IoT based Smart Water Quality Monitoring and Flow Control System

Prof. Rajendra prasad P
Faculty: Electronics and Communication Engineering Dept,
Sri Venkateshwara College of Engineering, Bangalore
Bangalore, India
rajisvec@gmail.com

Megha D.M
Dept. of Electronics and Communication Engineering
Sri Venkateshwara College of Engineering, Bangalore
Bangalore, India
meghadm456@gmail.com

***Abstract*- Water pollution is certainly one of the most important fears for the inexperienced globalization. In order to make certain safe supply of the consuming water the quality needs to be monitor in real time. In this paper we present a layout and improvement of a low cost system for real time tracking of the water quality in IOT(Internet of Things). The system consist of numerous sensors which is used to measure both physical and chemical parameters of the water. The parameters including temperature, PH, turbidity, water flow sensor can be measured. The measured values from the sensors can be processed through the core controller. The Arduino uno can be used as a core controller. Finally, the sensor value can be viewed on IoT by using WI-FI module.**

Keywords- Water quality parameters, Arduino Uno, WI-FI module, Internet of things, Thingspeak cloud.

I. INTRODUCTION

Water is precious for all the people. Excessive water usage, pollution, growing population, old infrastructural facilities etc. have caused a steep decrease in the water resources. Hence there may be a need of higher methodologies for tracking the water. Traditional strategies of water involve the manual collection of water sample at locations, accompanied through laboratory analytical strategies in order to characterize the water quality. Such approaches take longer time and are no longer considered efficient. The water monitoring technologies have made a significant progress for source water surveillance [1]-[6]. By focusing on the above issues our paper design and develop a low cost system for real time monitoring of the water quality in IOT environment. In our design Arduino UNO is used as a core controller. The design system applies a specialized IOT module for accessing sensor data from core controller to the cloud. The sensor data can be viewed on the cloud using a special IP address. Additionally the IOT module also provides a Wi-Fi for viewing the data in system.

II. IOT APPLICATION

Real-time water quality observation is examined by data acquisition, method, and transmission with an increase in the wireless device network method in the IoT [2]. Processed values are remotely sent to the Arduino UNO and WI-FI module is used to interface the measured values from the sensors. An external Wi-Fi module is connected to the Arduino UNO, which enables the controller to get connected to the nearest Wi-Fi hotspot and subsequently to the Cloud (i.e. Thingspeak cloud).

III. METHODOLOGY

In this section, we present a project that will automatically determine the water quality parameters of the water that is being passed through the sensors. Based on the parameters collected by the sensors, the water is either sent to the tank or is passed through the filter to purify it. All the data being detected is sent to the cloud through the Wi-Fi module where it is stores and can be accessed from any location. Constant detection of parameters happens and hence real-time data is obtained. The methodology of the proposed system has been divided into five stages which are as shown in figure 1.

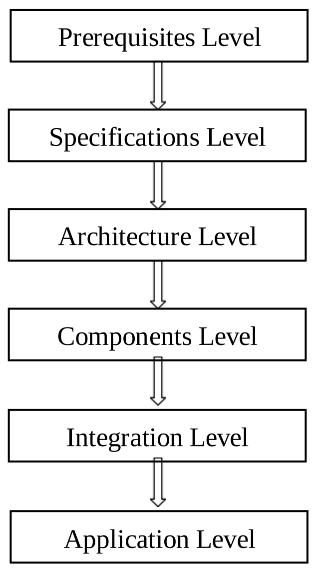

Figure 1: Sequence of flow of the proposed system

A. Prerequisites Level

Prerequisites are conditions or tasks required to perform a particular task successful. This provides clear cut instructions on the tasks and functions to be performed by each and every component being used so that their performance is according to the objectives defined for the project.

- Functional Prerequisites

Functional prerequisites usually include the technical details, calculations to be carried out, the manipulations and the processing that has to be done by the system to obtain specific results. They also include the components being used and what the components are supposed to do. Here, we use different sensors to detect data and we specify the range for each sensor. These are the functional prerequisites.

