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Software for marine ecological environment comprehensive monitoring system based on MCGS

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Abstract. The automatic integrated monitoring software for marine ecological environment based on MCGS configuration software is designed and developed to realize real-time automatic monitoring of many marine ecological parameters. The DTU data transmission terminal performs network communication and transmits the data to the user data center in a timely manner. The software adopts the modular design and has the advantages of stable and flexible data structure, strong portability and scalability, clear interface, simple user operation and convenient maintenance. Continuous site comparison test of 6 months showed that, the relative error of the parameters monitored by the system such as temperature, salinity, turbidity, pH, dissolved oxygen was controlled within 5% with the standard method and the relative error of the nutrient parameters was within 15%. Meanwhile, the system had few maintenance times, low failure rate, stable and efficient continuous monitoring capabilities. The field application shows that the software is stable and the data communication is reliable, and it has a good application prospect in the field of marine ecological environment comprehensive monitoring.

1. Introduction

It is the prerequisite and basis for the research and protection of marine ecological environment to obtain continuous and long-term comprehensive observation data and to objectively analyze the present situation and dynamic trend of marine ecological environment. At present, more than 100 marine environmental monitoring stations built in China are mostly for hydrometeorological observation, and there is no comprehensive observation of marine ecological environment. Moreover, the integrated monitoring equipments used in monitoring stations are heavily dependent on import and they can't be fully applied to China's complex marine environmental monitoring Condition [1-3]. It is of great significance to the marine environmental protection and marine ecological science research in China to make full use of the existing marine station infrastructure, observation equipment and security conditions, to carry out the long-term comprehensive observation system integration technology research of the marine station ecological environment, and to develop stable, reliable, automatic, easy to operate and highly integrated long-term comprehensive observation system, Which can make up for the shortcomings of the existing marine environmental observation system in the long-term continuous online observation.

To this end, the project team developed a set of integrated monitoring system for China's marine environment. This paper introduces the design, development and real-time application of MCGS-based PC software applied to the system. The software enables real-time online data monitoring, display, storage and network transmission of a wide range of marine ecological parameters. It is simple to operate and flexible in configuration and it can ensure ocean monitoring information collection, processing and control operation more systematically and efficiently.

2. System overall design

2.1. System composition

The marine ecological environment monitoring system designed and developed by this project is mainly composed of seawater acquisition and distribution subsystem, monitoring sensors subsystem, data acquisition hardware subsystem and host computer software subsystem. The system integrates common parameters of seawater quality, such as temperature, salinity, turbidity, dissolved oxygen, chlorophyll, pH, total organic carbon, silicate, ammonia nitrogen, nitrite, nitrate, phosphate and so on, and it has the characteristics of high reliability, simple operation and low maintenance frequency. The overall structure of the system is shown in figure 1.

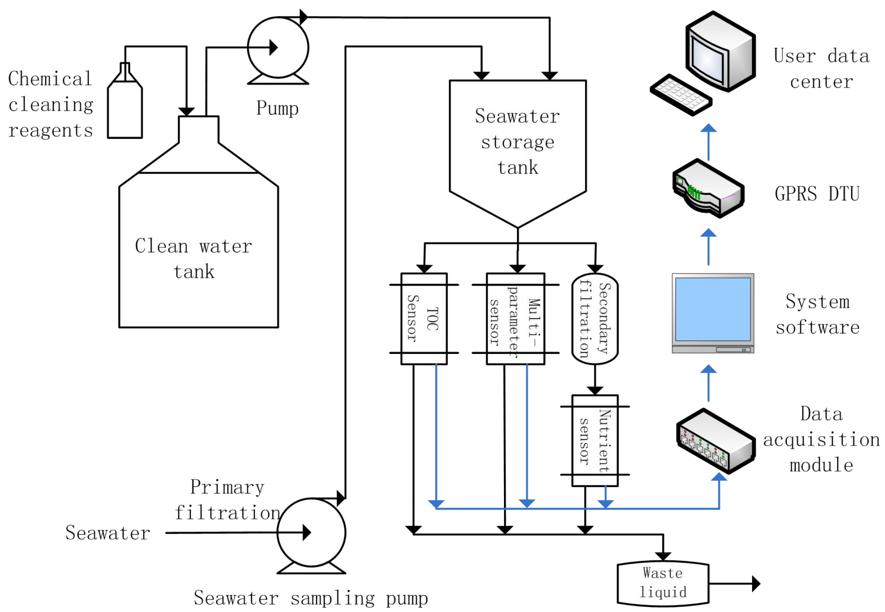

Figure 1. The overall structure of the system.

