IoT Based Water Quality Monitoring System

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1. Abstract:

Due to the combined effects of rising population, pollution, and climate change, safe water is becoming a scarce resource. Monitoring water quality is so essential, especially for domestic water and the ground water also. Because of massive advancements in Internet-of-Things (IoT) technology, which may be used to construct more efficient, secure, and less expensive systems with real-time capabilities.

Our aim is to create a water monitoring system which will measure water quality in real time and sent it any one with internet who would prefer to monitor and analyze it as it can send exact location with the data. Thus, the system can monitor the water quality of specific area. We can incorporate the water quality data with weather prediction applications where people can find out both air and water quality of the region. The system can not only measure water quality but also capable of controlling the flow of water when it finds dangerous or harmful to health by closing the valve of water supplying pipeline. There is no doubt that our system will any individual who is willing to use it to measure and control the flow of their water. This way the system ensures the quality water for the user.

2. INTRODUCTION:

Water has been the essential part for every living being in this planet. It is a fact that we have been blessed and cursed in so many ways when it comes to water. The quality of water is declining each single day yet there is very little efforts has been made to prevent it. But to know the answer we need to know the problem and we need to know it extensively. Our efforts have been made to the problem identifying part. Water pollution has been a growing concern for most of the countries. Now considering a country such as Bangladesh here more than 700 rivers flow through its area with no shortage of fresh water has a similar problem which is providing drinkable water as the water borne diseases is still an issue. This is what led us to the realization that continuous monitoring of water quality is necessary. Like the city of development country where people use supply water they are worry about the quality supply water provide by the city corporation. It ensures every single user about the water quality if the system is installed in the water tank and main supply line. The area where ground water is used, they can use this device. It also helps to collect and analyze the data regularly who work on environmental science and the responsible person of a rural where it mandatory to aware the people about water quality.

The Internet of Things (IoT) is a set of technologies for collecting network information of distributed sensors and controlling devices connected to the Internet, as well as storing, processing, and displaying data on local or remote servers. Any stand-alone device that is connected to the Network and can be tracked and/or controlled is considered an Internet of Things device.

The Public Utilities Board of Singapore exhibits how commercial smart-water monitoring systems can be used to manage a water distribution network. However, as previously said, commercial solutions are often costly and are unlikely to be substantially adopted.

There is no effort has been made to aim this work for the need of domestic needs for such device even though maintaining the quality of drinking water above a minimum threshold is vital. The proposed system employs use of multiple sensors to measure the quality of water in real time so that people not necessarily have to rely on other words. This system is economical, accurate and requires a single person to handle.

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A. RELATED WORK

Several Internet-of-Things (IoT)-based water monitoring solutions have been developed recently, fueled by advancements in IoT [1]. In comparison to earlier systems based on older technology, most commercial systems (e.g., Hach guardian blue, Canary, optiEDS, Libelium Inc., Biz4Intellia, and Bluebox) have reported increased efficiency [1]. However, these systems are either extremely expensive or their architectures are not available to the public. As a consequence, such commercial systems have only been used in developed countries. This act prompted plenty of studies aimed at developing a low-cost, dependable IoT-based smart water monitoring solution that takes advantage of existing communication infrastructure for smart applications.

As an open research area of concern, several related review/survey articles have been published to highlight progress in the sensor and wireless communication technology, cloud services, and computing devices among others. In, authors present an excellent review on WSN technology for leak detection, but the article offers no contents on water quality monitoring. While Pule et al. focus their survey on environmental monitoring with emphasis on water, they mainly cover WSN technology missing new IoT based smart systems. Similarly, Ahmed et al. centered their review paper on water quality monitoring, covering all technologies including WSN, but new IoT based systems. Geetha and Goutham in their review paper also included the real-time dimension of smart water quality monitoring systems but kept a rather generic scope while covering IoT based techniques. Damor and Sharma in their review paper made a first attempt to cover IoT based systems, but a critical analysis, and comparison of methods is missing. In their study, Banna et al. provide a survey of existing and emerging sensors technologies for water monitoring. However, it also has given very less attention to IoT based systems. Adu-manu et al. published an exclusive review on water quality monitoring using WSN technology. This is a great resource of knowledge, but unfortunately only covers up to WSN-based water monitoring systems and needs to be extended to include the new IoT applications in the same field. In the Public Utilities Board Singapore provides a success story of the application of commercial smart-water monitoring technologies for managing water distribution network. However, as we mentioned earlier, these commercial systems are generally expensive and can hardly be widely adopted. Finally, Pujar et al and Li et al. address in their recent respective review papers smart water systems, but they fail to focus on the quality aspects of the water.

