VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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Project Report
on

IoT BASED SMART WATER QUALITY MONITORING AND FLOW CONTROL SYSTEM

Submitted by

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[1VE16EC055]

In partial fulfillment of the requirement for the award of degree of

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Under the Guidance of
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SRI VENKATESHWARA COLLEGE OF ENGINEERING
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Department of Electronics & Communication Engineering
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CERTIFICATE

Date: 6-08-2020

This is to certify that the project work entitled **“IoT BASED SMART WATER QUALITY MONITORING AND FLOW CONTROL SYSTEM”** carried out by ***Ms. MEGHA D M*** *bearing USN (1VE16EC055)*, bonafide students of Sri Venkateshwara College of Engineering in partial fulfillment for the award of Bachelor of Engineering in Department of Electronics & Communication Engineering of the Visvesvaraya Technological University, Belgaum during the year 2019-2020. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said degree.

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DECLARATION

I, ***Ms. MEGHA D M*** *bearing USN (1VE16EC055)* student of final semester Bachelor of Engineering in the Department of Electronics and Communication Engineering, Sri Venkateshwara College of Engineering, Bangalore. It is hereby declared that the work entitled "**IoT BASED SMART WATER QUALITY MONITORING AND FLOW CONTROL SYSTEM**" has been carried out under the supervision of **Prof.RAJENDRA PRASAD P**, Assistant Professor, Department of Electronics and Communication Engineering of Sri Venkateshwara College of Engineering, Bengaluru, for the partial fulfillment of the requirements for the award of the degree of Bachelor of Engineering in Electronics & Communication Engineering by Visvesvaraya Technological University, Belgavi during the academic year 2019-2020. Further the work embodied in the dissertation has not been submitted previously by anybody for the award of any degree or diploma to any other university.

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ABSTRACT

Water pollution is the root cause for many diseases in the world. It is necessary to measure water quality using sensors for prevention of water pollution. There are a number of processes and factors affecting the water quality during transmission and distribution which are little understood. The effective and efficient system of Water Quality Monitoring (WQM) are critical implementation for the issue of polluted water globally, with increasing in the development of Wireless Sensor Network (WSN) technology in the Internet of Things (IoT) environment, real time water quality monitoring is remotely monitored by means of real-time data acquisition, transmission and processing. This project presents a reconfigurable smart sensor interface device for water quality monitoring system in an IoT environment. The smart WQM system consists of Arduino UNO microcontroller, sensors; IoT and Wireless Fidelity (Wi-Fi) based wireless communication module. The proposed WQM system collects the five parameters of water data such as water pH, water level, turbidity, conductivity and water temperature in parallel and in real time basis with high speed from multiple different sensor nodes. This system is integrated with the IoT technology for real-time water quality monitoring. It aims to determine the contamination of water, purifies the water and also automatic measure of parameters in real time using Arduino UNO. This system is fine-tuned with additional sensors and reduced cost. The results show that the proposed system outperforms the existing ones and produces better results.

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LIST OF ABBREVIATIONS

DC	Direct Current
GSM	Global System for Mobile Communication
IoT	Internet of Things
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LM	Linear Monolithic
LSTM NN	Long and Short-Term Memory Neural Network
LQER	Link Quality Estimation based Routing protocol
MLR	Multiple Linear Regression
ORP	Oxidation Reduction Potential
pH	Potential of Hydrogen
PLC	Programmable Logic Controller
TDS	Total Dissolved Solids
UIA	Un-Ionized Ammonia
USEPA	United States Environmental Protection Agency
Wi-Fi	Wireless Fidelity
WQM	Wireless Quality Monitoring
WQP	Wireless Quality Parameters
WSN	Wireless Sensor Network

CHAPTER 1

INTRODUCTION

Over the past few decades, water has gradually succumbed to a fair degree of pollution. Chemical waste and oil-spills have become major pollutants. Eliminating pollution altogether seems impossible but limiting its effects is certainly possible. Dirty or contaminated water is used for drinking purpose without any proper treatment in many developing countries. The reason for this is the lack of water quality monitoring system and which creates serious issues. To take preventive actions for water quality maintenance, a system is being proposed for the same. The system should be implemented to monitor the quality of water in easy way, so it can easily analyse some of the critical and important factors of water. Various environmental parameters such as temperature, Potential of Hydrogen (pH), oxygen density, turbidity and so on from water can be collected by these systems using different sensors.