When a certain analysis process begins, the seawater sampling pump collects surface seawater into the storage tank of the detection system. After seawater acquisition is completed, the software assigns the seawater in the storage tank to every sensor inspection cabin according to each sensor's demand for specific parameter detection. After the end of an analysis process, the water samples in the module are emptied and the test data is uploaded to the system software via the data acquisition module. Then, the software will process, display and save the data. Depending on different situations, users can set different data transmission frequencies. The data can be transmitted to the user data center immediately after the end of each detection process, or it can be packed and transmitted after the whole day detection completed to the user data center, via GPRS Data Transfer Unit (DTU).

In order to prevent the impact of biological attachment on data detection, users can regularly clean the system according to seawater quality. When the system chemical cleaning process begins, system will fill storage tank and sensor detection cabins with cleaning fluid which is mixture of chemical reagents and clean water. Then, empty the cleaning fluid after a few minutes and repeat above process several times to wash off the biological attachment. At last, use seawater to flush the system storage tank and sensor detection cabins several times.

2.2. Seawater acquisition and distribution subsystem
The seawater acquisition and distribution subsystem is mainly composed of water collection module, water distribution module and filter module. The water collection and distribution module are responsible for collecting the surface seawater and distributing the water samples to the monitoring sensor subsystem. The filter module mainly includes a primary filter on the pump and a secondary nutrient filter with a diameter of 1 um.

2.3. Monitoring sensors subsystem
The monitoring sensors subsystem is mainly composed of ecological sensors, used to monitor the marine ecological parameters. At present, the system mainly integrates the self-developed nutrient sensor, multi-parameter sensor and TOC sensor, and reserves interfaces for other sensors. The sensors communicate with the host computer software according to the system's communication protocol, receive software instructions to monitor the parameters, and upload monitoring data to the software, to achieve the real-time monitoring of marine ecological environment parameters.

2.4. Data acquisition hardware subsystem
Data acquisition hardware subsystem uses modular architecture and bus design and its core control system uses high-performance embedded integrated industrial computer TPC1561Hi. The subsystem is mainly responsible for power supply of the system and sensors and state control of a variety of pumps, valves and other devices. The subsystem achieves interaction with monitoring sensors through the serial port and complete data transmission and communication connection with the host computer software by Mod-bus protocol, to ensure data stability and reliability.

2.5. Host computer software subsystem
The host computer software is mainly composed of data acquisition and processing module, graphical display interface, parameter configuration module, flow control module, data storage module and network transmission module. It is responsible for data transmission and communication connection with data acquisition hardware subsystem. It collects, processes, displays, saves and calls the eco-environment parameters, and transmits the monitoring parameters to the user data center over the wireless network.

3. System software design

3.1. Software design overview
The host computer software is the intelligent core of the system and it uses Monitor and Control Generated System (MCGS) based on windows system as the development platform. MCGS can solve the practical engineering problems in a variety of ways such as animation display, process control, alarm processing, report output, etc., and has been widely used in the field of automation control [4, 5]. The software adopts multi-thread technology, multi-layer architecture and functional modular design, which can realize the operation control of subsystems, interactive communication between subsystems, data acquisition, analysis and processing, data graph display and database storage, historical data calls, external data communication and other functions.

The system software mainly includes four modules, the system parameters setting module, the analysis process control module, the data collection and processing module, and the data transmission module. The system parameters setting module includes system initialization, parameter settings of manually run and parameter settings of automatically run. It is mainly responsible for setting process trigger time and system valve status. The analysis process control module is the core of the software

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which can control the operation of each analysis processes of the system. It is divided into automatically run process control and manually run process control, both of which include TOC, multi-parameter and nutrient analysis process, system chemical cleaning process, filtration system recoil process and force interrupt of process. The data collection and processing module is responsible for achieving the detection of marine ecological parameters, data processing and display, data storage and invocation. The data transmission module can achieve local data exchange and network data communication. GPRS DTU equipment is used to achieve the network communication with user data center to realize real-time remote data transmission. The system software structure design is shown in figure 2.