B. Motivation:

Contaminated water is hazardous to human health and can affect aquatic life and vegetation. Bacteria, viruses, and diseases are all possible microorganisms. According to the World Health Organization, millions of people die each year as a result of water-borne infections. More pathogenic bacteria may emerge and spread via water in the future, according to the literature [16]. It could occur as a result of rapid population growth, agricultural expansion, climatic change, and increased migration. Another reason these germs might appear is their potential to acquire disinfectant resistance. It is not essential for water acquired from different sources to be pure and free of infectious bacteria. Water obtained from some sources (e.g., groundwater) may, for example, be suitable for home use. Other sources of water, such as those obtained from ponds, lakes, rivers, or rains, sometimes might not even be drinkable. As a result, it is essential to regularly evaluate water quality in order to prevent the spread of any health concerns to the consumers. Water quality is described as "the fitness of water for a particular application (e.g., drinking) as determined by its physical, chemical, and biological qualities.

We are aiming our system for the home or domestic usage as it will help any number of people who is either financially incapable of affording factory produced drinkable water or any other means where they have to spend money on to survive. Our device allows them to spend very little to ensure regardless of sources the water they are using how much drinkable is it. It also help if installed in a system it stops the flow of water if it’s harmful for health. This is what motivates us to develop such system.

3. METHODOLOGY:

In the proposed system, three sensors and GPS and GSM module, solenoid valve is used. Microcontroller Unit (MCU) is the main processing module and store the firmware in HEX file to execute its command. GSM module 900M is used to connect weather application system and IoT cloud and transferring the data to the server. GPS module can precisely collect the geolocation info from the satellite to track down the Water Quality Monitoring info for analyzing the info for further research.

The microcontroller unit is significant part to develop this project and Arduino UNO is of the most used development board which consumes low power and cheaper than other development board like Raspberry pi, Asus Thinker Board, Intel IoT board, NVidia Jetson board and many more. Among the four sensors, two of sensors collect analog signal to the MCU analog I/O port. The MCU has a on-board ADC to translate analog input signal to digital signal. Other sensors collect digital data from digital pin. All the data are processed in the MCU and send the sensor reading to the weather server and IoT cloud along with GPS data. In the same time the 16*2 LCD dot matrix display will show the result of the monitoring data and control water flow by stopping and continuing the water flow. In this way, if the system kept in out of GSM coverage, then it can function perfectly and the does not any worry about the using of harmful water.

The block diagram of the system proposed is given below.

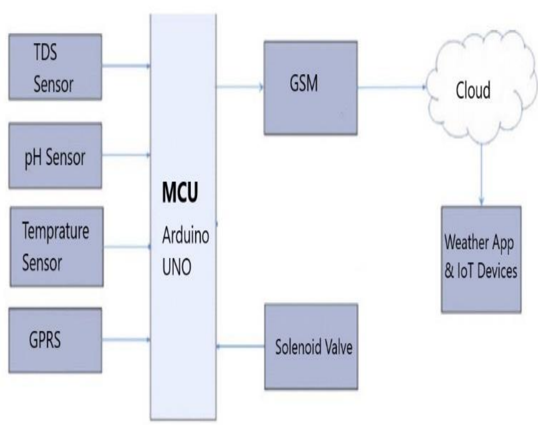


Figure Block diagram of the system proposed in

The whole system is designed in Embedded-C and the written code is simulating using Arduino IDE. Design the schematic and visual simulation is completed via Proteus 8.11 software. All the data will be updated in every 3 seconds (approx.). The information is gathered, stored, and analyzed and transmitted in real-time.

3.1 The GSM 900D

The GSM 900D is low-cost GSM (Global system for Mobile Communication) module can transmit and received the data in 2G network. Whereas 2G is most reliable in the sense of network coverage. It uses 2nd generation GPRS packet transfer-based internet communication. It can also communicate via Phone call and SMS. This GSM module has one Tx and Rx pin to transmit and receive data from the MCU. That makes the device more user friendly and cost efficient.

3.2 The GPS module

The u-blox NEO-6M GPS module is the one of cheapest GPS. It has fetched the geolocation info like Latitude and Longitude. It can also collect the value of Altitude. The Tx and Rx pin is used to transmit and receive data from MCU.

3.3Target boards

The target board is a development board integrated with a microcontroller, ADC, DAC, Crystal Oscillator etc. components are fabricated on it. The Arduino and NodeMCU two boards are proposed for this system.

