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Design and Implementation of a Control Water Quality System using IOT

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Abstract

(Our aquatic ecosystems' health depends on the quality of the water. Although continuous water quality monitoring at high temporal and geographical resolution is still prohibitively expensive, it is a crucial tool for watershed management authorities since it provides real-time data for environmental protection and locating the sources of pollution. A reasonably priced wireless system for monitoring aquatic ecosystems will make it possible to gather data on water quality efficiently and affordably, helping watershed managers to preserve the health of aquatic ecosystems. A low-cost wireless water physiochemistry sensing system is introduced in this research. This system has been proposed to measure water quality (pH, salinity, and turbidity) in stations or at home using the Internet of Things system and by controlling the system using the Arduino Microcontroller and using special sensors for this purpose. The findings show that a trustworthy monitoring system may be developed with the right calibration. Catchment managers will be able to sustain this surveillance for a longer period and continually check the quality of the water at a greater spatial resolution than was previously possible. The system has been tested in more than one location and the results have proven its success of this system).

Keywords: ESP8266 Controller; LCD Display; Water Quality Monitoring; Salinity; Temperature; and Turbidity Sensor

Introduction

Water is one of the secrets of life on earth because of its great importance and impact on the life of any being on earth, as it constitutes (45%-70%) of the components of the human body and contributes greatly to fighting diseases and infections, improving skin health, and healthy body growth. It removes toxins, improves kidney health, and improves muscle performance [1]. It is a very necessary element for the survival of humans and living organisms, as it is used in many fields such as food manufacturing, electrical energy transmission, and cleaning, in addition to its importance in sustainable economic development. Due to its high percentage in the human body, any chemical process in the body of any living organism cannot be completed correctly without the presence of a sufficient amount of water, as it contributes to improving blood circulation, decreasing the body temperature, reducing constipation, contributing to the delivery of oxygen and important nutrients necessary for the health of the body's cells, facilitating the process of digesting food, lubricating the joints, moisturizing the important membranes of the body, and many other benefits that God Almighty made it one of the secrets of human existence [2]. Water pollution, whether direct or indirect, is considered a major cause of the end of life on the Earth. Pollution can be classified into two types: chemical pollution (resulting from oil spills, pollution with agricultural materials and waste, or sewage pollution) or natural pollution (resulting from a change in the characteristics of the water in general, such as a change in its temperature from the normal range, a change in its salinity, or an increase in suspended matter of organic or inorganic origin. Pollution in general leads to a change in the color, taste and smell of the water, which makes it toxic and unfit for human consumption, which is therefore unpalatable. The taste is bad for humans and also leads to infection with many deadly diseases that lead to the death of humans and living organisms [3]. Pollution in general may be the result of other sources, such as pollution resulting from oil through intentional destruction that occurred in the First and Second Gulf War, which led to disastrous consequences for the contamination of Gulf waters with oil. According to the latest statistics of the Institute for Studies in the Arabian Gulf, pollution in Gulf waters has reached 47 times more than global pollution due to oil per unit area, according to the study [4]. Pollution resulting from sewage is considered very dangerous, as the problem of disposing of sewage and turning it into rivers is classified as one of the most dangerous problems facing the entire world, as this type of water includes water resulting from sanitary detergents, which contain toxic and heavy metals, as well as organic materials and substances. Carbohydrates and substances containing bacteria that cause the collapse of the human health system through the transmission of dangerous diseases to humans, such as cholera resulting from vibrio bacteria, typhoid resulting from Salmonella bacteria, diarrhea resulting from Shigella bacteria, and diseases of the nervous system and kidneys resulting from Leptospira bacteria, as all the types mentioned are Bacteria are caused by pollution in sewage, whether directly through drinking water or even eating fish, which is deposited in insoluble materials, or indirectly through bathing, for example [5]. Environmental degradation (the deterioration resulting from the depletion of one of the most important environmental resources, such as soil, air, or water, which results in the environment being unable to meet the needs of living organisms) is considered as one of the ten most important threats in the world that the United Nations team has warned about [6]. The prosperity of a society depends on the safety of its environment and its suitability for living in it. Obtaining safe, healthy water for the individual and society is the greatest challenge facing the World Health Organization. This requirement, in addition to obtaining safe and secure wastewater, is a global requirement for the prosperity of global societies, as it