- Non-functional Prerequisites

Non-functional prerequisites specify the different criteria that are used in the project to obtain specific results. This describes how to system should perform the tasks to achieve the objectives. The different sensors and their ranges are specified but the behaviour of these sensors to reach the specified range falls under non-functional prerequisites.

B. Specifications Level

Specifications are technical standards of the different components being used in this system. The components are chosen based on the requirements of the project. The specifications of the components are as shown on table 1.

Sl. No	COMPONENTS	SPECIFICATIONS
1.	Microcontroller	Arduino UNO ATmega328P
2.	Sensors	pH, Turbidity, Conductivity, Temperature, Water Level
3.	Wi-Fi Module	ES8266
4.	LCD Display	16x2 LCD
5.	Filter	Sediment RO Filter

Table 1: Specifications of the components used

C. Architecture Level

Every system is designed according to the specified objectives. The proposed system will be having remote monitoring capability and the monitoring system combined with the server and database. This will be helpful for the proposed system.

The system IoT based Smart Water Quality Monitoring and Flow Control System has a controller that is interfaced with turbidity sensor, PH sensor, LCD, Temperature sensor, Conductivity Sensor, Water Level sensor and Wi-Fi module. It has an LCD display and a Cloud platform to view all the collected values from any location. All these sensor interfaces with the microcontroller are shown in Figure 2.

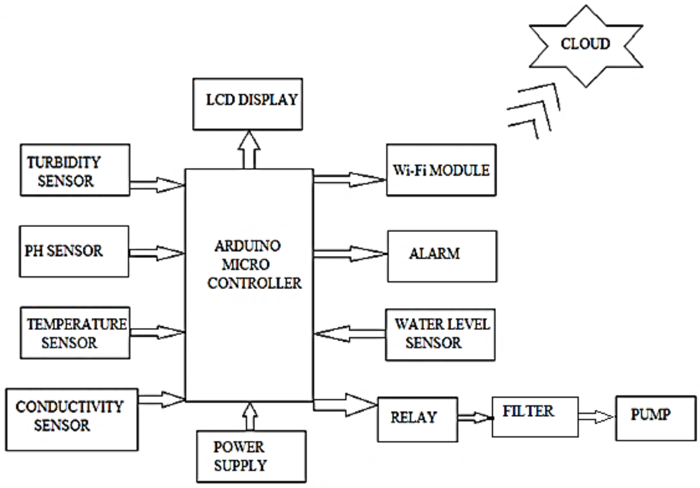

Figure 2: Block diagram of the proposed system

The Arduino UNO microcontroller is interfaced with all the different sensors and the values detected by these sensors are sent as serial data to the Arduino board which displays it on the LCD display. These real time values being displayed are sent to the cloud through the WI-Fi module. These values can be accessed through the cloud platform from any location.

These collected values are compared with the standard industry specified values and if the values are greater than the given values then the water is passed through the filter to purify it. The water later is sent to a tank. The water level sensor in the tank detects the level of water and based on the indication of the sensor, the pump is either turned on or off. That is, if the water is less than the specified level then the pump is turned on and when the water in the tank exceeds the required level, then the pump is turned off automatically.

D. Components Level

Hardware components are the physical devices that being used in a system which is connected with one another to perform specified tasks and to provide input and send outputs to the application. The different hardware components used in this system are Arduino UNO microcontroller, Turbidity sensor, pH sensor, Temperature sensor, Conductivity sensor, Water level sensor, WiFI module, Relay, LCD and Filter.

- Arduino UNO

Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control both physically and digitally. Most Arduino boards consist of an Atmel 8-bit AVR microcontroller (ATmega8, ATmega168, ATmega328, ATmega1280, ATmega2560) with varying amounts of flash memory, pins, and features. The boards use single or double-row pins or female headers that facilitate connections for programming and incorporation into other circuits.