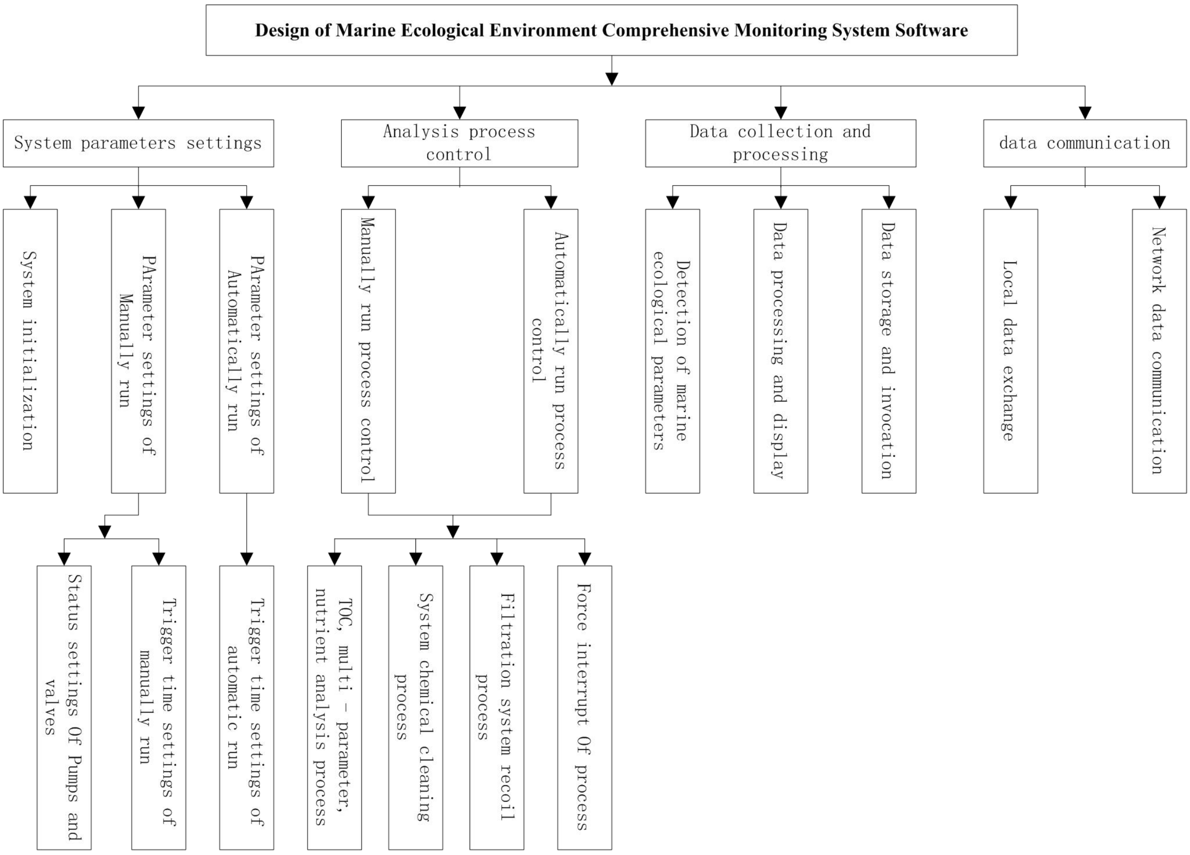

Figure 2. Structure of the software for marine ecological environment monitoring system.

3.2. Software function design

3.2.1. Software process design. The software is modularized design and is divided into four independent processes: TOC analysis process, multi-parameter analysis process, nutrient analysis process and chemical cleaning process. Among them, the nutrient analysis process is divided into nutrient pretreatment process, separate analysis process of the five nutrient parameters and nutrient post-processing process. Every process can be both automatic and manual controlled. The automatic operation process is triggered by time scanning. Users can set the trigger time of the analysis flow every day in the time setting interface. When the system time meets the time that users set, the corresponding analysis process will be triggered. The manual operation flow is triggered by the trigger button corresponding to each process. The trigger block diagram of each analysis process is shown in figure 3. With the automated operation of nutrient analysis process for example, the operation flow chart is shown in figure 4.