is considered one of the most important. Sustainable development requirements that are achieved by separating drinking water from other water uses by building advanced structures of sanitation systems and separating drinking water from other uses, as well as treating drinking water before using it through sterilization and development, and building advanced water desalination systems according to health standards. Global, as well as reaching the countries from which the water sources originate and treating them through international and local agreements, as deforestation in some countries leads to the risk of changing the direction of river flow and thus the risk of floods and reducing the evaporation process, which directly reduces the rainfall that we need for agriculture and industry. Limiting these practices through agreements between countries contributes to controlling and overcoming the occurrence of problems [7]. The Ministry of Health in each country takes many measures that contribute to maintaining the quality of clean water, including: urging the writing of the necessary reports to monitor water quality and improve its quality. The health department monitors the reports and corrects the results based on these reports, and samples are taken from time to time from places various methods to ensure and monitor water quality completely and according to the controls approved by the World Health Organization, relying on international policy and UNICEF organizations [8]. With the development of modern science and the development of remote-control methods and the Internet of Things, many studies and research have been conducted that have effectively contributed to monitoring water quality remotely and sending results and reports via mobile phone, email, laptop, and other means of communication. Water quality is monitored through a group of sensors that are placed on water bodies and sending data via the Internet, where the quality of drinking water or wastewater is monitored, as well as the percentage of contamination of healthy water in terms of pH value, average temperature, water turbidity, conductivity, and other measurement standards. Global water quality. Early detection of water pollution can contribute to taking the necessary measures in a timely manner to solve the water problem and prevent further deterioration. This pollution (which is increasing rapidly due to remarkable industrial and agricultural development) is considered a major cause of the loss of biological diversity and the contamination of the food chain through pollution. Water in agriculture and livestock raising, thus deteriorating the life of the ecosystem for humans or animals through the widespread spread of diseases [9]. Since the late twentieth century, the development and need for an intelligent system to monitor water quality has grown by monitoring the percentage of salts, bacteria, and the amount of dissolved oxygen in the water. The water quality detection system can sense a lack of dissolved oxygen or when some chemical elements enter the water that cause pollution, such as nitrogen [10]. The economic activity of humans on Earth contributes to the deterioration of the current state of the Earth's surface, which negatively affects the quality of water in lakes and dams. One of the key components of the environment that determines the existence of life on Earth influences the climate, and restricts the growth of civilization is water. It is amazing the variety of demands and priorities used to evaluate surface waters. Water supply for domestic use, agriculture, transportation, recreation, fisheries, hydropower, and flood wave management are among the motion regions [11]. Before starting the design of the system, the main objective was to identify the gaps within the work environment and fill them for water sampling and analysis [12]. For hominids, water pollution is one of the main causes of many different kinds of water-borne viruses including dengue, cholera, and malaria, among others. Water pollution causes 40% of all deaths worldwide [13]. With the recent advancement of smart technology, a tiny, portable system with low-power concepts would be required to assess the various environmental conditions [14]. The hardware for the suggested system is relatively basic and consists of a power supply, an ESP8266 controller, a temperature sensor, a PH sensor, a turbidity sensor, a TDS sensor, and an LCD (16x4) screen. By connecting the user with a realistic system and producing excellent results when the parameters don't exceed a certain threshold and terrible results when the threshold is exceeded, android applications are used to falsify tasks. Our aquatic ecosystems' health depends on the quality of the water [15]. For catchment management authorities, continuous water quality monitoring is a crucial tool [16], providing real-time information for environmental protection [17] and locating the sources of pollution [18]. However, continuous water quality monitoring at high temporal and spatial resolution is still prohibitively expensive [19]. With the use of an inexpensive wireless aquatic monitoring system, watershed managers would be able to gather water quality data efficiently and affordably, maintaining the health of aquatic ecosystems [20]. The purpose of this system is to provide a compact, portable device that is simple, affordable, and easy to use that can inform us of the water's condition. This solution uses an easy-to-use Android application to provide us with information concerning water turbidity via a mobile device. The flowchart is shown in Figure 1. The rest of the paper is: section (II) describes related works, the method and procedure are described in Section (III), section (IV) explains the result and discussion, and Section (V) shows the conclusion.

