
ORIGINAL RESEARCH

Intelligent fish tank based on WiFi module

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ABSTRACT

In the paper, the intelligent fish tank using STC89C52 as the control core embedded HC-SR04 ultrasonic distance measurement module and DS18B20 temperature sensor is introduced. This system can be used to remotely control and collect the data of the temperature and the level of water in the fish tank through WiFi module (ESP8266-01). When the water level is less than the default value, the system will be adjusted by adding water into the tank. At the same time, people could also get the data and control the tank whenever they want. The micro-controller is connected to the Internet through the WiFi module. With the help of MicroPython firmware, python programs are compiled within this WiFi module in order to connect to the WiFi at home, providing data transfer function. Android smart phones could connect to this system through WiFi and send commands. In this way, the fish tank could be controlled remotely to ensure the stability of the water temperature and level in the tank.

Keywords: *Internet of things; fish tank; WiFi module; Android; MicroPython*

ARTICLE INFO

Received: July 6, 2017
Accepted: May 10, 2018
Available online: May 13, 2018

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CITATION

Yan F, Wang F. Intelligent fish tank based on WiFi module. Journal of Autonomous Intelligence 2018; 1(1): 6.

1. Introduction

With the rapid development of the Internet in recent decades, all walks of life has been inseparable from the application of the Internet. The Internet helps people improve the quality of life and work efficiency. In order to meet the growing market demand, and constantly meet the process of social development, intelligent and convenient Internet of things on the basis of the Internet came into being. The study and development of Internet of Things (IoT) applications, web and mobile, is on the increase. The Internet of Things is an advanced network of objects with unique identities, each of which interconnects or connects to a remote server, providing more efficient services^[1]. Internet of Things is a platform where daily devices become smarter, daily processing becomes intelligent, and daily communication becomes informative. While the Internet of Things is still seeking its own shape, its effects have already started in making incredible strides as a universal solution media for the connected scenario^[2].

Computer networks have played a major role in expanding the operational boundaries in organizations today. Until now traditional methods of networking, which involves computers, wired directly to a hub or switch is the norm. Recent advances in networking technology have made it possible for devices to communicate through various light and wave emitting technologies. WiFi is a perfect example of one of these emerging technologies, which has enabled computers to communicate with each other without the use of traditional cables^[3]. It has been widely used in the trend of the rapid development of information technology and network technology, and has helped people to improve the Working environment, quality of life and work efficiency. The WiFi application is also widely used in smart home, smart home is actually derived from home automation. Smart home is an emerging interdisciplinary subject, which has already enjoyed flourish development all over the world and has become the mainstream of the development of the construction industry in the 21st century^[4]. Nowadays almost all smart phones including WiFi has become an indispensable part of people's lives. The greater the reliance on WiFi, the greater the demand.

People want to control the production through WiFi technology in order to achieve the purpose of convenience under the circumstance that life is full of variety of equipments.

For this purpose, this paper designs and develops a intelligent fish tank system, using Android phone which connected to the WiFi module in order to remotely control the fish tank. The STC89C52 micro-controller is using as the control core, through the ESP8266-01 WiFi module to establish server transit data. With the help of MicroPython firmware, we wrote python program within the ESP8266-01 to make it become a transit station. Android mobile phone is used as a terminal. Water temperature and water level acquisition are achieved by the DS18B20 temperature sensor and HC-SR04 ultrasonic module, with Keil software to write C language program to control STC89C52 micro-controller. The data would be translated through the WIFI module to people when the water temperature or water level exceeds the specified value, the buzzer will also alarm. When people notice the alarm or they want to just simply adjust the temperature or the level of water, they could do it. The selected components are fully functional and low cost, making them ideal for the design and development of this system.

Low cost and user-friendly operation can really achieve the purpose of improving people's lives and work quality.