- Turbidity sensor

Turbidity sensor detects water quality by measuring the levels of turbidity, or the opaqueness. It uses light to detect suspended particles in water by measuring the light transmittance and scattering rate, which changes with the amount of total suspended solids (TSS) in water. As the TTS increases, the liquid turbidity level increases. The turbidity sensor contains a light transmitter and receiver. At clear waters, light scattering is minimum and so the light receiver receives the most amount of light. As turbidity of the water increases, the light receiver receives less and less light.

- pH sensor

A pH meter is a scientific instrument that measures the hydrogen-ion activity in water-based solutions, indicating its acidity or basicity expressed as pH. The pH of water is an important parameter to monitor because high and low pH levels can have dangerous effects on human health. The pH of a solution can range from 1 to 14. One method of measuring pH is through the use of a conventional glass electrode with a reference electrode setup, the other is using an Ion-Selective-Field Effect-Transistor (ISFET). pH probes measure pH by measuring the voltage or potential difference of the solution in which it is dipped. Hence, a pH probe measures the potential difference generated by the solution by measuring the difference in hydrogen ion concentration.

• Temperature sensor

Temperature Sensor is a device, typically a thermocouple or RTD that provides for temperature measurement through an electrical signal. A thermocouple (T/C) is made from two dissimilar metals that generate electrical voltage in direct proportion to changes in temperature. The LM135 series are precision, easily-calibrated. Directly Calibrated to the Kelvin Temperature integrated circuit temperature sensors. Operating as scale a 2-terminal zener, the LM135 has a breakdown 1°C initial accuracy available voltage directly proportional to absolute temperature. The LM35 device does not require any external calibration or trimming to provide typical accuracies. For temperature reading the analog volt received is to be converted to temperature equivalent and response displayed over serial communicator.

• Conductivity sensor

Water conductivity sensor is used in water-quality applications to measure how well a solution conducts an electrical current. This type of measurement assesses the concentration of ions in the solution. The more ions that are in the solution, the higher the conductivity. Conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. The Vernier Conductivity Probe measures the ability of a solution to conduct an electric current between two electrodes. In solution, the current flows by ion transport. Therefore, an increasing concentration of ions in the solution will result in higher conductivity values.

• Water level sensor

Water level sensor is designed for detecting the water level in the reservoir and overhead tanks. This is generally utilized in sensing the water leakage, water level, and the rainfall. It consists of mainly three parts: 1MΩ resistor, an electronic brick connector and numerous lines of bare conducting wires. Water level indicators work by using sensor probes to indicate water levels in a storage tank. These probes send information back to the control panel to trigger an alarm or indicator.

• WiFi module

The ESP8266 WiFi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and micro-controller. This small module allows micro-controllers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands.

• Relay

A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. It is used to send a signal when it there is sudden variation in the temperature. The main use of Relay Driver circuit is to shut down the electric connection throughout the house and ensure that the fire accident does not cause much more severe impact on the electrical connections.

• LCD

A liquid-crystal display is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals combined with polarizers. LCD displays designed around LCD module are inexpensive, easy to use, and it is even possible to produce a read out using 16 character*2 lines, 8x10 pixels of the display. Hitachi LCD display have a standard ASCII set of characters plus Japanese, Greek, and mathematical symbols.

• Filter

Even though RO filter is the most effective filter in the purifying system, it only removes the dissolved or suspended impurities present in water. RO (Reverse Osmosis) process is carried out by passing a solvent through a porous membrane. Using a Sediment filter prior to RO will help in increasing the life and improving the performance of the RO cartridges.