Related Works

To design a good water quality system, we must discuss various systems developed by researchers efficiently. The proposed systems for measuring the level of water quality varied depending on the sensors associated with the system itself such as pH, salinity, turbidity, etc. It is designed by considering all the aspect that is discussed in the past view. In 2016, Islam [21] suggest a water quality system that uses the Wireless Sensor Network (WSN) to collect the real reading of the system. it is very good at tracking pollution sources but it suffers from a delay time which is about 35 seconds while receiving the result from sensors and this is because there are too many sensors that are connecting. In 2018, Abedin [22] develop an online water monitoring system using the GPRS/GSM technology. It is a clever tool to monitor the water turbidity, but the collected information is sent remotely and this results in a delay of about 20 seconds. After that, the focus going to use a simple hardware component with an easy communication system to avoid real-time delay in the system. In 2020, Adu-Manu [23] suggest a monitoring system using the ZigBee and WiMAX networks to reduce the time delay of the system. The system collected the sensor reading, processed it, and then sent it using the ZigBee gateway through the webserver. The result proved that the suggested system is very good but still suffers from about a 10-second delay time since it is used a WiMAX network to communicate. In 2021, B. Chen [24] develop a system that used all the above ideas. The quality of water is monitored via a (WSN) wireless sensor network. The ZigBee network is used to send the sensor's reading remotely [25]. The collected information from sensors is gathered using the web server [26]. Till now, the suggested system is efficient and its performance is very good and it does not suffer from delay time. The researcher solves all the above problems in designating such a system but it is costly. From above, we note the urgent need to propose a system that works with a centralized control unit, as well as using Android applications to send and receive information in a short time and at high speed without the need to use one of the communication systems that suffer from slow access time for sensor readings. When the power is switched ON, the water quality system is initialized reading the status of the sensors and then the microcontroller collects the reading and compares it with a threshold according to the regain setting and sends the results via the ESP controller. When the sensors are initialized to sense from the Arduino microcontroller then the sensors get the real value and the result of the sensors is sent to the Arduino microcontroller board. In which the Arduino is programmed to save a threshold value for each reading of the sensors. When all the threshold values are less than the sensors' reading, then the sensors are initialized automatically and when they are larger than it, then the sensor data is sent to the GSM module and sent the status of the water module. This system has been proposed to measure water quality (pH, temperature, salinity, and turbidity) in stations or at home using the Internet of Things system and by controlling the system using the Arduino Microcontroller and using special sensors for this purpose. The suggested system is efficient and its performance is very good and it does not suffer from delay time. The problems that appeared in the literature review are eliminated and discarded designating such a system which is a low cost in comparing with other systems [21-25]. From above, we note the urgent need to propose a system that works with a centralized control unit, as well as using Android applications to send and receive information in a short time and at high speed without the need to use one of the communication systems that suffer from slow access time for sensor readings. Figure 2 shows the block diagram, which consists of a temperature sensor, PH sensor, Turbidity sensor, and TDS sensor. All of them is connected through the ESP8266 Controller, then the results appear on the LCD (16x4).

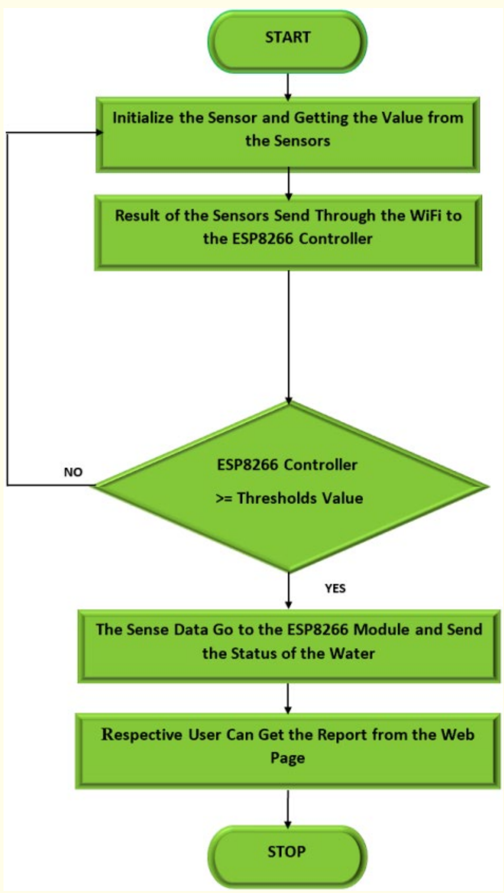

Figure 1: Flow Chart of the Water quality Control system.