The development of Internet of Things (IoT) technology provides us approach to real time data acquisition, transmission and processing. In general the user can get real time water quality data from faraway, but in this system there are several nodes and a base stations where each node contains a group of sensors and the nodes are distributed in different water bodies. By those sensors in water the collected date is sent to base station via IoT channel. To analyse the water quality data and when water quality detected is below present level, Alarm is automatically raised. Using various software tools the recorded data can be analysed for future correspondence and actions. Here a standalone Arduino micro series is used to monitor pH level, turbidity sensor is used to monitor the transparency of water, Linear Monolithic 335 (LM335) temperature sensor is used to measure temperature, and conductivity of water is more when number of solvents dissolved in water is more than the normal level. In order to detect the conductivity in water conductivity sensor is used. Espressif Systems (ESP8266) is used to send the sensor information to the cloud so that one can access the data from anywhere in world. Keeping track of water quality in current era is big challenge because of the large amount of chemical use in day to day activities and in industry that that ultimately make their way into water. Resource of clean water is very less on the earth. It is very important for the health of human.

Clean water is one of the most important resources required to sustain life and the quality of drinking water plays a very important role in the well-being and health of human beings. Water supply to taps at urban homes and water sources available in more rural areas, is however, not necessarily safe for consumption. Even though it is the government’s responsibility to ensure that clean water is delivered to its citizens, ever aging infrastructure, which is poorly maintained and continual increase in population, puts a strain on the supply of clean water. Traditional water quality monitoring methods involve sampling and laboratory techniques. These methods are however time consuming (leading to delayed detection of and response to contaminants) and not very cost effective. There is thus a need for more extensive and efficient monitoring methods. Water quality monitoring can be achieved through microbial measurements as well as physiochemical measurements. Physiochemical parameters include electrical conductivity, pH, Oxidation Reduction Potential (ORP), turbidity, temperature, chlorine content and flow. These parameters can be analysed quickly and at less cost than the microbial parameters and can also be measured with on-line instrumentation. Studies conducted by the United States Environmental Protection Agency (USEPA) have shown that water parameters are affected by contaminants in specific ways and can be detected and monitored using appropriate water quality sensors.

Commercially available products capable of monitoring such parameters are usually bulky and quite expensive. Monitoring with sensor technology is still not very effective, as they do not always meet the practical needs of specific utilities; although cheaper than traditional equipment, cost, reliability and maintenance issues still exist; and data handling and management can also be improved. In this paper the development of a low-cost, wireless, multi-sensor network for measuring the physicochemical water parameters; enabling real-time monitoring, is presented. The system implements flow, temperature, conductivity and pH sensors from first principles. All the data from the sensors are processed and analysed, and transmitted wirelessly to a notification node. Algorithms are developed to detect possible contaminations. The notification node informs the user as to whether the water quality parameters are normal or abnormal. At present, China's water pollution situation is getting worse. Strengthen the management of water resources, protect the people's livelihood; water security has become a major event. Wide distribution of surface water, surface water quality is often affected by coastal pollution emissions, weather conditions and other factors, water quality changing over time and space, and because the traditional manual monitoring sections less, conditions behind, it is difficult to achieve long term, continuous and real-time water-quality monitoring. Therefore, the study of water-quality pollution line monitoring system, improve the level of water quality monitoring technology is important. To solve this problem, the system can collect the real time data for scientific data analysis and display of water quality information and then to achieve these purposes, such as real-time monitoring, early warning and historical information query etc. A system is to be implemented to monitor various factors such as temperature, pH, oxygen, density, turbidity and so on from the water using the approach of IoT and sensors. The data collected using these sensors are analysed and if the values are below the threshold level, alarm is automatically raised. Using various simulation tools the recorded data can be analysed for future correspondence and actions.

Problem Definition

Water is one of the main natural resources available to human kind. Our drinking water sources are finite: less than 1% of freshwater is accessible to us.70% of this 1% fills oceans, lakes, and other water bodies but over the past few decades, water has gradually succumbed to a fair degree of pollution. Chemical waste and oil-spills have become major pollutants. Eliminating pollution altogether seems impossible but limiting its effects is certainly possible. Dirty or contaminated water is used for drinking purpose without any proper treatment in many developing countries. Water pollution is any chemical, physical, or biological change in the quality of water that has a harmful effect on any living things that drink or uses or lives in it. When humans drink polluted water it often has serious effects on their health. The main problem caused by water pollution is that it kills organisms that depend on these water bodies. Dead fish, crabs, birds and sea gulls, dolphins, and many other animals often wind up on beaches, killed by pollutants in their habitat. Pollution disrupts the natural food chain as well. Waterborne diseases are caused by drinking contaminated or dirty water. Contaminated water can cause many types of diarrheal diseases, including Cholera, and other serious illnesses such as Guinea worm disease, Typhoid, and Dysentery. Water related diseases cause 3.4 million deaths each year.