2. Scheme design

System block diagram is shown in **Figure 1**. STC89C52 micro-controller is embedded ESP8266 WIFI module to achieve remote transmission of data. Android mobile phone could obtain data through the APP. The HC-SR04 ultrasonic module

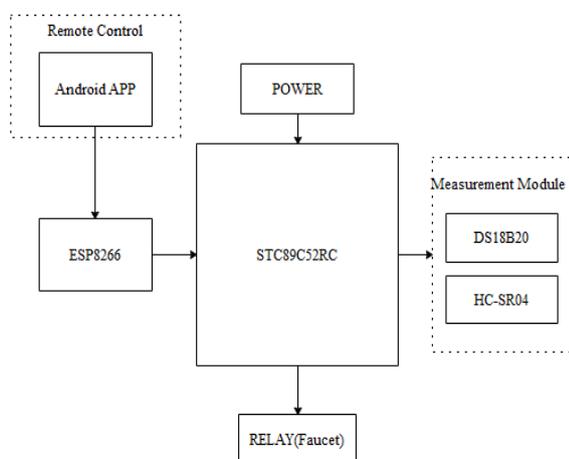


Figure 1. System Block Diagram

and the DS18B20 temperature sensor measure the water temperature and water level separately. People could send commands through WiFi to get water temperature and water level data or control the system to start or stop adding water in order to adjust the water level. WiFi module would analyze the command and send final instructions to the micro-controller. Finally, the sensor measurement results would return to the app, being displayed to the user. When the water level is less than the default value, the microcontroller will control the relay to start adding water to the tank until the value is correct.

3. Hardware design

3.1. STC89C52 Micro-controller

Figure 2 shows the system schematic diagram.

STC89C52RC is STC's low-power, high-performance CMOS 8-bit micro-controller with 8K bytes of system-programmable flash memory. STC89C52 uses classic MCS-51 core, but made a lot of improvements which made the chip has the function that a traditional 51 micro-controller does not have. On the single chip, a smart 8-bit CPU and a programmable Flash make the STC89C52 with many embedded control applications have the ability to provide highly flexible, effective solutions. Data can be directly transited through the serial port. This micro-controller could fully meet the intelligent fish tank system design requirements. So using STC89C52 micro-controller as the main body of this system is absolutely suitable.

3.2. HC-SR04 ultrasonic distance measurement module

HC-SR04 ultrasonic distance measurement module can provide 2 cm–400 cm non-contact distance sensing function. Ranging accuracy up to 3 mm. The module includes ultrasonic transmitter, receiver and control circuit.

Basic working principle:

(1)Using I/O port, work through TRIG trigger, to a minimum of 10us high letter;

(2)The module automatically sends eight 40khz square waves and automatically detects whether the signal is back;

(3)When there is a signal returns through the I/O port, sending a high level through ECHO. The high level duration time is the time between ultrasound launched and returned.

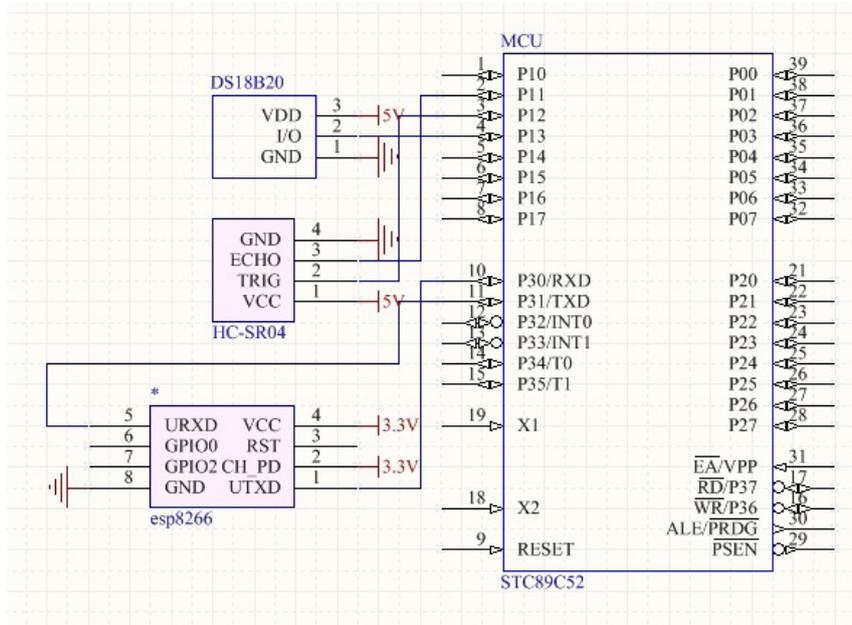


Figure 2. Schematic Diagram

Test distance = (high time * sound velocity (340M/s)) / 2.

