Scholar Publishing Group
Academic Journal of Environmental Biology
https://doi.org/10.38007/AJEB.2021.020304
ISSN 2789-8407 Vol. 2, Issue 3: 28-38

Water Environment Biological Monitoring System under the Background of Big Data

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Keywords: Big Data, Water Environment, Biological Monitoring, Water Environment Monitoring

Abstract: Under the background of the rapid development of high and new technologies such as the Internet of Things and BD and the in-depth advancement of ecological civilization construction, water management has changed the traditional model of the information society with "green development, environmental protection, and ecological civilization". Using high quality and new technology to improve water management efficiency and bring real benefits of water management is very important for building a complete water management strategy. Therefore, the main purpose of this paper is to study the composition and development of the biological monitoring system (MS) of the water environment (WE) based on the background of big data (BD). Based on the understanding of key water quality factors, this paper finally selects three basic and most common water quality parameters for prototype debugging, namely pH value, turbidity, and temperature, making the water quality monitoring platform more versatile. Experiments show that the results obtained by the laboratory test method are close to the results obtained by the water quality MS in this design, indicating that the water quality monitoring lower computer system can accurately detect water quality-related parameters, and experiments show that when the turbidity value exceeds the preset alarm value, the The alarm function will be activated normally, and the alarm function will be normal.

1. Introduction

After the reform and opening up, my country's economy has ushered in a leap-forward development, but what followed was the sacrifice of clear waters and lush mountains for the sake of economic development. The deterioration of my country's WE has reached the level that must be rectified. There are many ways to cause water pollution, including industrial, agricultural and domestic pollution sources. The tip of the iceberg of WE pollution directly affects the quality of human drinking water resources, seriously threatens the ecological balance of nature, and even more, restricts the sustainable development of my country's economy [1-2].

In a related study, James et al. analyzed WA tissue for more than 200 organic pollutants [3]. The results suggest that marine organisms are widely exposed to trace levels of organic pollutants, including the synthetic opioid oxycodone, which are present at three urban sites, and the chemotherapy drug melphalan, which is present at nine sites, at levels that may be biologically problematic. Gupta et al mentioned that Underwater Wireless Sensor Network (UWSN) is becoming an advanced term for monitoring and controlling underwater aquatic life [4]. The technology uses computational intelligence (CI) techniques to identify undiscovered resources present in the water. CI here has to do with the ability of the system to acquire specific tasks from underwater data or experimental surveillance. In this day and age, data is considered the identity of everything that exists in nature, whether that data relates to humans, machines, or any type of device.

Based on the background of BD, this paper studies the composition and development of the biological MS of the WE. Through the understanding of key water quality factors, three most basic and common water quality parameters were finally selected for prototype debugging, namely pH value, turbidity, and temperature, making the water quality monitoring platform more versatile. The three sensors selected are currently the most mainstream sensors in the field of water quality monitoring, with high accuracy. The communication between the platform and the Gizwits cloud platform is completed, and the limitation of data transmission distance is solved; the data processing of GPS positioning is completed, so that users can grasp the location information of the device more accurately and intuitively, and ensure the normal operation of the system.

2. Design Research

2.1. WE Monitoring Methods

At present, in the development of my country's WE monitoring field, many key technologies are immature and need to be further explored [5-6]. There are mainly two types of WE monitoring methods in China:

(1) Combination of manual sampling and laboratory analysis

According to the actual situation of the target water area, select the appropriate sampling section for manual sampling, and bring the sampled book to the laboratory for analysis and statistics through physical and chemical means [7-8]. However, the method of combining manual sampling with laboratory analysis has many shortcomings:

1) The demand for human and financial resources is too much and the cost is high

2) Limitations of the actual monitoring range

3) The analysis and statistics period is long, the real-time performance is poor, and the efficiency is low

The advantage of the monitoring method combining manual collection and laboratory analysis is that the measured parameter data has high accuracy and high reference value.

(2) Embedded MS

The embedded MS is composed of parameter monitoring points, water quality parameter transmission network and remote monitoring center, which can realize the functions of automatic sampling of WE, parameter selection, data transmission, storage and management, and reporting. However, the embedded MS requires staff to observe the results regularly, and the observation period is long, and the cost of the entire MS is high.