Motivation

The system being proposed here analyses the innovative ways to improve water quality monitoring. There is the need for an improved system with higher frequency of data input, higher accuracy of higher quality sensors, and a wider range of parameters being monitored. The motivation behind this project is to develop a transfer function between water quality monitoring system and source of data collection till its transmission to the destination. This system also has an option to save all the transferred data which will be helpful in future research. This will help have a better understanding and variation of level of pollution.

Organization of the Report

Chapter 1 introduces the problem statement we have considered and how it has motivated us to come up with this project idea.

Chapter 2 gives an idea about the related work carried out with respect to this topic and made us realize the possible areas for further improvements.

Chapter 3 includes the complete working flow of our proposed model, here it provides the detailed discretion about the interconnection of various sensors with Arduino and we have advanced features add on to our proposed work. Finally this chapter gives the complete overview of our model.

Chapter 4 focuses on the list of Hardware and software components which is required for our proposed model. Then we have provided the functionality and description of each component which have been used.

Chapter 5 addresses the overall results obtained from our working model. And then we have provided the detailed description of each stage. And it also defines the interaction between cloud and Arduino.

Chapter 6 mentions the successful completion of our proposed model. This system is fine-tuned with additional sensors and reduced cost. The results show that the proposed system outperforms the existing ones and produces better results and also may require few more upgradation in future.

CHAPTER 2

LITERATURE REVIEW

The basic idea behind conducting a literature survey is to find out the current work being done in a chosen field. This includes the problem faced as well as the current progress on developing a complete solution for the said problem We got the basic idea to develop such a system because of the problem we faced and based on the drawbacks of a few existing systems. The papers that we have referred are as follows:

In paper [1] illustrations of the relationship between pH, Total Dissolved Solids (TDS) and Conductivity Water Quality Parameters (WQPs) has been done. It was stated that those parameters will be involved in the detection of hexavalent chromium contamination in the drinking water system. WQPs are obtained for four different hexavalent chromium contaminated samples experimentally using pH, TDS and conductivity sensors. With the use of different combination of estimated and measured values using several samples the estimation of WQPs computed. It was stated that the Multiple Linear Regression (MLR) mode3l is utilized to determine the correlation among the considered WQPs. According to the results the errors between the actual and estimated the results can be finalized. It was found that the estimated values are closer to measured values and the estimated errors lie between 0.33% and 19.18%.

Water quality prediction method based on LSTM Neural network [2] implemented a new water type prediction method based on Long and Short-Term Memory Neural Network (LSTM NN). Firstly, a prediction model based on LSTM NN is established. Secondly, the data set of water quality indicators in Taihu Lake which measured monthly from 200 to 2006 years is used for training model. Then they stored data in a database. Thirdly, the predictive accuracy of the model was improved and a series of simulation and parameters selection was carried out. Finally the proposed method is compared with 2 different methods: one is based on back propagation neural network and the other is based on online sequential extreme learning machine.

Water monitoring system using Arduino [3] exhibited a system to develop, implement, monitor and control some parameter of water such as pH level, temperature, and turbidity. The main objective of this system is remotely monitors and control of water quality. The system built with Arduino UNO R3 board using ATmega328 as the main controlling unit. Lab VIEW is used as a display unit in the system. This system is more economical system and reliable, flexible for water monitoring.

The Cost Effective Water Quality Evaluation System [4] proposed an Embodiment of low cost and immensely proficient water quality monitoring system. The system is a microcontroller based system with high degree of accuracy. It mainly determines several parameters of water such as temperature, turbidity, and potential of hydrogen (pH). This system makes possible to detect the sensor values and display it on LCD display.

Design of Smart Sensors for Real-Time Water Quality Monitoring [5] proposed a microcontroller based real time system which notifies the user of the various parameters of water based on the various sensors used here. ZigBee receiver and transmitter modules are used for communication between the measuring and notification node. The notification node presents the reading of the sensors and outputs an audio alert when water quality parameters reach unsafe levels. The results demonstrate that the system is capable of reading physiochemical parameters, and can successfully process, transmit and display the values obtained by the sensors.

Water quality monitoring system based on GPRS is designed [6] system consists of monitoring stations subsystem, data communications subsystem and master station subsystem. Utilizing the existing stable GPRS network technology, according to the need of water-quality testing. The system can timely and accurate collect the real water-quality data for scientific data analysis and display of water-quality information and then to achieve these purposes, such as real-time monitoring, early warning and historical information query etc.