3.3.1 The Arduino UNO

The Arduino UNO is an ATmega 328P microcontroller which has 14 digital input/output pins. Five of them 8-bit PWM. 0,1 (Tx, Rx) two receive and transmit TTL serial data. [2]

3.4 pH Sensor

pH is the measurement of how acidic or basic the water is. The calculation is an acidity balancing test or the alkaline of the ions of hydrogen in the water. The pure natural water which also called distilled water pH is about 7. pH range 6.5 to 9.5 is considered safe for drinking. The source of pH is low (0) for acidic and high (14) basic (alkaline) solution.[3]

3.5 TDS sensor

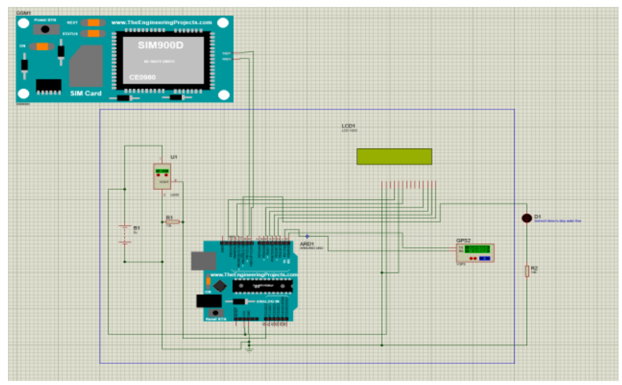
Total Dissolved Solids (TDS) indicates how many milligrams of soluble solids are dissolved in one liter of water. In general, the higher TDS value, more soluble solids dissolved in the water. And the less clean. Therefore, TDS value can be used as one reference point of standard for the cleanings of the water. [4]

3.6 Solenoid Valve

It is an electronically controlled valve. Solenoid valves are used wherever fluid flow has to be controlled automatically. They are being used to an increasing degree in the most varied types of plants and equipment. Whenever electricity passed through the device a magnetic field is created thus actuator activate and stop the liquid flow.

4. RESULT ANALYSIS:

The experimental simulation setup consists of an MCU with a sensor network that takes the samples for every 3 seconds from the water storage tanks or the place or pipeline where the device set up. The parameters are displayed in the LCD display. The measured value is showed up for 1 second for temperature, one second for pH value and another 1 second for the showing the TDS value. In the meantime, if the water measured and harmful for health first it stop flowing to the tape. In the meantime, its collect geolocation info of that place we are monitoring the water quality and send all the data pH value, TDS value, temperature, geolocation info (latitude and longitude) to the weather server and IoT cloud. If GSM is out of network coverage, then measurement value can be visible by display, and it can be stopping the water flow whenever it requires no need to worry about GSM or GPS network coverage.



5. Contribution:

Now the goal of our project is not very new but sometimes it is better to improve something that might have better chance to help the society rather than building something new from the scratch. Our system monitors the water quality in real time which means once the system is installed it literary starts calculating the data for monitoring and sends it to the receiver end. Once the data reaches receiver it receives it and shows the values in the monitor. Then from a basic analysis it is easy to decide whether the water is polluter or contaminated on not. The data our device created can also be sent with the very location it was measured in.

We are very familiar with the weather applications where we get to know a regions weather forecast. In the weather forecast we can know wind speed prediction of a sunny or rainy day and the quality of water and precipitations percentage. Since it is possible for our device to sent data to the internet (i.e. server) it is very much possible to incorporate it with the weather application so that the people will also get to know the water quality of that specific region. It can help avoid any factory or industry's accidental spill of wastage in the drinkable water harming people's health as they will know if the water is contaminated or not. Our system doesn't stop there any indication of the water being polluted it will automatically stop the water flow. As it has previously been told that our system will sent data for monitory anywhere in the world but just in case the embedded internet module does not work it will sure do everything it supposed to do without any issue except sending the data through internet. Now just in case of any emergency which is closely related to water like a epidemic spreading through water will be identified and the data will be sent with exact pointer of the location which will help control the situation.

6. Limitations:

We are a firm believer that there is no such technology that is perfect. Everything has flaw even if it's very little. Our device is no exception. There are quite a few flaws in our system that needed to be taken into consideration before using it and they are pointed out as below:

Our system is designed to work as long as there is no new type of water pollution elements harmful but very naturally dissolved element in the water.

Once the internet module fails to perform there is no other means to send the data to internet for long distance monitoring. The same goes for the network failures too.

Our device is not robust enough that we can say it is immune to damage. Hardware failures are possible and if not properly position it is open to the other elemental damage.

Our system requires occasional maintenance. It also requires electric power 24/7.