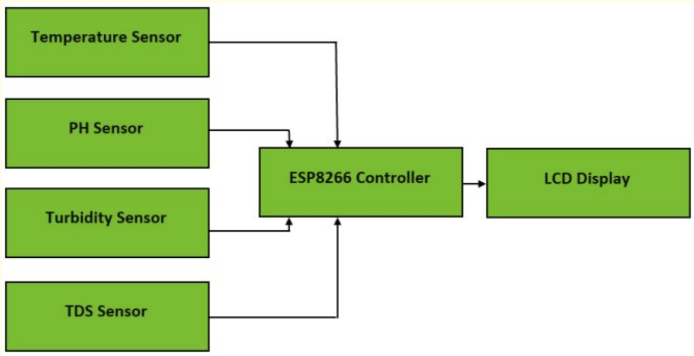

Figure 2: Block Diagram of the Control System.

Methods and Procedures

The system consists of two parts to ensure the efficient result in monitoring and controlling the water quality control system. We decided to measure nitrates in water because they show old pollutants from municipal wastewater. The first part (see Figure 3 and Figure 4) is representing the hardware components which consist of many sensors (temperature sensor model DS18B20 from KOOKYE, UK, pH-sensor model HS_1234 from Hitachi, Japan, Total Dissolved Solids (TDS) model CQRADS1115 from England, and turbidity Mixed Water Detection model B09TQ1MTLZ with PartsBeiz) that connect through the (Serial Control Module) ESP8266 Controller (model B0B37N3CJH, from England), to collect the status of the water and display the reading on the LCD (16x4) screen model B0BY59ZMMV, from Generic company.

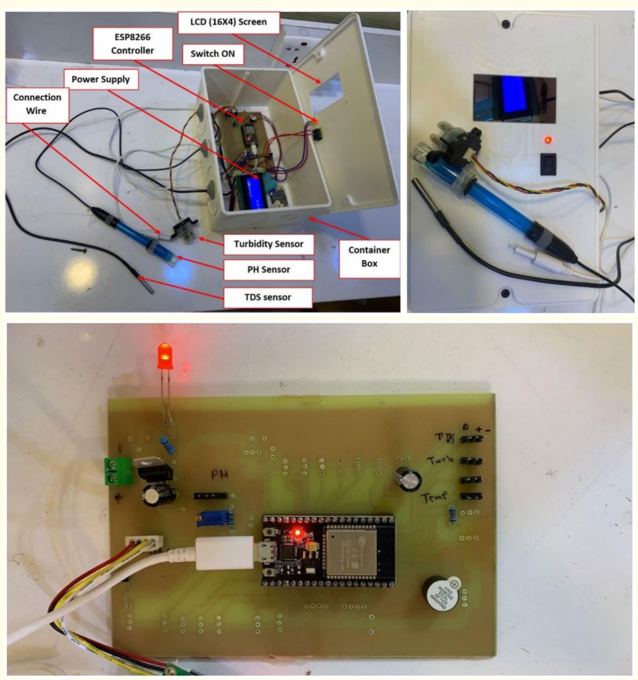

Figure 3: Hardware Component of the System.

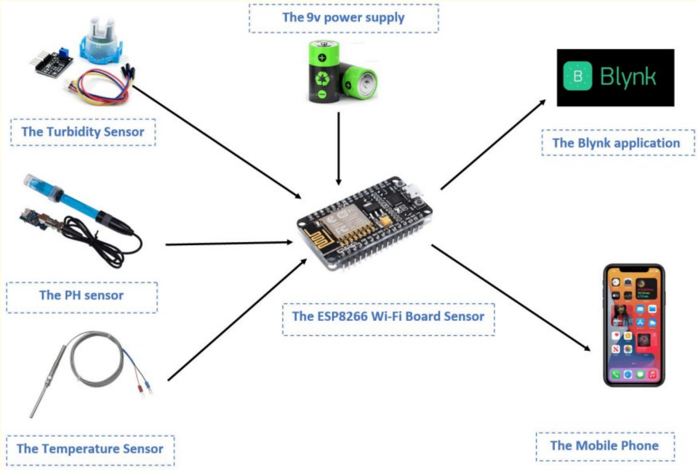

Figure 4: Topology of the System Components.