3.3. DS18B20 digital temperature sensor

DS18B20 digital temperature sensor is a convenient component which could be packaged into a variety of occasions to be applied. People could change its appearance depends on the needs on different occasions. DS18B20 also has some other characteristics^[5-7]: it can be programmed to achieve 9–12 digital temperature directly reading. Temperature range is -55–125 °C, the highest resolution is 12 bit, the accuracy is s bit °C. It can also be set a temperature alarm, and there are search commands to identify the alarm conditions. What's more, the single line interface, only one input and output lines to communicate with the microcontroller is convenient..

With an unique single-line interface, DS18B20 needs only one line to achieve the two-way communication between the micro-processor and DS18B20. Writing programs to read the digital temperature data is easy. The temperature data can be displayed on a liquid crystal display and simultaneously transmitted to a personal computer (PC) via serial interface for remote monitoring after it is detected by sensors^[8].

The temperature collecting point of this system is located below the surface of the water, so we need to wrap DS18B20 with a tarpaulin, to ensure a strong non-water circumstance.

3.4. Water level control module

This fish tank needs a circuit to adjust the water level automatically, so a water level control module is necessary.

The solution we have chosen is design a relay to work with the microcontroller together. When the water level exceeds the default value, in another word, when the microcontroller needs to adjust the level of water, the microcontroller will set the relay circuit to open. The relay connects to the faucet, as the result, the water level could be controlled.

The relay circuit is as follows:

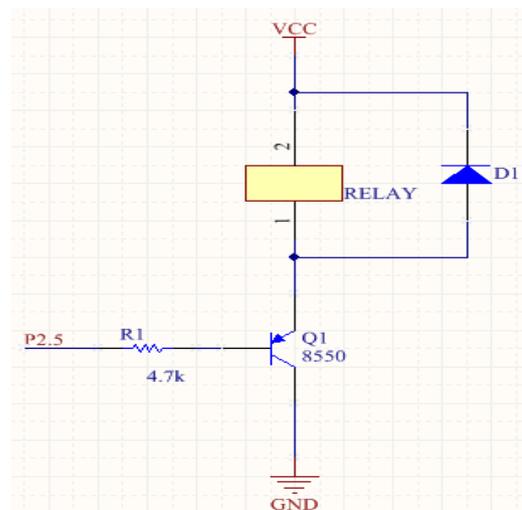


Figure 3. Relay circuit

3.5. WIFI module ESP8266-01

ESP8266-01 is an ultra-low power WIFI monolithic solution with a micro-processor core within the chip. In another word, only one single chip can achieve WIFI + micro-controller function. The embedded system features the ubiquitous low-cost 32-bit ESP8266 System-on-chip (SoC) module interfaced to some sensors and actuators for interaction at home^[9].

ESP8266-01 has both AP and STA modes. AP is the access point mode which could be used as routers at each home, and other mobile devices can access. STA is the device mode, which is a mode can connect to other devices as a device. This system uses AP mode to make ESP8266-01 a server. Android APP could connect to the module as a client.

4. Software design

System flow chart is shown in **Figure 4**.

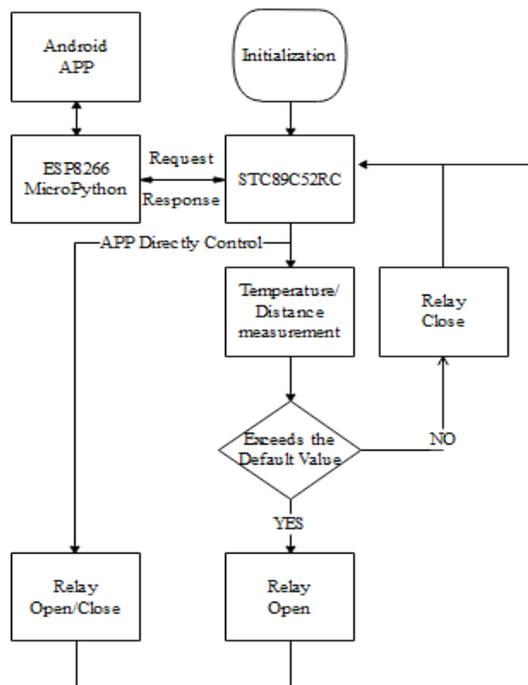


Figure 4. System flow chart

4.1. Water level and temperature measurement

The water level measurement in this project is achieved by HC-SR04 ultrasonic sensor. The module periodically transmits sound waves by periodically

activating the ultrasonic emission module and then the state changes of the receiving end controls the internal timer switch. In this way, the module could intercept a time difference between the launch and the receive. Using the sound velocity and the relevant physical formula we could calculate the distance value. In this system, the value obtained is the distance between the top of the tank and the water surface. We could calculate the final water level: the height of the tank minus this distance value.