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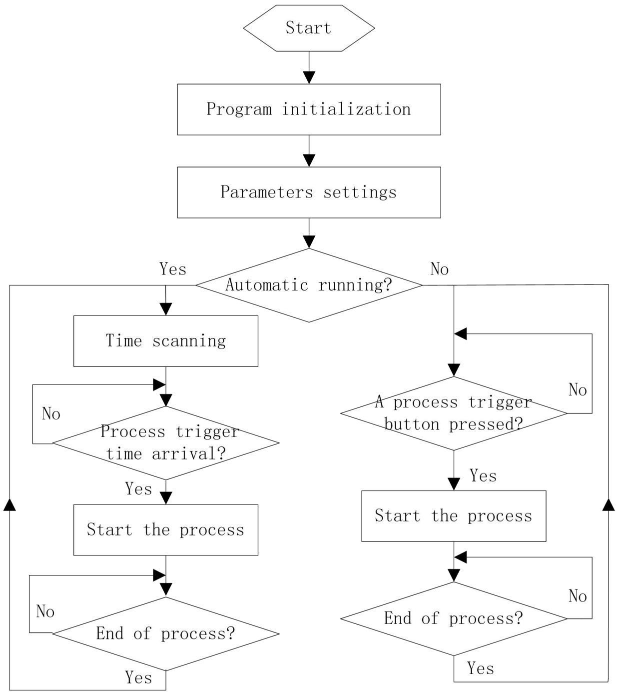

Figure 3. Block diagram of analysis process triggers.

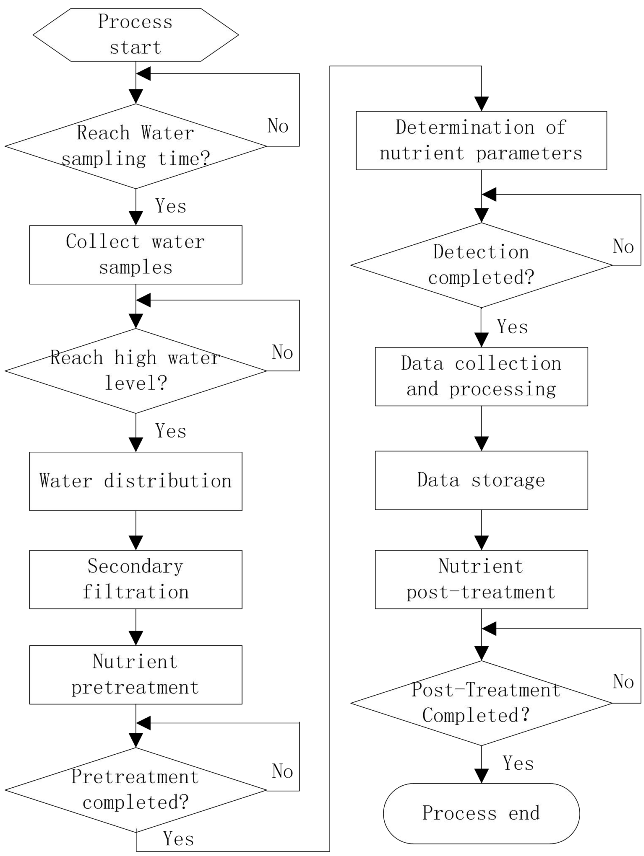

Figure 4. Automatic detection and analysis flowchart of the nutrient.

3.2.2. Software communication design. The software achieves remote network communications with user data center through the Data Transfer Unit (DTU). DTU is a wireless terminal device that is used to convert serial data into IP data or to convert IP data to serial data by a GPRS wireless communication network. It doesn't need background computer support and utilizes GPRS network. It has the characteristics of stability, speed, always online and etc.. It is widely used in meteorological, geological, hydrological and hydrological related industrial monitoring, environmental monitoring and other fields [6-8]. DTU can convert the raw data on the serial port into TCP/IP packets for transmission without having to change the original data content. Therefore, the DTU can be connected with various user devices that use serial communication, and there is no need to make changes to the user equipment.

The software communicates with the DTU via RS232 serial port, and it sends the detected marine ecological environment parameters to the DTU according to the format requested by the user. DTU encapsulates the data into TCP/IP format data packets through the GPRS module. The data packet is sent from the GPRS network to the user data center which has fixed public IP address or fixed domain name. User data center can directly read and analyze the data to achieve remote monitoring and analysis of marine ecological environment parameters. The data communication principle of DTU is shown in figure 5.

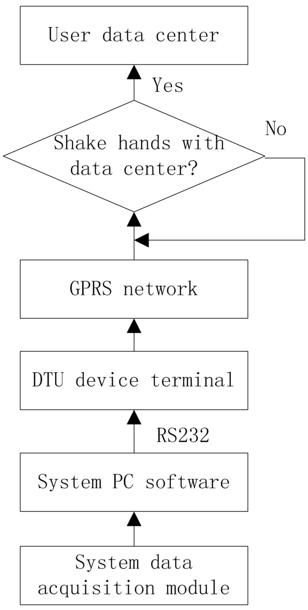

Figure 5. DTU data communication schematic.