The design of remote water quality monitoring system based on WSN [7] was designed to resolve the problem of manual analytical method in water quality detection. This system had a simple architecture and introduced a measuring and monitoring system based on WSN utilizing wireless system to transmit the data made it easy to transmit over a large distance. This system is able to grasp the current water quality conditions and predict the future trend of development based on the continuous real-time online monitoring.

Online water quality monitoring technologies [8] have been improving continuously. At the moment, water quality is defined by the respective range of few chosen parameters. However, this strategy requires sampling and it cannot provide evaluation of the entire water molecular system including various solutes. As it is nearly impossible to monitor every single molecule dissolved in water, the objective of our research is to introduce a complimentary approach, a new concept for water screening by observing the water molecular system changes using aqua photonics and Quality Control Chart method. Here UV-light spectrometer is used to measure the impurities present in water based on the spectral pattern produced but this method is very costly.

The paper [9] presents a smart water management system using the microcontroller ZR16S08 as IoT solution, for water distribution support and losses prevention. The system operates through the smart monitoring of the water flow in pipes of the water distribution network, aiming to ensure quality of the water supply, knowing that water losses characterize one of the great problems in the world, as pipe holes may be open doors to water contaminants. As an alternative to circumvent this issue, a series of experiments were taken to create a network of sensors capable of monitoring water pipes in real time. Adopting criteria such as low consumption and low cost, the use the ZR16S08 microcontroller in the design of wireless sensor nodes that will be coupled in the water pipes was adopted.

In paper [10] the implementation of Un-Ionized ammonia (UIA) in freshwater is a primary source of toxins that kill freshwater fish. Concentrations as low as 0.03 mg/L can harm fish and concentrations of more than 2.00 mg/L can kill them. The availability of water quality monitoring systems that can directly measure UIA without any chemical treatment on samples is limited. This designs a new system by using a programmable system on chip and non-destructive types of measurement instruments. Four water environment parameters are measured, namely, pH, temperature, dissolved oxygen, and ammonium. Algorithms are applied on the system to calculate the UIA using data from the measurement instruments. The designed system can measure UIA in freshwater at 95% confidence level. Data from the system are monitored and recorded using a data acquisition system. Ammonia is an important compound that can be used in various domestic, industrial, and agricultural applications. The main application of ammonia is the production of nitrogenous fertilizers such as urea, ammonium phosphate, ammonium sulphate, and ammonium nitrate. Anhydrous ammonia is used in agriculture.

The authors in paper [11] present the development of a web based wireless sensor network application for monitoring water pollution using Zigbee and WiMax technologies. The developed system consists of a local Zigbee network, capable of acquiring various water quality parameters, a WiMax network and a host computer for web based monitoring. The system is designed to collect and process information, thus making decisions in real time via a remote web server. The data is sent from sensor nodes through the Zigbee gateway to the web server via WiMax network, thus allowing users to remotely monitor the water quality from their offices instead of gathering data from the scence. Experimental results demonstrate the ability of the sensor network to monitor water pollution in real time. This system can be easily configured to support other applications, such as e-health and security. Advances in electronics and wireless communications have enabled a new evolution in wireless sensor networks (WSNs). Over the last decade, WSN s have attracted a great deal of interest due to their cost-effectiveness, ability to perform multiple functions simultaneously and make decisions based on information gathered from various sensing elements placed at different locations.

The paper [12] investigates a wireless sensor network deployment — monitoring water quality, e.g. salinity and the level of the underground water table — in a remote tropical area of northern Australia. Our goal is to collect real time water quality measurements together with the amount of water being pumped out in the area, and investigate the impacts of current irrigation practice on the environments, in particular underground water salination. This is a challenging task featuring wide geographic area coverage (mean transmission range between nodes is more than 800 meters), highly variable radio propagations, high end-to-end packet delivery rate requirements, and hostile deployment environments. We have designed, implemented and deployed a sensor network system, which has been collecting water quality and flow measurements, e.g., water flow rate and water flow ticks for over one month. The preliminary results show that sensor networks are a promising solution to deploying a sustainable irrigation system, e.g., maximizing the amount of water pumped out from an area with minimum impact on water quality. This explores the use of wireless sensor network technology to study the impacts of current irrigation practice on the environment in the Burdekin area, Queensland, Australia.