The typical WE MSs in China include: the integrated MS of heaven and earth in the Taihu Lake Basin, the wireless sensor network system deployed in the Chaohu Lake Basin, and the water quality management system of the Wuliangsuhai Wetland in Inner Mongolia [9-10].

Today, with the rapid development of BD technology, traditional WE monitoring methods can no longer meet the needs of intelligent, fast and efficient work in today's society. The WE monitoring equipment uses robotic fish as the carrier, which greatly reduces the original limitations. The robotic fish is networked to achieve the acquisition of two-dimensional or three-dimensional data of the target waters, achieve the purpose of distributed monitoring, and make the entire monitoring process more intelligent.

2.2. Software Design Principles of WE Online MS

(1) Advancement

With the improvement of the hardware resources and processing capability of embedded devices, more and more monitoring tasks begin to be moved down from traditional PCs or servers to embedded devices. Embedded devices start with simple data organization, forwarding and gateway functions, and gradually increase data storage and processing, data analysis, curve display, and some even have simple configuration software functions [11-12].

The design goal of this software is to realize data processing, engineering or field-based data analysis, multi-sensor data fusion and presentation, open communication protocol, parallel transmission of multiple communication methods, and good Extensible embedded software [13-14]. The function is not weaker than the monitoring software on the traditional PC or server, which fully reflects the advanced nature of the software.

(2) Openness and scalability of the system

The software is compatible with common standard protocols in industrial control occasions, and has good openness and scalability. For different types of sensors, it can be easily and quickly connected to the system.

(3) Real-time

On-site data collection is refreshed in real time, and the communication status is displayed in real time, which is convenient for debugging on the engineering site.

(4) Good man-machine interface

The end users of the software are the engineers on site, so a good human-machine interface is particularly important. Reasonable design of human-computer processing interface, using a relatively fluent language prompt mode, make the user's operation more intuitive, so that users who have never been in contact before can also quickly learn and apply. The software is based on the increasingly popular Android system, and the operation mode and operation habits are as close as possible to the operation mode of the current smart phone, so that users can quickly become familiar with the software process [15-16].

2.3. Design of Data Acquisition System

It mainly collects the information data of the WE automatically, locates the monitoring points, and stores and uploads the information data. The system framework is shown in Figure 1:

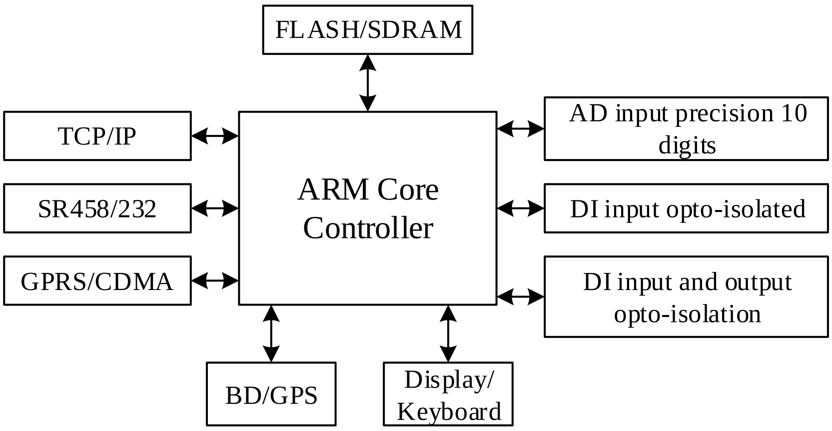

Figure 1. Data acquisition system framework

Function introduction:

Safety protection function. Its main functions are the automatic switching of the system, the protection of power failure and power recovery. There are also status testing skills, which can be used to perform routine maintenance and emergency handling of sudden events and problems.

Automatic positioning function. Its main function is to use 3S technology to automatically locate the detection point, and upload the geographical information of the monitoring point and other data to the control center.

Local display storage function. Its key function is to be able to query and display data information locally. And can store data locally, its capacity can store data between 30-50 days;

Automatic metering function. Its main function is to calculate the pollution discharge of the detected monitoring points, as well as the operation of the automatic monitoring equipment, and can automatically complete the data information of various parameters of the WE of the monitoring points, and automatically store and transmit these data information to the control server., followed by the data processing and analysis phase.