4. Experimental validation

The system was installed at Zhoushan Tidal Station of the East China Environmental Monitoring Center. S.O.A.. From March to August of 2016, a 6-month follow-up monitoring test was conducted at Zhoushan Tidal Station. During the six-month trial, the system was run continuously for 24 hours a day. Test data was uploaded regularly to user data center according to the requirements of the East China Environmental Monitoring Center. S.O.A.. A site comparison test lasting six to nine days was performed every month, to compare the results of the system monitoring with the standard manual method. As shown in figures 6-9, this paper selected the site comparison test results of salinity, pH, dissolved oxygen and $SiO4^{2-}$ from May 23 to May 31, 2016 as a representative. The results showed that the relative error of the parameters such as temperature, salinity, turbidity, pH, dissolved oxygen with the standard method was controlled within 5% and the relative error of the nutrient parameters was within 15%. Therefore, the test results showed that the system had good stability and accuracy. The continuous operation of 6 months showed that the system had few maintenance times, low failure rate, stable and efficient continuous monitoring capabilities. Meanwhile, the system was easy to operate and easy to maintain. Therefore, the system can be well applied in the field of marine ecological environment monitoring.

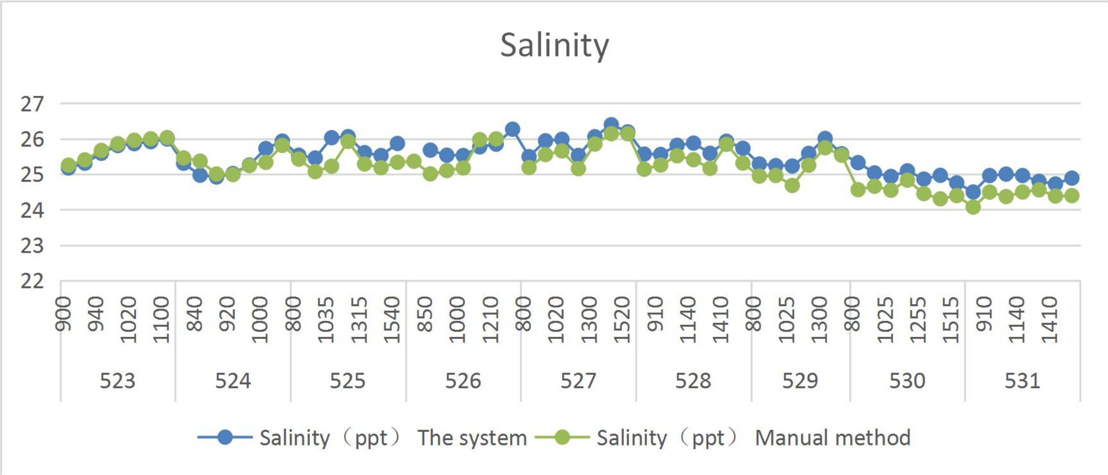

Figure 6. Site comparison test results of salinity.

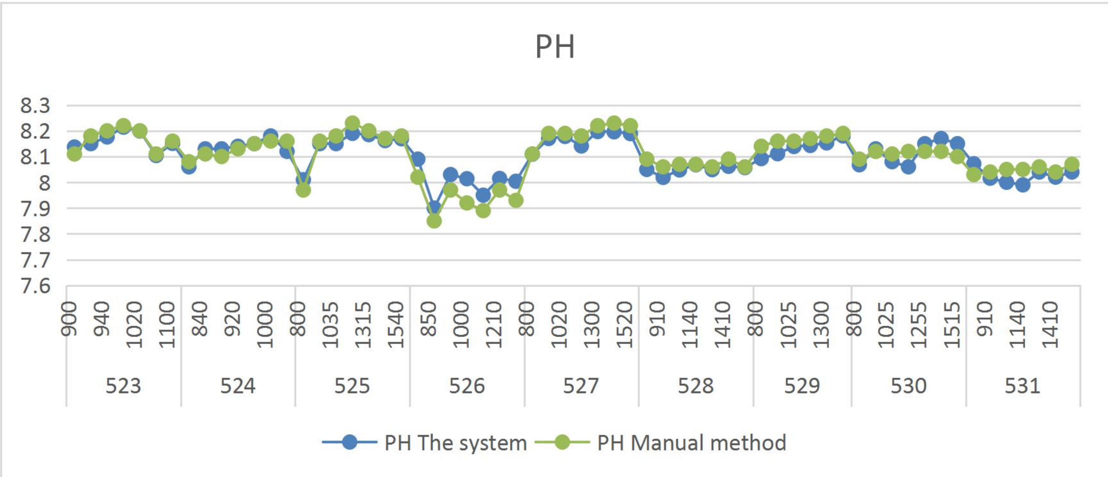

Figure 7. Site comparison test results of pH.