A Link Quality Estimation based Routing protocol (LQER) [13] is proposed to meet the high reliability of transmitting data in water environment monitoring in wetlands based on (m,k)-firm link quality estimating. It considers both energy efficiency and link qualities when the route is selected, which makes routing data more reliable and decreases the probability of retransmission, thus saves the energy and prolongs the lifetime of the whole network. Simulation results show that LQER can meet the requirements of energy efficiency, reliability and scalability for water environment monitoring in wetlands. Presently, two kinds of technologies in water environment monitoring are adopted: 1) through artificial sampling with portable monitors of water quality, and analysis in the labs, this method is restricted to sampling sections of rivers or lakes, and its sampling frequencies are normally several times per month or daily 2) through automatically continuous monitoring of parameters of water environment by automatic monitoring system consisting of a central control room and several other monitoring stations, data are transmitted automatically for a long distance and parameters of water environment where there is a station can be inquired in real time.

The paper [14] reviewed the wireless communications and electronics has enabled the development of low-cost sensor networks. The sensor networks can be used for various application areas (e.g., health, military, home). For different application areas, there are different technical issues that researchers are currently resolving. The current state of the art of sensor networks is captured in this article, where solutions are discussed under their related protocol stack layer sections. This article also points out the open research issues and intends to spark new interests and developments in this field. Recent advances in wireless communications and electronics have enabled the development of low cost, low-power, multifunctional sensor nodes that are small in size and communicate for short distances.

In paper [15], authors have proposed the water quality monitoring system is a critical implementation for the issue of pollution of water, with increase in the development of technology and advancement in the Internet of Things (IoT) environment, the real time water quality monitoring system is remotely monitored by the means of storing the data, transmission and processing. This paper presents a smart water quality monitoring with sensor interface device in internet of things. The smart water quality system consists of design board, sensors, Wi-Fi module and personal computer. It is programmed in high speed integrated circuit hardware description language and embedded c programming language. The proposed system collects the five parameters of water such as water pH, water level, turbidity, conductivity and temperature of water with high speed from various sensors using thing speak.

The paper [16], reviewed the water pollution has been an increasing problem over the last few years. Water personal satisfaction may be a standout amongst those primary variables with control wellbeing and the state for sicknesses. The objective of this water quality monitoring system using internet of things is to find the quality of the water i.e. how the pH content varies and sending message to the corresponding authorities. We are going to implement this project at municipal water tanks and drinking water reservoir. For that we are using an Arduino board for finding pH value and Global System for Mobile Communication (GSM) module for message technique. We use a led display to have continuous observation on water parameters. Finally the user gets message of pH value of water Further we extend this project by sending the sensor data to cloud for global monitoring of water quality.

In paper [17], investigates water quality monitoring and control system using Internet of Things and Industrial Automation. Using this system, remote monitoring and controlling is achieved. Power requirement is also reduced greatly as embedded based web servers are used instead of using PC based servers. Input of this system consists of water quality measurement sensors such as temperature, pH and turbidity sensors, interfaced with raspberry pi. This sensed data is passed to cloud/Node red server, where stored data can be monitored remotely. If any of the data is found above some threshold value, then appropriate controlling action is taken on the device, which is connected at the output of Programmable Logic Controller (PLC), from any remote location. This is achieved by using Node red webpage. Sensed data is stored, analysed and accordingly controlling action is taken on the device. Device used here for controlling action is DC motor connected to motor pump.

The authors in paper [18], have implemented the need for effective and efficient monitoring, evaluation and control of water quality in residential area has become more demanding in this era of urbanization, pollution and population growth. Ensuring safe water supply of drinking water is big challenge for modern civilization. Traditional methods that rely on collecting water samples, testing and analyses in water laboratories are not only costly but also lack capability for real-time data capture, analyses and fast dissemination of information to relevant stakeholders for making timely and informed decisions. In this paper, a real time water quality monitoring system prototype developed for water quality monitoring in Residential home is presented. The development was preceded by evaluation of prevailing environment including availability of cellular network coverage at the site of operation. The system consists of a Raspberry Pi, Analog to Digital Converter, Water quality measurement sensors. It detects water temperature, dissolved oxygen, pH (potential of hydrogen), and electrical conductivity in real-time and disseminates the information in graphical and tabular formats to relevant stakeholders through a web-based portal and mobile phone platforms.

In paper [19], the implementation of the conventional method of testing water quality is to gather samples of water manually and send to the lab to test and analyze. This method is time consuming, wastage of man power, and not economical. The water quality measuring system that we have implemented checks the quality of water in real time through various sensors (one for each parameter: pH, conductivity, temperature, turbidity) to measure the quality of water. As a variation in the value of this parameter points towards the presence of pollutants. The Wi-fi module in the system transfers data collected by the sensors to the microcontroller, and transfers the data to the smart phone/PC. This system can keep a strict check on the pollution of the water resources and be able to provide an environment for safe drinking water.