The information processing system mainly covers WE monitoring and processing software, information transmission and processing software, and this system runs on the cloud platform of the center. Through a large amount of data processing, the trend of changes in the WE can be obtained through analysis, and possible future events can be predicted to form weather forecast conclusions, which can be used by users to query [17-18].

2.4. Model Analysis

(1) Detection of WE pollution sources

In order to make up for the working limitations of the original WE MS, the WE MS is endowed with flexible and operable attributes, and the data collected by the WE MS is analyzed, combined with the diffusion law of pollution sources in the water, to cooperate in a carpet-like manner. Search until the approximate location of the pollution source is found to achieve distributed positioning.

(2) Analysis of pollution source diffusion model

1) One-dimensional river pollution diffusion model

The one-dimensional river pollution diffusion model refers to a model that describes the change of pollutant concentration in this direction with only one direction of the pollutant concentration gradient in the Cartesian coordinate system. When the depth and width of the measured channel are relatively small, or the length of the measured channel is much larger than the depth and width, a one-dimensional channel pollution diffusion model is selected for pollutant concentration analysis.

The basic model equations are as follows:

$$\frac{\partial c}{\partial t}=D_x\frac{\partial^2 c}{\partial x^2}-u_x\frac{\partial c}{\partial x}-kC \tag{1}$$

In the formula, C represents the pollutant concentration (mg/L), k represents the degradation rate constant, Dx represents the longitudinal dispersion coefficient; ux represents the average flow velocity of the section (m/s)

The object studied in this paper is for the situation of stable emission. Under the steady-state condition, the one-dimensional model is described as:

$$D_x\frac{\partial^2 c}{\partial x^2}-u_x\frac{\partial c}{\partial x}-kC=0 \tag{2}$$

2) Two-dimensional river pollution diffusion model

The basic model equations are as follows:

$$\frac{\partial c}{\partial t}=D_x\frac{\partial^2 c}{\partial x^2}+D_y\frac{\partial^2 c}{\partial y^2}-u_x\frac{\partial c}{\partial x}-u_y\frac{\partial c}{\partial y}-kC \tag{3}$$

Two-dimensional river pollution models are mostly used for wide rivers and shallow lakes. For the case of stable discharge, the two-dimensional river pollution model can be expressed as:

$$D_x\frac{\partial^2 c}{\partial x^2}+D_y\frac{\partial^2 c}{\partial y^2}-u_x\frac{\partial c}{\partial x}-u_y\frac{\partial c}{\partial y}-kC=0 \tag{4}$$

3. Experimental Study

3.1. Host Computer System

There are five main functions:

(1) Data acquisition function: The water quality parameters transmitted by the serial port reader are correctly configured and temporarily stored in the serial port read buffer area after processing.

(2) Real-time data display function: Real-time display of the current value and historical curve of each water quality parameter read from the serial port.

(3) Over-limit alarm function: Set the upper and lower limits of the alarm. When each water quality parameter exceeds its alarm limit, the alarm module will be activated, including sound alarm and indicator light flashing alarm, and notify the relevant staff to find the pollution source that caused the abnormal data in time and deal with it.

(4) Data analysis and processing function: According to the display of the historical curve, the maximum and minimum values in the historical curve of each water quality parameter are counted, and the average value of all the data is obtained by calculation, and the preliminary diagnosis report of the current water quality can also be generated as required to provide a basis for managers to make decisions.

(5) Data storage function: save the processed data from the water quality detection lower-level computer system and save it in the computer for later search and use.

The overall architecture and functions of the data monitoring host computer subsystem in this system are shown in Figure 2.

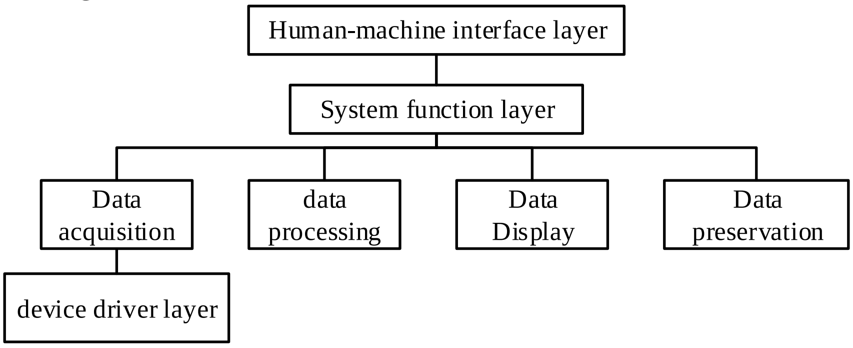

Figure 2. Host computer system architecture and functions

3.2. System Construction and Joint Debugging

The test method for the accuracy of data acquisition of the lower computer is as follows:

(1) Test method for temperature: Select solutions at different temperatures, test the same solution with a standard laboratory thermometer and a water quality detection system, count the experimental data obtained by the two methods, and then draw a characteristic curve according to the experimental data. Comparing the two test results, draw the experimental conclusion.

(2) Test method for pH value: select the normal temperature of 25 ℃, equipped with standard pH value measurement solutions, including acid, neutral and alkaline solutions, and use laboratory test methods and water quality MSs for the same solution to be tested. Carry out the test, count the experimental data obtained by the two methods, draw the characteristic curve after linearizing the experimental data, compare the experimental results, and draw the experimental conclusion.

(3) Test method for turbidity: select a standard turbidity value solution under the condition of normal temperature 25 ℃, test the same solution to be tested by laboratory measurement method and water quality detection system, and count the results obtained by the two measurement methods. The experimental data is linearized and the characteristic curve is drawn, and the experimental data is obtained by comparing the experimental results.

4. Experimental Test Result Analysis

4.1. Verification of Temperature Measurement Accuracy

The data statistics at different temperature values are shown in Table 1.

Table 1. Statistical table of experimental data obtained by two determination methods

Monitoring means	Temperature value (℃)							
Standard Thermometer Monitoring	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00
Check this system	11.50	22.70	30.40	43.50	49.00	59.30	73.10	82.20

The curves of each group of experimental data were drawn as shown in Figure 3.