E. Integration Level

1. Interfacing all the different sensors

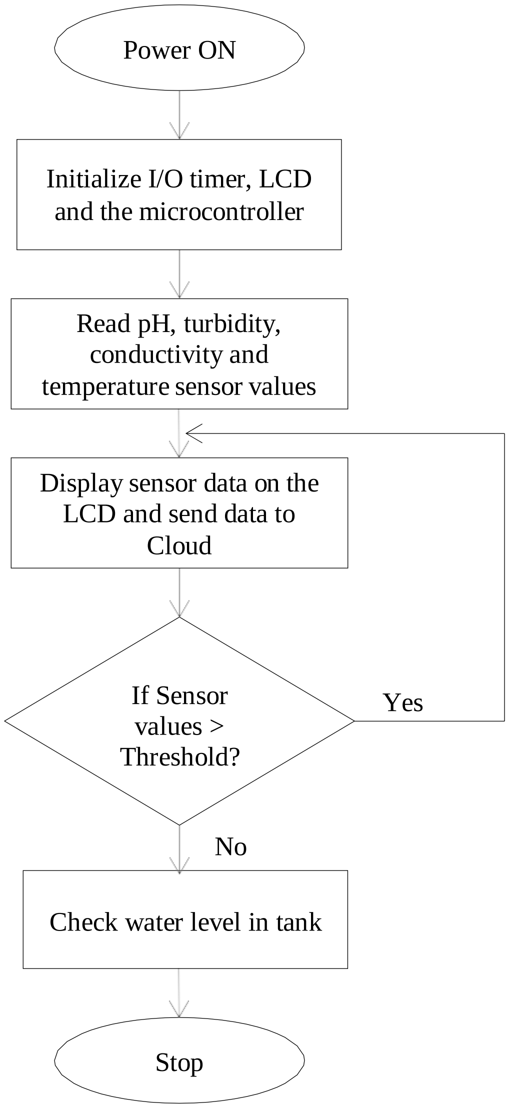

Figure 3: Flowchart for the interfacing of sensors

- The different sensors used like the pH sensor, Turbidity sensor, Conductivity sensor and the Temperature sensor all get initiated when the power is supplied to the system.
- All the measured data are displayed on the LCD and the same values are sent to the Cloud through the WiFi Module.
- If all measured values are within the threshold value range, the water is passed to the tank else the water is sent to the filter and again the sensors detect the parameters.