When the water level exceeds the specified value, the system will control the level automatically, ensuring the tank is in a stable state.

Then the temperature. The oscillation frequency of the low temperature coefficient crystal is hardly affected by the temperature and the pulse signal for generating the fixed frequency is sent to the counter 1. The high temperature coefficient crystal changes apparently through temperature changes, so its oscillation rate changes significantly. The resulting signal serves as the input pulse of counter 2. The counter 1 and the temperature register are preset to a base value corresponding to -55 °C. The counter 1 subtracts the pulse signal generated by the low temperature coefficient crystal. When the preset value of the counter 1 is reduced to 0, the value of the temperature register will add 1 and the preset value of the counter 1 is reloaded and the counter 1 is restarted. The pulse signal generated by the low temperature coefficient crystal is counted and circulated until the counter 2 counts up to 0 to stop the accumulation of the temperature register value. The value in the temperature register now is the measured temperature. The slope accumulator is used to compensate and correct the non-linearity in the temperature measurement process, and its output is used to correct the preset value of the counter 1.

4.2. Serial data transmission

ESP8266-01 WiFi module connects to single-chip through serial port. STC89C52's serial port is a full-duplex serial port, you can both send data and receive data at the same time. When the serial transmission is completed, the flag bit will be set to 1. When the data is received, it will be set at RI. Regardless of RI or TI appeared 1, as long as the serial interrupt is open, the microcontroller will enter the serial interrupt handler. In the interrupt program, what we need to do is distinguishing whether the interruption was caused by sending data, or it was caused by receiving data, and then handled them separately. When the ESP8266 sends a command 0 to the microcontroller, the temperature value is

requested. When the instruction 1 is sent, the water level value is requested.

4.3. MicroPython and the ESP8266-01WiFi module

The common instruction of ESP8266 is sending AT commands to achieve the function. AT commands are generally used to provide communication function between terminal equipment and PC applications. This instruction of ESP8266 is widely used. But the disadvantage is not flexible enough. This fish tank system uses MicroPython firmware to control the ESP8266. The detailed steps are as follows:

Using USB-TTL Serial to connect the ESP8266-01 and PC.

Using ESPFLASHDOWNLOADTOOL to burn the MicroPython firmware which could be downloaded from mycropython.org into the ESP8266 module.

Writing python script, and use the webrepl tool to import the .py file into the ESP8266 to implement the function.

With the help of MicroPython, we can access and control the underlying hardware through Python scripts, and it is very flexible to control the ESP8266 system for transmitting and sending data. **Figure 5** displays the using of webrepl tool to start the Python program.

In the python script, we initialize WiFi firstly, set ssid as BAI_001 with no encryption. Then initialize serial port. The serial port baud rate is 9600, start bit is 1, stop bit is 0, data bit is 8, no parity. And then the module creates a TCP socket, listens to the 8080 port at the same time, begins to wait for the client. When the client accesses, the module begins to read the contents of the socket, if the read data is 0 x 00 at the beginning, then began to identify the command word. If reads the data is non-0 x 00 at the beginning, the module will response nothing.

If the command word is another 0 x 00 after the first 0 x 00, then the module sends character 0 to

the serial port in order to request for temperature value to microcontroller. If the command word is 0 x 01, then the module sends character 1 to the serial port, request water level value. After sending the character, the module will wait for the serial port to return. Finally, the module returns the data through the TLV package and sends back the data to the client through the socket.

TLV Encapsulation:

T: Data type 0 x 00 indicates request command; 0 x 01 indicates response command;

L: Data length, using dynamic representation, if data length is 0x00, length field is 0 x 01;

V: The Data wait to be sent.

Example: The temperature query command is 0 x 000100, and the water level query command is 0x000101. Assume that the return example is 0 x 1234, then return to the socket data is 01021234.