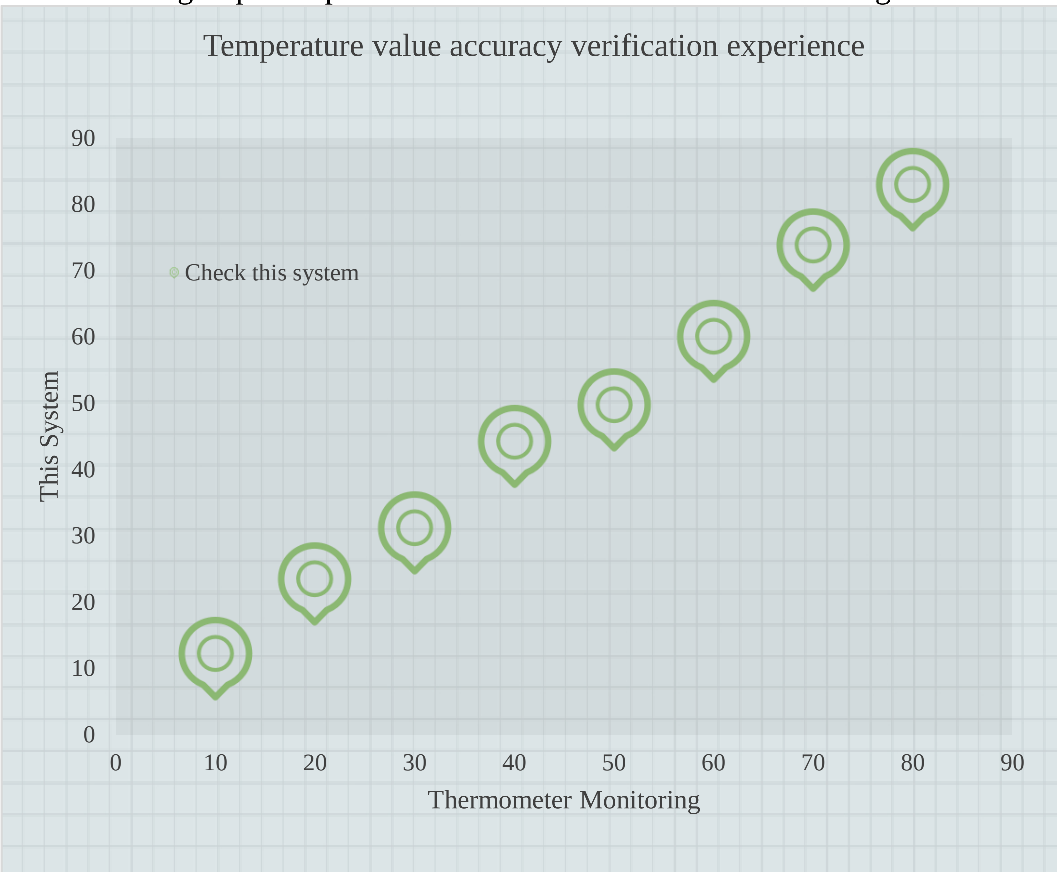

Figure 3. Temperature value accuracy verification curve

It can be seen from the figure that the results obtained by the laboratory test method are close to the results obtained by the water quality MS test in this design, indicating that the water quality monitoring lower computer system can accurately detect water quality related parameters, and the system alarm function is normal.

4.2. Verification of pH Measurement Accuracy

The experimental data statistics are shown in Table 2.

Table 2. Experimental data of pH value obtained by two detection methods

Monitoring means	pH value		
Standard pH paper monitoring	4.00	6.86	9.20
Check this system	4.20	7.00	9.30

The curves of each group of experimental data were drawn as shown in Figure 4.

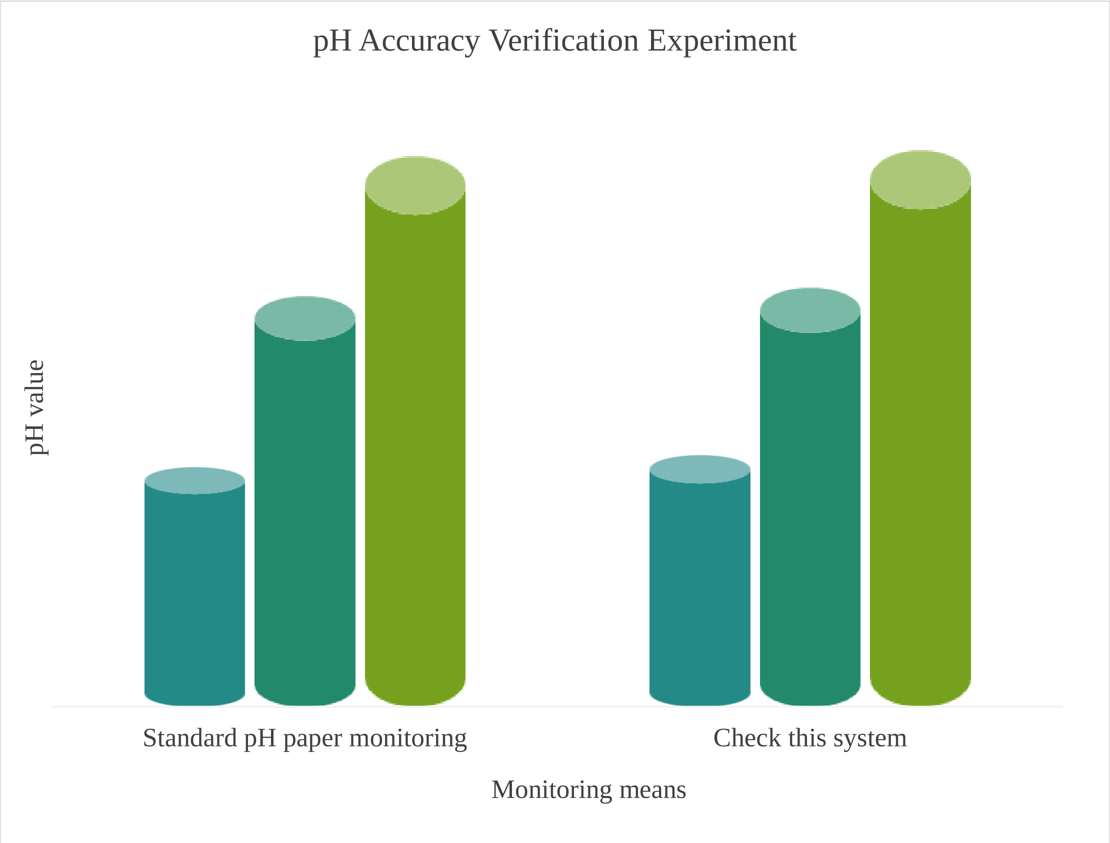

Figure 4. pH accuracy test curve

It can be seen from the figure that the results obtained by the laboratory test method are close to the results obtained by the water quality MS in this design, indicating that the water quality monitoring lower computer system can accurately detect water quality related parameters, and the experiment shows that when the pH value exceeds the preset alarm value When the alarm function is activated normally, the alarm function is normal.