2. Interfacing the automatic pump

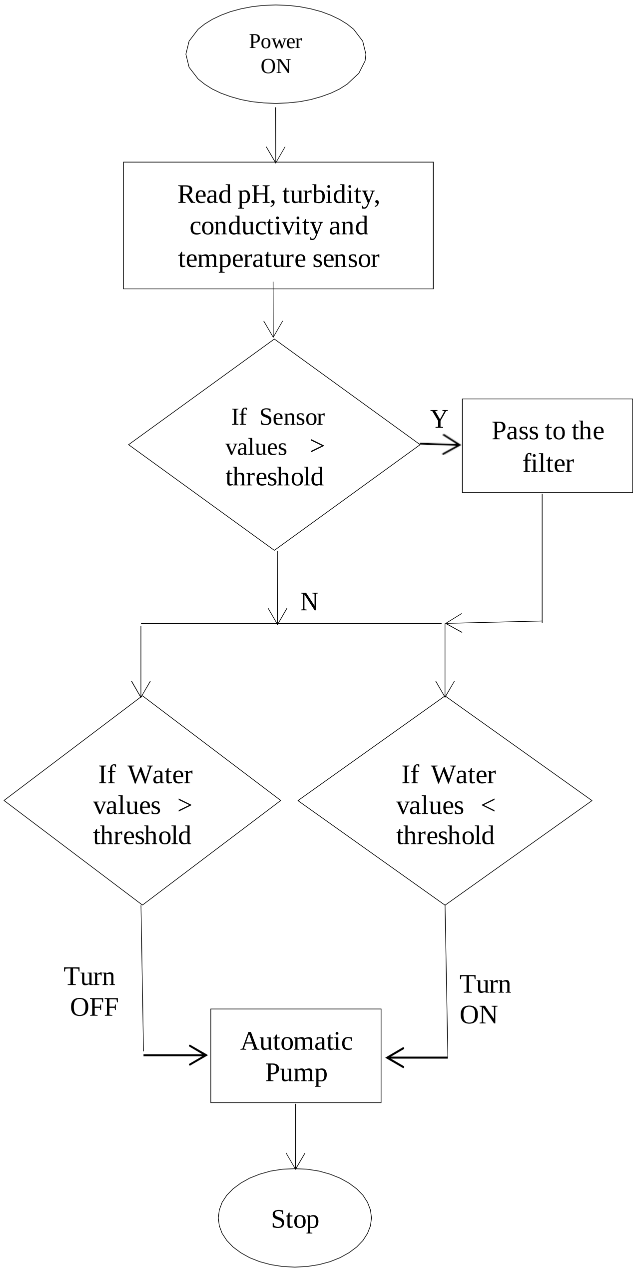

Figure 4: Flowchart for the operation of automatic pump

- After all the sensors detect the various parameters, they are compared with the threshold values which are already set. With this, even the water level in the tank is detected.
- If both the sensor values and the water level in the tank is less than the threshold values, the pump gets turned on and the water starts to fill up.
- When the water level sensor detects that the water is at the threshold level, then immediately the pump is turned off.
- This is a good way to prevent wastage of water.

3. Data transmission from the Arduino board to the Cloud using WiFi module

A single system

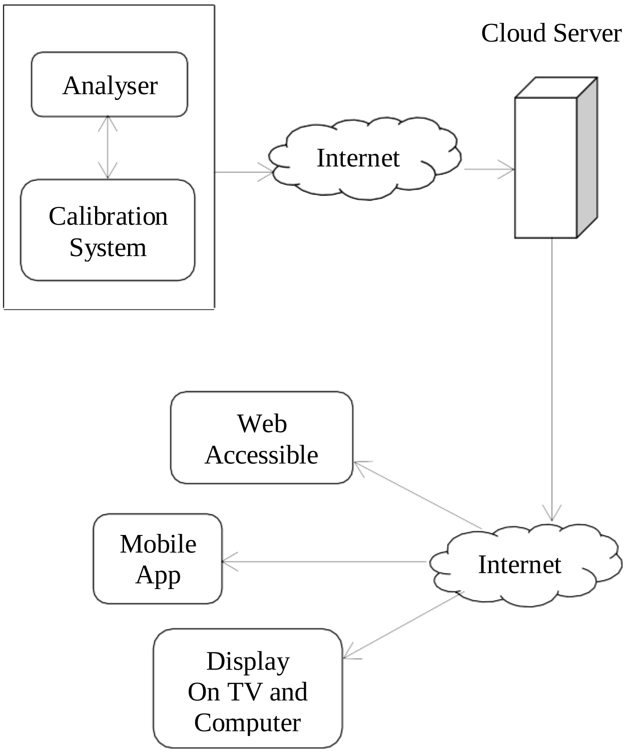

Figure 5: Flowchart of the process of sending data from Arduino UNO to the Cloud

- The data being collected from the sensors are analysed and they get calibrated to the right format. All this happen internally and hence there is no human interference.
- After calibration the values are sent to the cloud server through the internet.
- These values can be accessed using internet from the cloud through web access or mobile or normal computer display.
- The values are expressed in a graphical form for easy understanding.

F. Application Level and Results

The table 1 shows the safe and acceptable range of the turbidity sensor, pH sensor, conductivity sensor and temperature sensor according to the WHO standards.

PARAMETERS	QUALITY RANGE	UNITS
Turbidity	5-10	NTU
pH	6.5-8.5	pH
Conductivity	300-800	micro S/ cm
Temperature	27-29	Celsius

Table 1: Range for all sensors used

The specific threshold ranges for each and every sensor has been initialised before the proposed system starts to operate. The ranges and values specified are as follows:

- Temperature sensor
  Normal water temperature = 25 degrees
- pH sensor
  pH value ranges from 0 to 14
  pH < 7 is Acidic
  pH > 7 is Alkaline or Basic
  pH=7 is Neutral
- Conductivity sensor
  Normal water in the range of 5–50 mS/m (Siemens per meter)
- Turbidity sensor
  For drinking water, turbidity < 0.1 NTU
  For household purpose < 0.5 NTU
  Should not exceed 5 NTU (Nephlometric Turbidity Unit)

The application level and the results obtained are as follow.