7. Future Work:

If the potential of our device or system has been considered it is worth saying its needs furthermore improvements. Cheap cost and simple design helps is affordability is the very indication of its business potential. Therefore, it is without question needed to be upgraded to something even better. Now it implements on a development board. Further it can be developed in embedded system. Thar make it cheaper and smaller as well. Now to develop it further we plan to upgrade its modules and a few more sensors giving it a more robust infrastructure. We would like it to adapted with both AC DC power source and add battery so sudden electrical outage should keep it self-powered for at least a few hours. We would like to add two network carriers in case of one losing signal won't stop it from sending data. More importantly we will improve its pollution detection capabilities.

8. Conclusion:

In this progressive and advance time of human era is fighting a war against a lot of things. Our ignorance toward nature is about to cause us a lot of disastrous events from climate change to the extinction of life of many specious in earth. Water crisis is another element out of many. If not prevented it could be the first one to hit us exploiting all of our weakness and a dire need for a clean water source. Our device helps identify notify and also helps monitoring the water quality and take action according to it. We really do see such devise to be the technology to battle the upcoming crisis. It will help improve the daily life of the group of people who lives more rural side of the country where the awareness towards water quality is the least. Our product being reasonably affordable helps pave the way to improve the life of its users.

Reference:

[1] F. Jan, N. Min-Allah, and D. Düştegör, "Iot based smart water quality monitoring: Recent techniques, trends and challenges for domestic applications," *Water (Switzerland)*, vol. 13, no. 13, pp. 1–37, 2021, doi: 10.3390/w13131729.

[2] "Arduino Uno Pinout, Specifications, Pin Configuration & Programming." https://components101.com/microcontrollers/arduino-uno (accessed Sep. 09, 2021).

[3] S. Pasika and S. T. Gandla, "Smart water quality monitoring system with cost-effective using IoT," *Heliyon*, vol. 6, no. 7, p. e04096, Jul. 2020, doi: 10.1016/J.HELIYON.2020.E04096.

[4] USGS, "pH and Water." https://www.usgs.gov/special-topic/water-science-school/science/ph-and-water?qt-science_center_objects=0#qt-science_center_objects (accessed Sep. 09, 2021).