On the other hand, the second part of the system represents the software design which consists of the Blynk application that is programmed to send the result through the mobile phone (see Figure 5). When the power is switched ON, the water quality system is initialized reading the status of the sensors and then the microcontroller collects the reading and compares it with a threshold according to the regain setting and sends the results via the ESP controller. When the sensors are initialized to sense from the Arduino microcontroller then the sensors get the real value and the result of the sensors is sent to the Arduino microcontroller board. In which the Arduino is programmed to save a threshold value for each reading of the sensors. When all the threshold values are less than the sensors' reading, then the sensors are initialized automatically and when they are larger than it, then the sensor data is sent to the GSM module [27] and sent the status of the water module. Water quality is monitored through a group of sensors that are placed on water bodies and sending data via the Internet, where the quality of drinking water or wastewater is monitored, as well as the percentage of contamination of healthy water in terms of pH value, average temperature, water turbidity, conductivity, and other measurement standards (as Global water quality) [28].

Hardware Design

The suggested system collected the data in different station such as home or river using the IOT wireless sensor network through the C++ language which has been proposed to measure water quality (pH, salinity, and turbidity) in real time with high speed and by controlling the system using the Microcontroller and using different special sensors for this purpose. When the sensors are initialized to sense from the microcontroller then the sensors get the real value and the result of the sensors is sent to the Arduino microcontroller board. In which the Arduino is programmed to save a threshold value for each reading of the sensors according to World Health Organization, relying on international policy and UNICEF organizations [29]. This system is used to measure the level of water quality varied depending on the sensors associated with the system itself such as pH, salinity, and turbidity, where all these components are connected to ESP8266 Controller, then the results appear on the LCD (16x4).

Software Design

The required steps to complete the software design, that is first to establish the connection between the ESP8266 controller and the IOT network using the Blynk application on the mobile phone. Water quality (temperature, PH, Salinity and Turbidity) sensors detect the sample and determine the value of the threshold to compare it with the result. Then the ESP8266 controller is loaded with the data (gathered from multiple sensors). In this step, there is a synchronization between the smartphone and the data collected in the controller via the Wi-Fi module and the result appears on the smartphone screen (see Figure 5). when the sensors are initialized to sense from the Arduino microcontroller then the sensors get the real value and the result of the sensors is sent to the Arduino microcontroller board. In which the Arduino is programmed to save a threshold value for each reading of the sensors. When all the threshold values are less than the sensors' reading, then the sensors are initialized automatically and when they are larger than it, then the sensor data is sent to the GSM module and sent the status of the water module. The steps required to complete the software design of the Blynk application [30], on the smart phone is displayed on Figure 6.

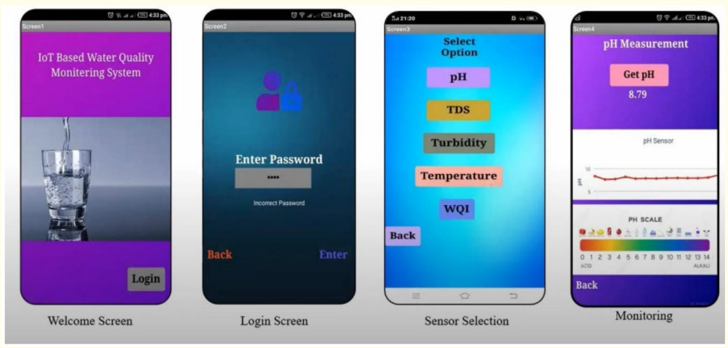

Figure 5: The Software Design of the System on the Smartphone.