4.4. Android APP design

Firstly, we give permissions to the AndroidManifest.xml file in order to use Wi-Fi function and Internet permission then connect to the server.

Secondly, the main UI cannot be used to access the network application, so the use of threads and Handler is necessary. Modify the MainActivity.java, setting up a socket and connect to the specified port firstly. The default is 192.168.4.1:8080. Then, adding a listener method to the button. When the button is pressed, the app sends 0x000100 and 0 x 000101 at the same time, both the request command of water temperature and water level could be passed to the WiFi module.

Finally, when the thread receives the response, the handler will pass the result to the TextView. When the water temperature or water level exceeds the specified value, the font would be displayed in red.

5. Experimental results and analysis

According to the experiments, the system could complete the mission well. For example, the fish tank we used is 70cm height and we set that when the water level is less than 55 cm, the buzzer would alarm, at the same time, the system would also adjust the current water level. The APP display is shown in **Figure 6**.

The system could also control the water level according to its owner's mind. For instance, when the owner is worrying that his fish tank is in a

```
ws://192.168.4.1:8266/ Disconnect
Welcome to MicroPython!
Password:
WebREPL connected
>>> import wifiAgent
>>> agent = wifiAgent.Agent()
>>> agent.start()
█
```

Figure 5. Webrepl

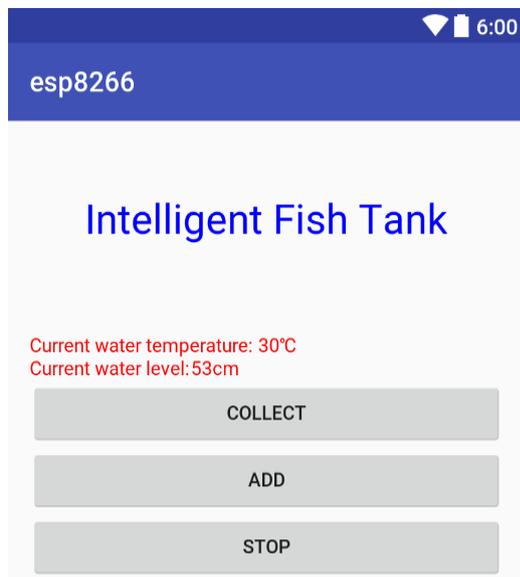


Figure 6. APP display

suitable situation but he cannot check out by himself immediately. What he needs to do is to press the Collect button, then the current water temperature and level will be displayed. If he wants to adjust the water level, just press the Add and Stop button to adjust.

We also did many experiments to make sure the system we designed could perform well in the real circumstance. The results of those experiments reveal some problems. After our analysis, we figured out how to solve these problems. For example, we need to make sure that the DS18B20 is absolutely waterproof. The experiments data is shown below (Figures 7 and 8, Tables 1 and 2).

The standard deviation is used to reflect the average discrepancy of the value of each actual variable and its trend value (or arithmetic mean), which occupies a very important position in the statistics^[10]. By calculating the standard deviation we can see that the system works well. But there is still an abnormal data in the temperature measurement result. We analyzed the fourth experimental data, the final conclusion is that the DS18B20 component will have errors in very few cases^[11]. It is caused by the component's characteristics. But in general it does not affect the operation of the entire system, because in real situation, the temperature of water in the fish tank will not have a sudden change.

We also tested how long the system would take since the add water command is sent from App till water is starting to add. The result is shown in Figure 9.

The function of adding water performs well in experiments. It will probably take 0.6 s since

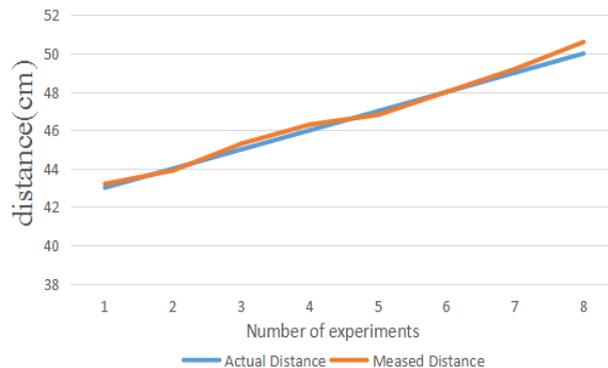


Figure 7. The results and actual values of water level

Table 1. Water Level Standard Deviation

Times	Actual distance	Measured distance	Standard deviation
1	43.0 cm	43.2 cm	0.141421356
2	44.0 cm	43.9 cm	0.070710678
3	45.0 cm	45.3 cm	0.212132034
4	46.0 cm	46.3 cm	0.212132034
5	47.0 cm	46.8 cm	0.141421356
6	48.0 cm	48.0 cm	0
7	49.0 cm	49.2 cm	0.141421356
8	50.0 cm	50.6 cm	0.424264069