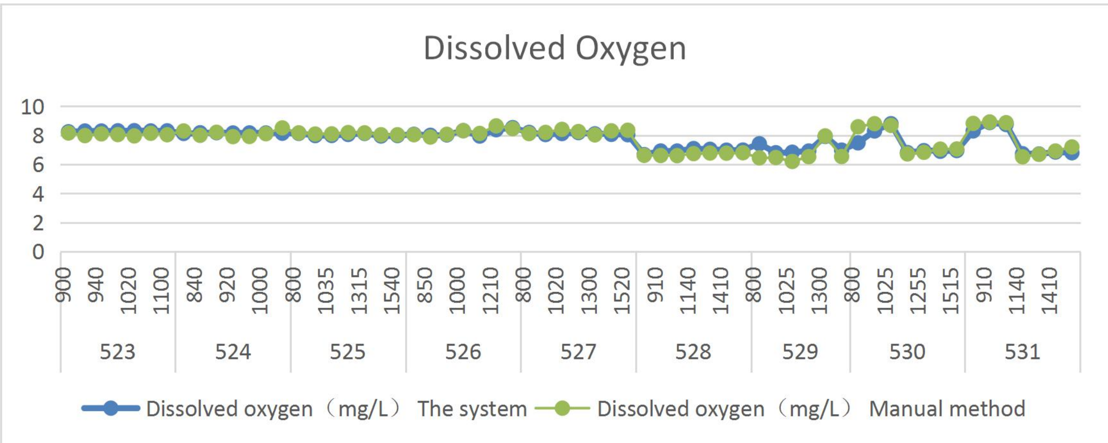

Figure 8. Site comparison test results of dissolved oxygen.

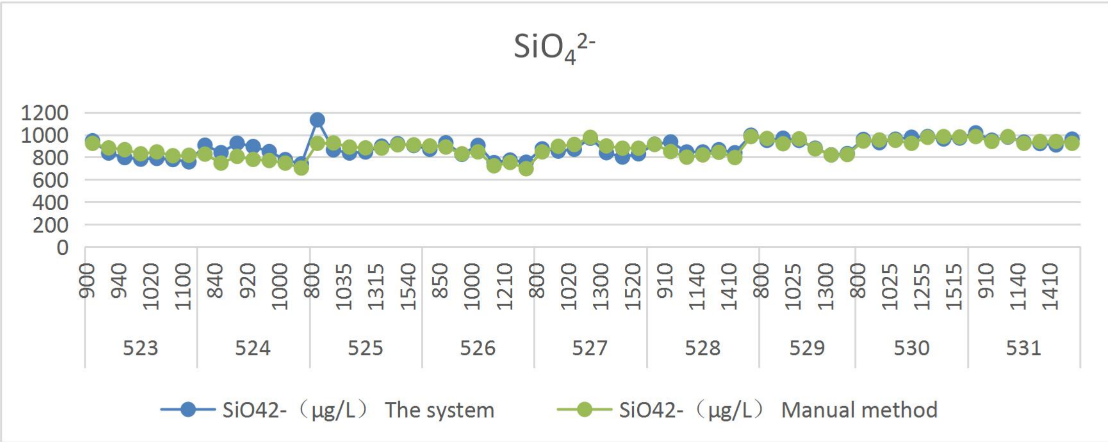

Figure 9. Site comparison test results of SiO_4^{2-}.

5. Conclusions

The software realizes the functions of automatic data acquisition and processing, real-time display and preservation of marine ecological parameters stably and efficiently. It provides a simple and quick historical data display and query interface, and completes the multi-network data transmission.

The software has the following main innovations:

- MCGS configuration software has the advantages of stable data structure, flexibility, versatility, portability and scalability, clear and easy user interface, simple user operation and so on.
- The software has flexible data acquisition and control methods, high data storage and transmission efficiency. It can be set according to the actual needs of different users to achieve real-time data efficient storage and daily data network transmission.

After the actual engineering application, the software can accurately display, store and regularly transmit the marine ecological environment parameters. In the absence of external interference, it can stably and continuously work. Therefore, it can be applied to marine ecological environment comprehensive monitoring field.

Acknowledgments

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