Project Objectives

The main aim here is to develop a system for continues monitoring of water quality at different places using sensor network with low power consumption, low cost and high detection accuracy. pH, conductivity, turbidity level, etc are the parameters that are analysed to improve the water quality .

The main objectives of the proposed system are:

- To understand the existing water purification systems.
- To build a system to determine a various water parameters such as pH, temperature, conductivity, turbidity and to measure the level of water.
- To design a system to purify the polluted water using a filter.
- To implement a system where the pump is turned ON and OFF automatically based on the water level.

- To analyse and store the recorded data and to use it for future purpose.

Chapter Summary

All the above expressed literature review about the related work was considered and made us realize that further improvements can be done in this regard and hence we have proposed the present system which includes the improvements that we thought were necessary. The objectives of the proposed system have also been mentioned.

CHAPTER 3

DESIGN of IoT BASED SMART WATER QUALITY MONITORING and FLOW CONTROL SYSTEM

The design of the system IoT based Smart Water Quality Monitoring and Flow Control System has been shown and explained using the below block diagrams and flow charts.

Introduction

The proposed system will be having remote monitoring capability and the monitoring system combined with the server and database. That will be helpful for the proposed system. In this system controller is interfaced with turbidity sensor, PH sensor, LCD, Temperature sensor, Conductivity Sensor, Water Level sensor and Wi-Fi module.

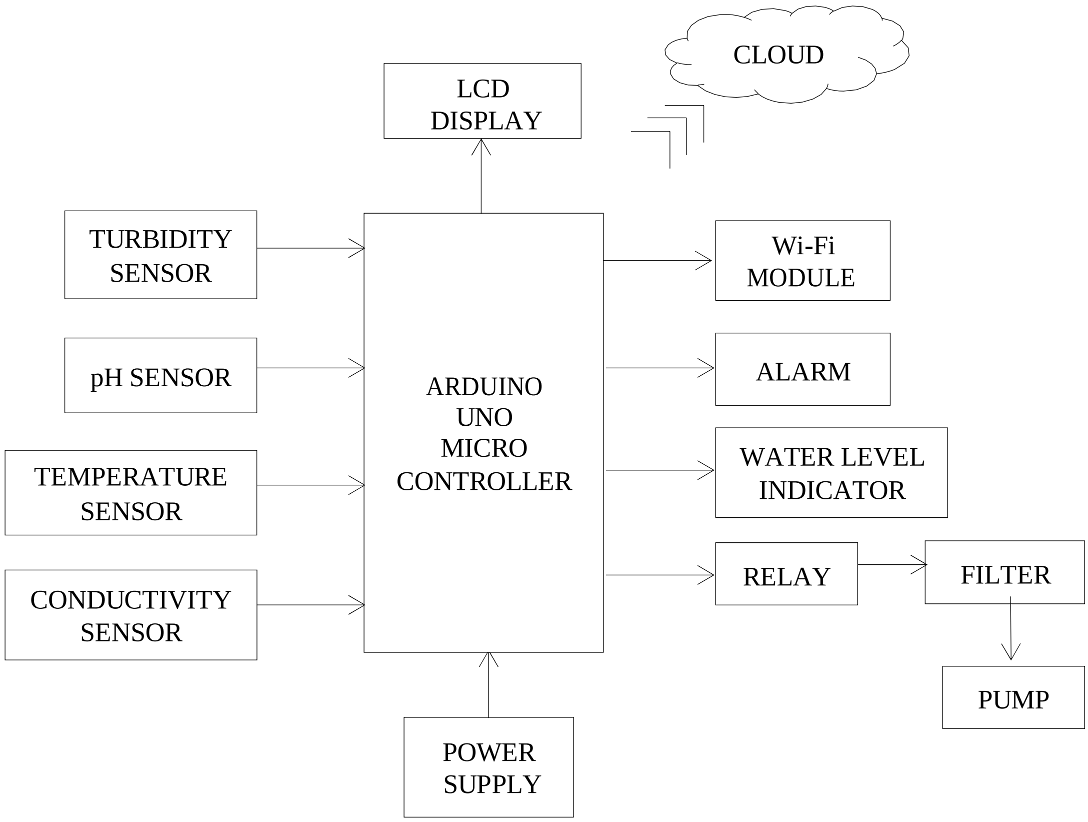

Figure 3.1: Block diagram of the system

As soon as connects power supply to the system controller reads all sensor information continuously and display it in LCD and same data will be sent to Wi-Fi module to save and to display data in the cloud. The block diagram of the proposed system is shown in figure 3.1. In our proposed method, Arduino UNO is used as a core controller. The temperature sensor, conductivity sensor, turbidity sensor, dissolved oxygen sensor, pH sensor can be read directly from the LCD interfaced with the sensor system.