Result and Discussion

In this system, a water turbidity sensor was used to measure the turbidity percentage in the water by placing it in the environment in which the turbidity percentage is to be measured and sending the turbidity readings directly through an application that uses the Internet of Things to send information via the mobile phone. Also, the salinity sensor was used to measure the water salinity and include it within the readings on the part of my brother, the acidity of the water is measured through the pH sensor and then the results are sent via the Internet of Things. All these parts were connected and controlled through a special microcontroller. A special electronic circuit for this system was printed, consisting of the control itself via Wi-Fi. A special map of the proposed system was printed and the results were sent Through a small screen connected to the printed circuit (see Figure.7), the regulator also contains a five-volt regulator, an amplifier, a variable resistor, a button, an amplifier, a variable resistor, and a group of complementary wires for the proposed system. This system has been proposed to measure water quality (pH, salinity, and turbidity) in stations or at home using the Internet of Things system and by controlling the system using the Arduino Microcontroller and using special sensors for this purpose. when the sensors are initialized to sense from the Arduino microcontroller then the sensors get the real value and the result of the sensors is sent to the Arduino microcontroller board. In which the Arduino is programmed to save a threshold value for each reading of the sensors. When all the threshold values are less than the sensors' reading, then the sensors are initialized automatically and when they are larger than it, then the sensor data is sent to the GSM module and sent the status of the water module. Figure 8 shows the result of the sensors sent by IOT through the mobile phone in various locations and different conditions. Also, Figure 9 shows the result of using the turbidity sensor (NTU) with (908) data at a different time (4:50 pm-5:40 pm). It is found that over time there is a different result for the turbidity and its range between (500-1500) NTU and the best result is obtained at 5:00 pm with 1000 NTU. At the same water sample, the result of using the TDS sensor (PPM) at different times with (486) data is shown in Figure 10 at a different time (5:45 pm-5:53 pm). It is found that over time there is a different result for the TDS and its range between (250-500) PPM and the best result is obtained at 5:53 pm with 500 PPM. In the same manner, the PH sensor result is concluded in Figure 11, It is found that over time there is a different result for the PH and its range between (4-7). Table 1. show the different locations are used to test in the proposed.

Figure 6: The Flowchart of the Software.

locations	A	B	C	D
Temperature (^{0} C)	44	40	38	38
Salinity (ppt)	18.4	25.3	18.7	13.9
Turbidity (NTU)	25.7	10.6	9.10	13.7
pH	7.13	7.63	7.66	7.60

Table 1: Different locations are used to test.

Figure 7: Water quality system with LCD screen result.

Figure 8: The result of the sensors sent by IOT through the mobile phone in various locations and different conditions.

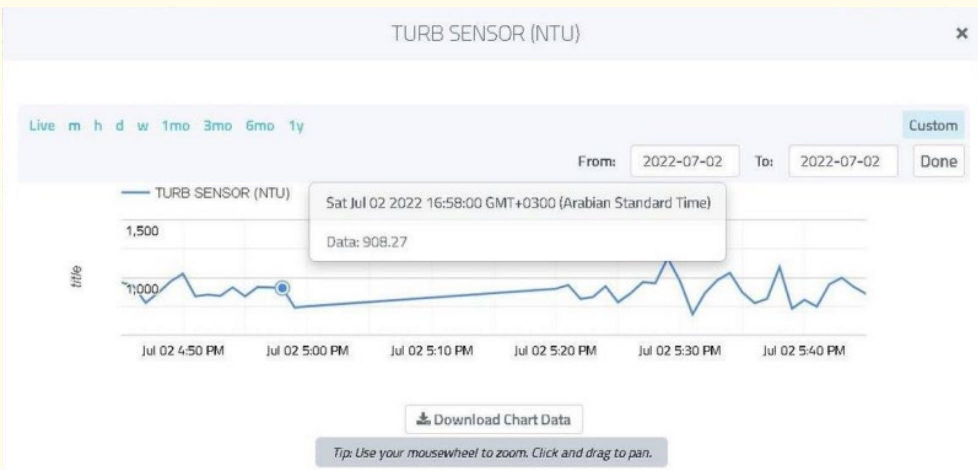

Figure 9: The result of using the turbidity sensor (NTU) at a different time.

Figure 10: The result of using the TDS sensor (PPM) at different times.

Figure 11: The result of using the PH sensor at different times.

Conclusion

In this paper, a water quality control system was used to measure the turbidity percentage in the water. Furthermore, this system has been suggested to measure water quality (pH, salinity, and turbidity) in stations or at home using the Internet of Things system and by controlling the system using special sensors with software design that is used to decrease the time delay and avoid the transmission error in sending and receiving the data. In this system, the parameters used to calculate can be expanded to measure the quality of water in a local zone and other parameters for instance dissolved oxygen, oxygen demand, and total dissolved solid. The system has been tested in more than one location and the results have proven its success of this system.

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