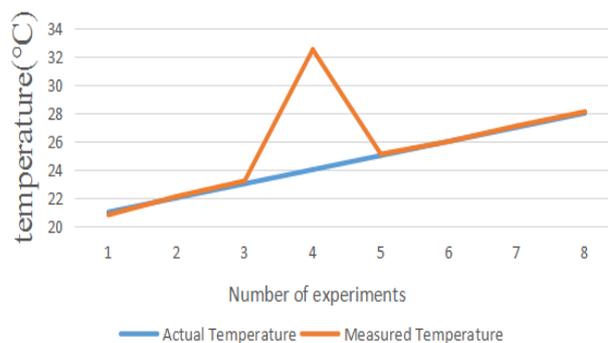


Figure 8. The results and actual values of water temperature

Table 2. Water Temperature Standard Deviation

Times	Actual temperature	Measured temperature	Standard deviation
1	21.0 °C	20.8 °C	0.141421356
2	22.0 °C	22.1 °C	0.070710678
3	23.0 °C	23.2 °C	0.141421356
4	24.0 °C	32.5 °C	6.010407641
5	25.0 °C	25.1 °C	0.070710678
6	26.0 °C	26.0 °C	0
7	27.0 °C	27.1 °C	0.070710678
8	28.0 °C	28.1 °C	0.070710678

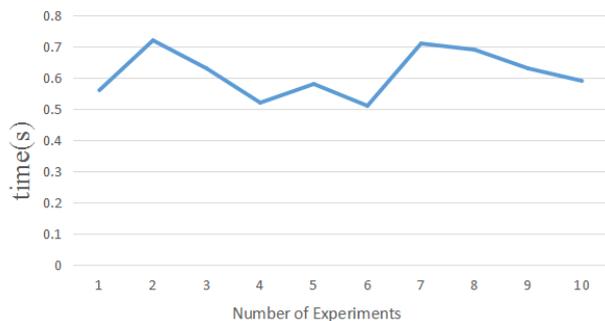


Figure 9. System response time

the command is sent until the water start to add. This is because the WiFi transmission process and microcontroller control process will both take some time^[12]. In general, the system could start or stop to add water immediately, almost no error.

With the help of WiFi module ESP8266-01, people could get to know and control the situation of their fish tanks at anytime and anywhere. Experimental measurement results have almost no error, the measurement is accurate, the entire system could be applied to actual projects^[13].

6. Conclusions

In this paper, the intelligent fish tank we designed works well in the experiment, solved the problem of remote control. The system cost is low, the power consumption is small, the data transmission speed is quick, the reliability is high, it has a very strong practicability can meet the basic needs in people's life. It has a good economic prospect. The use of WiFi technology will provide a lot of space for the development of Internet of things.

The Internet of Things has given another impetus to economic development so as to realize the real-time information transfer between people and things, and to improve the operation of various functions in the process of social activities, and to promote economic efficiency. Its function is to improve the time and space by real-time management. On the allocation of resources, promote economic development, improve the efficiency of social operations, and promote the improvement of social development; improve the association of people and things at the micro level to promote the

improvement of quality of life. The development of the Internet of Things (IoT) can continuously improve the efficiency of economic activities in all aspects and continuously reduce the costs in various fields, thus contributing to the healthy development of the economy and an effective path for economic recovery and development. What's great about this product is the ability to apply intelligence to life. People are raising fish just for leisure, for fun, not for themselves. Through intelligent control, can make fish more convenient, worry, people do not have to go back to work, but also for the aquarium water. Or worry about working in the process because of seasonal changes, the fish tank temperature is not suitable for fish survival.

Conflict of interest

The authors declare no potential conflicts of interest.

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