Flowchart of the Complete System

Right now, microcontroller, I/O clock, UART and the LCD are introduced to their particular beginning qualities.

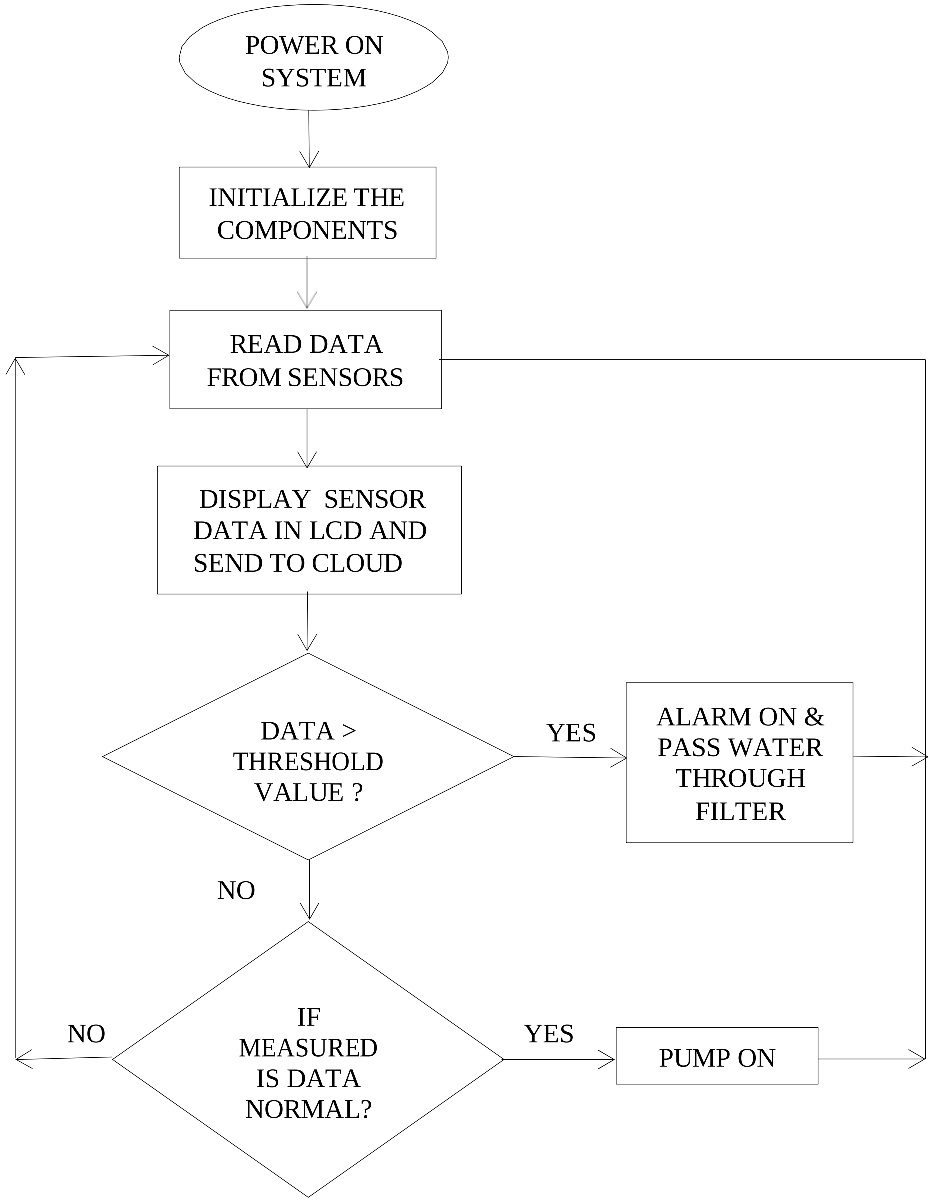

Figure 3.2: Flowchart of the system

At the point when the water streams the pH, temperature, water turbidity, conductivity and the degree of water present are totally estimated by the individual sensors. These qualities are shown on the LCD show. The flowchart of the proposed framework is as appeared in figure 3.2. All the measured values are compared with their respective threshold values. If all the values are less than the threshold values, then the water directly flows through the pump else the alarm is turned ON and the water is passed through the RO-Sediment filter for filtration. After filtrating, the water flows through the pump.

