Liu, S. J. Ke, and J. H. Xu, "Study on reasonable layout of the ecological environment monitoring station net," *Research of Soil and Water Conservation*, vol. 9, no. 4, pp. 113–116, 2002.

[11] L. B. Zhou and M. H. Zhou, "Ecological environment monitoring model based on the internet of things sensing," *International Journal of Advancements in Computing Technology*, vol. 5, no. 7, pp. 1152–1159, 2013.

[12] C. L. Liu, H. X. Tian, and Y. F. Ma, "Ecological monitoring of water quality in Fuziling reservoir," *Journal of Environment and Health*, vol. 27, no. 11, pp. 980–984, 2010.

[13] L. Cao and R. Liu, "Design of an ecological environment monitoring system for nature reserve," *International Review on Computers & Software*, vol. 7, no. 2, pp. 830–834, 2012.

[14] D. Zhang, "Dynamic monitoring and evaluation of ecological environment based on remote sensing technology in Xuzhou city," *Environmental Monitoring in China*, vol. 27, no. 5, pp. 86–90, 2011.

[15] A. A. Abrosimov, G. L. Gul'Din, and Y. Y. Erokhin, "Ecological monitoring of environment: SEKOM system," *Chemistry & Technology of Fuels & Oils*, vol. 34, no. 2, pp. 84–86, 1998.

[16] A. J. King, B. Gawne, L. Beesley, J. D. Koehn, D. L. Nielsen, and A. Price, "Improving ecological response monitoring of environmental flows," *Environmental Management.*, vol. 55, no. 5, pp. 991–1005, 2015.

[17] A. A. Buznikov, "Space-based spectrophotometry of the natural environment and global ecological monitoring," *Journal of Optical Technology*, vol. 65, no. 5, pp. 330–334, 1998.

[18] W. E. Rees, "Economic development and environmental protection: an ecological economics perspective," *Environmental Monitoring & Assessment*, vol. 86, no. 1/2, pp. 29–45, 2003.

[19] C. B. Schmitt, A. Belokurov, C. Besançon et al., "Global ecological forest classification and forest protected area gap analysis," *Marine Geology*, vol. 75, no. 1, pp. 201–219, 2009.

[20] J. A. Camargo, "The importance of biological monitoring for the ecological risk assessment of freshwater pollution: a case study," *Environment International.*, vol. 20, no. 2, pp. 229–238, 1994.

[21] D. Stroppiana, M. Boschetti, P. A. Briuio, P. Carrara, and G. Bordogna, "A fuzzy anomaly indicator for environmental monitoring at continental scale," *Ecological Indicators*, vol. 9, no. 1, pp. 92–106, 2009.