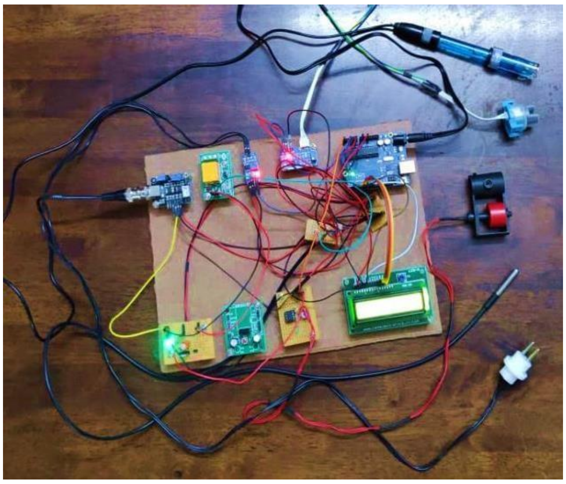

Figure 6: Interfacing all the sensors with the microcontroller

Figure 7: LCD displaying the project title

Figure 8: LCD displaying the Wi-Fi status

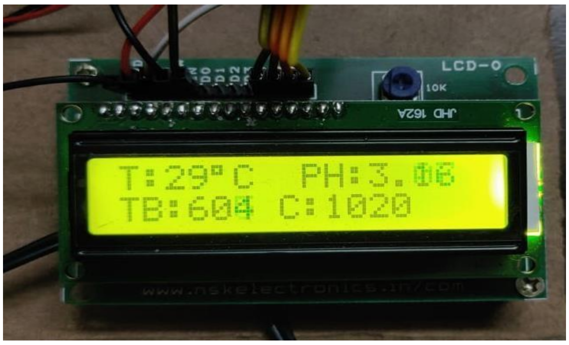

Figure 9: LCD displaying the different parameters measured by the sensors

The figure 6 shows all the sensors being interfaced with the Auduino UNO and the WiFi module. When the power is supplied, the LCD first displays the title of the project which is shown in firure 7 and figure 8 shows LCD displaying the Wi-Fi status as connected. Later all the different parameters, that are the temperature, pH, turbidity and the conductivity values are displayed which is shown in figure 9.

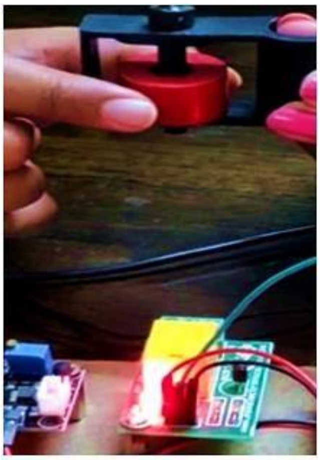

Figure 10: LED is on indicating that the pump is turned on as the water level sensor is down

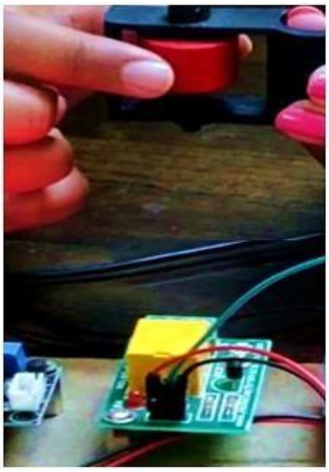

Figure 11: LED is off indicating that the pump is turned off as the water level sensor rises up

When the water level sensor starts to operate, it checks if the water level is below the threshold level or above the threshold level. The turning on and off of the pump is indicated by the blinking of LED. When the water is below the threshold level, the pump is turned on and this is indicated by the blinking of LED as shown in figure 10. When the tank fills and the water is above the threshold the pump gets turned off and the LED stops blinking as shown in figure 11.