4.3. Verification of Turbidity Value Measurement Accuracy

The experimental data statistics are shown in Table 3.

Table 3. Experimental data of turbidity values obtained by two detection methods

Monitoring means	Turbidity value (mg/L)				
Standard Turbidity Value Solution	1.00	10.00	30.00	60.00	90.00
Check this system	1.20	13.10	32.70	55.60	84.70

The curves of each group of experimental data are processed and drawn respectively, as shown in Figure 5.

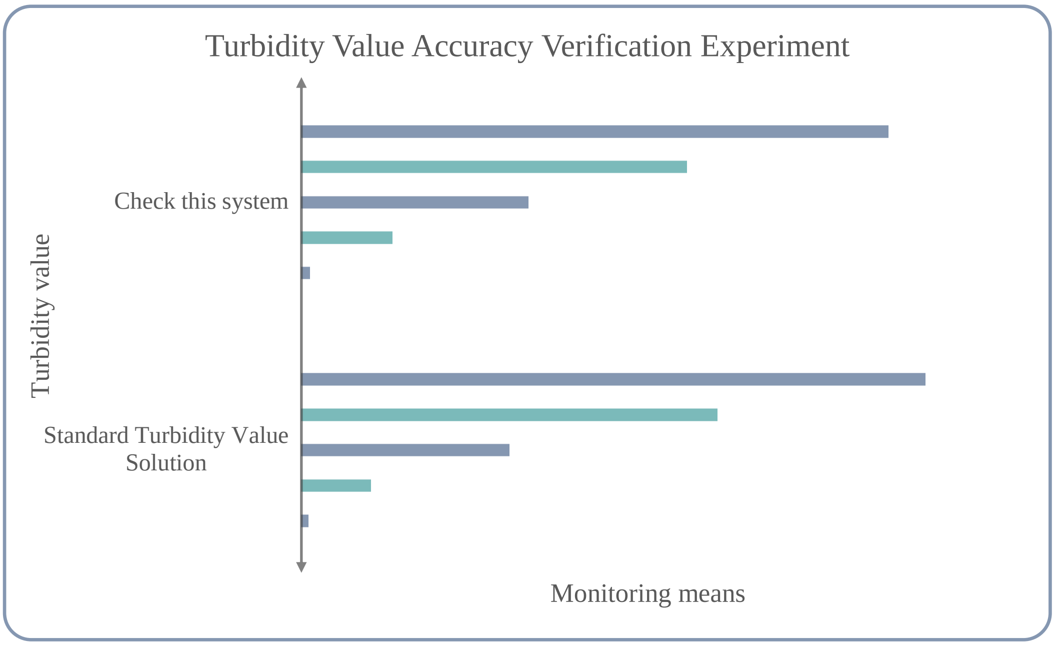

Figure 5. Turbidity value accuracy verification curve

It can be seen from the figure that the results obtained by the laboratory test method are close to the results obtained by the water quality MS in this design, indicating that the water quality monitoring lower computer system can accurately detect water quality related parameters, and the experiment shows that when the turbidity value exceeds the preset alarm When the value is set, the alarm function will be activated normally, and the alarm function will be normal.

5. Conclusion

In my country, the contradiction between the shortage of water resources and the large demand for water resources is obvious, but the pollution of the WE has intensified this contradiction. In addition, in the aquaculture industry, real-time monitoring of water quality parameters can effectively avoid the damage to organisms in the aquatic environment caused by human or natural factors, and minimize economic losses caused by external factors. Therefore, the real-time monitoring technology of WE has been put on the agenda of environmental protection science. The paper extends the application field of the system. The system can not only be used in water quality monitoring, but also can further find the location of pollution sources. A pollution source search method based on concentration gradient is used to establish a pollution source diffusion model, which verifies the Feasibility of application of the system in the field of pollution source search.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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