Source Code:

```
// include the library code:

#include <LiquidCrystal.h>
#include <SoftwareSerial.h>
#include <TinyGPS.h>
#include <GSM.h>


#define GSMrx "8"
#define GSMtx "9"
// APN data
#define GPRS_APN       "GPRS_APN" // replace your GPRS APN
#define GPRS_LOGIN     "login"    // replace with your GPRS login
#define GPRS_PASSWORD  "password" // replace with your GPRS password
// initialize the library instance
GSMClient client;
GPRS gprs;
GSM gsmAccess;

// URL, path & port (for example: arduino.cc)
char server[] = "weather.google.com";
char path[] = "/asciilogo.txt";
int port = 80; // port 80 is the default for HTTP


//GPS
float lat , lon ; // create variable for latitude and longitude object
```

```
SoftwareSerial gpsSerial(3, 4); //rx,tx
TinyGPS gps;
const int sensor = A0; // Assigning analog pin A1 to variable 'sensor'
float tempc;  //variable to store temperature in degree Celsius
float tempf;  //variable to store temperature in Fahreinheit
float vout;
float gpspin = 0;


// initialize the library by associating any needed LCD interface pin
// with the arduino pin number it is connected to
const int rs = 12, en = 11, d4 = 5, d5 = 4, d6 = 3, d7 = 2;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
const int sValve = 10;

// font matrix  of byte degree
byte degree_symbol[8] =
{
  0b00111,
  0b00101,
  0b00111,
  0b00000,
  0b00000,
  0b00000,
  0b00000,
  0b00000
};
```

```
void setup()
{
  while (!Serial) {
    ; // wait for serial port to connect. Needed for native USB port only
  }

  Serial.println("Starting Arduino web client.");
  // connection state
  boolean notConnected = true;


  while (notConnected) {
    if ((gsmAccess.begin(GSMrx) == GSM_READY) &
        (gprs.attachGPRS(GPRS_APN, GPRS_LOGIN, GPRS_PASSWORD) == GPRS_READY)) {
      notConnected = false;
    } else {
      Serial.println("Not connected");
      delay(1000);
    }
  }

  Serial.println("connecting...");

  // if you get a connection, report back via serial:

 // ****For simulation we cant add the host address of specific server information for this we need to
live the system
  if (client.connect(server, port)) {
    Serial.println("connected");
    // Make a HTTP request:
```

```
  client.print("GET ");
  client.print(path);
  client.println(" HTTP/1.1");
  client.print("Host: ");
  client.println(server);
  client.println("Connection: close");
  client.println();
} else {
  // if you didn't get a connection to the server:
  Serial.println("connection failed");
}
```

```
pinMode(sensor, INPUT); // Configuring pin A1 as input
pinMode(gpspin, INPUT);
pinMode(sValve, OUTPUT);
Serial.begin(9600);
lcd.begin(16, 2);
lcd.createChar(1, degree_symbol);
lcd.setCursor(0, 0);
lcd.print(" IoT Based Water ");
lcd.setCursor(0, 1);
lcd.print("Quality Monitoring System");
delay(1000);
lcd.clear();

//Displaying Name
```

```
lcd.begin(16, 2);
lcd.setCursor(0, 0);
lcd.print("Md. Ashrafur Rahman ");
lcd.setCursor(0, 1);
lcd.print("2017-1-60-125");
delay(1500);
lcd.clear();



//Displaying Name
lcd.begin(16, 2);
lcd.setCursor(0, 0);
lcd.print("Md. Sabbir Hossain ");
lcd.setCursor(0, 1);
lcd.print("2017-1-60-112");
delay(1500);
lcd.clear();

//Displaying Name
lcd.begin(16, 2);
lcd.setCursor(0, 0);
lcd.print("Aminul Islam ");
lcd.setCursor(0, 1);
lcd.print("2017-1-60-111");
delay(1500);
lcd.clear();

Serial.println("The GPS Received Signal:");
gpsSerial.begin(9600); // connect gps sensor
lcd.begin(16, 2);
```

```
}
void loop()
{
 vout = analogRead(sensor);
 vout = (vout * 500) / 1023;
 tempc = vout; // Storing value in Degree Celsius

 if (tempc > 50 || tempc < 5 ) // Also TDSvalue > 40 || pHvalue > 9 || pHvalue <5
 {
  digitalWrite(sValve, HIGH);   // stop water flow  --
  display();
 }
 else
 {
  digitalWrite(sValve, LOW); // Continue water flow
  display();
 }
}

void display(void)
{
 vout = analogRead(sensor);
 vout = (vout * 500) / 1023;
 tempc = vout; // Storing value in Degree Celsius

 Serial.print("in DegreeC=");
 Serial.print("\t");
 Serial.print(tempc);
 Serial.println();
```

```
lcd.clear();
lcd.setCursor(0, 0);
lcd.print("Temperature in C");
lcd.setCursor(4, 1);
lcd.print(tempc);
lcd.write(1);
lcd.print("C");
delay(1000);

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("TDS Count: ");
lcd.setCursor(4, 1);
lcd.print("Sensor error");
delay(1000);

lcd.clear();
lcd.setCursor(0, 0);
lcd.print("pH value: ");
lcd.setCursor(4, 1);
lcd.print("Sensor error");
delay(1000);

// check for gps data
lcd.clear();
gps.encode(gpsSerial.read());// encode gps data

gps.f_get_position(&lat, &lon); // get latitude and longitude
// display position
```

```
lcd.clear();
  lcd.setCursor(1,0);
  lcd.print("GPS Signal");

  lcd.setCursor(1,0);
  lcd.print("LAT:");
  lcd.setCursor(5,0);
  lcd.print(lat);
  Serial.print(lat);
  Serial.print(" ");
  Serial.print(lon);
  Serial.print(" ");
  lcd.setCursor(0,1);
  lcd.print(",LON:");
  lcd.setCursor(5,1);
  lcd.print(lon);



  lat = analogRead(gpspin);
  String latitude = String(lat,6);
  String longitude = String(lon,6);
  Serial.println(latitude+";"+longitude);
  delay(1000);



 // listen for incoming clients
```

```
GSMClient client = server.available();



if (client) {
  while (client.connected()) {
    if (client.available()) {
      Serial.println("Receiving request!");
      bool sendResponse = false;
      while (char c = client.read()) {
        if (c == '\n') {
          sendResponse = true;
        }
      }

      // if you've gotten to the end of the line (received a newline
      // character)
      if (sendResponse) {
        // send a standard http response header
        client.println("HTTP/1.1 200 OK");
        client.println("Content-Type: text/html");
        client.println();
        client.println("<html>");
        // output the value of each analog input pin
        for (int analogChannel = 0; analogChannel < 6; analogChannel++) {
          client.print("analog input ");
          client.print(analogChannel);
          client.print(" is ");
          client.print(analogRead(analogChannel));
          client.println("<br />");
```

```
      }
      client.println("</html>");
      //necessary delay
      delay(1000);
      client.stop();
     }
    }
   }
  }

}
```