In Figure 12 we can see that the PH, turbidity, conductivity sensors are dipped in drinking water and their corresponding values such as temperature, pH, conductivity, turbidity sensors are displayed in LCD.

Figure 12: LCD displaying the different parameter values of drinking water

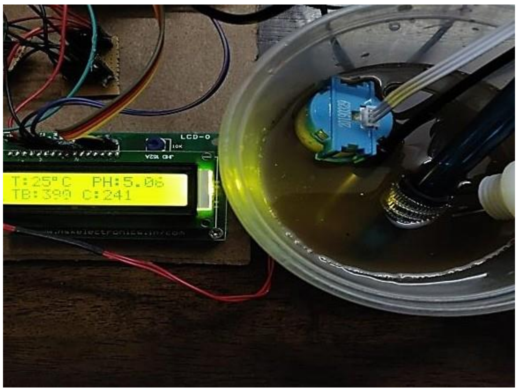

Figure 13: LCD displaying the different parameter values of mud water

In Figure 13 we can see that the sensors like pH, turbidity, conductivity are dipped in mud water and their corresponding values such as temperature, pH, conductivity, turbidity sensors are displayed in LCD.

WATER TYPE	**TEMP**	**pH**	**TRBIDITY**	**CONDUCTIVITY**
Drinking Water	26	6.36	629	363
Salt Water	26	6.39	520	435
Mud Water	25	5.06	390	241

Table 2: Different sensor values

All the values detected by the different sensors that are temperature sensor, pH sensor, turbidity sensor and conductivity sensor for different water samples such as drinking water, salt water and mud water are displayed in Table 2.

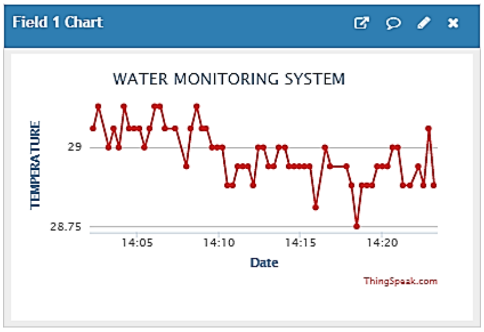

Figure 14: Graphical representation of temperature

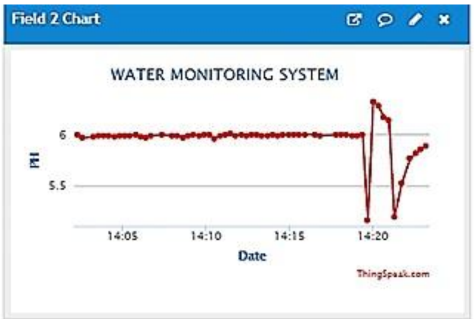

Figure 15: Graphical representation of pH

Figure 16: Graphical representation of turbidity

Figure 17: Graphical representation of conductivity

The above figures 14-17 are the graphical representation of all the different water quality parameters sensed and measured by the different sensors being used. The four different graphs are of temperature, pH, turbidity and conductivity. The values collected by the sensors are displayed on the LCD and simultaneously sent to the cloud as well. These values in the cloud are displayed as a graph so that it is easy to understand and analyse. These real-time values can be accessed by the pollution control board and the other authorities from any other location.

IV. CONCLUSION

Sequential follow up of water pollution status in remote region can be achieved by monitoring the quality of water & collecting comprehensive data. This IoT based system not only provides comprehensive evaluation of water environment but also can quickly discover urgent water pollution accidents or natural disasters, transferring the abnormal water quality information to monitoring centre by quicker communication network and provides graphical references for the decision making department to comprehend the status of the water. The automatic pump makes this system more autonomous and helps prevent wastage of water.

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