Flowchart of Working of All the Sensors

The flowchart in the figure 3.3 shows the flow of working of the sensors.

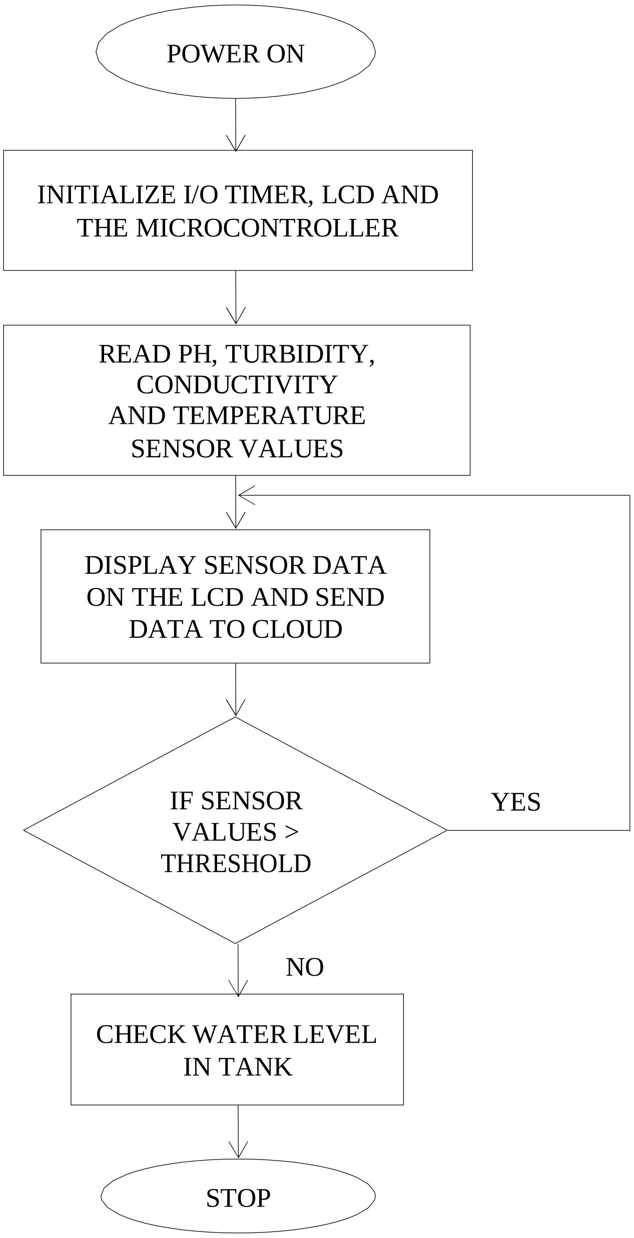

Figure 3.3: Flowchart of the working of all the sensors being used

After all the components get initialized and start sensing the values, the values obtained from the pH sensor, turbidity sensor, conductivity sensor and the temperature sensor are all displayed on the LCD and are simultaneously sent to the cloud. After this, the level of water in the tank is determined by the water level sensor and the pump operations are carried out based on this value.

Algorithm for Proposed Work:

- Firstly we should turn ON the framework.
- Initialize the microcontroller I/O Timer, UART, Arduino and LCD.
- Read the pH sensor, water level sensor, turbidity sensor, conductivity sensor, temperature sensor.
- Display sensor information in LCD and send all sensor information to cloud.
- If estimations of pH, turbidity, conductivity, temperature are for the most part more noteworthy than the edge esteem, at that point alert will be ON.
- Then the debased water is gone through the RO-Sediment channel for the filtration procedure.
- Water will be siphoned if the water level and sensor information is not exactly the limit esteem.

Flowchart of the Working of the Pump

The flowchart in figure 3.4 shows the working of the automatic pump that is being used in the system. After all the sensor values are collected, they are compared with the threshold values of each sensor that are the standard values or ranges fixed by the authority. If the sensor values are greater than the threshold, the water is passed onto the filter and then to the tank. If the values are within the range, then the water is sent to the tank. Before entering the tank, the water level sensor senses the level of water in the tank. If the water level is more than the threshold that we have set, then the pump is not turned on and the water does not flow to the tank. If the water level is less, then the pump is turned on automatically and the LED starts to glow as an indication and hence water starts to flow into the tank. When the level of water in the tank increases and reaches the level specified by us, the pump gets turned off automatically and the water flow to the tank is stopped. The filter used here is the RO-Sediment 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.

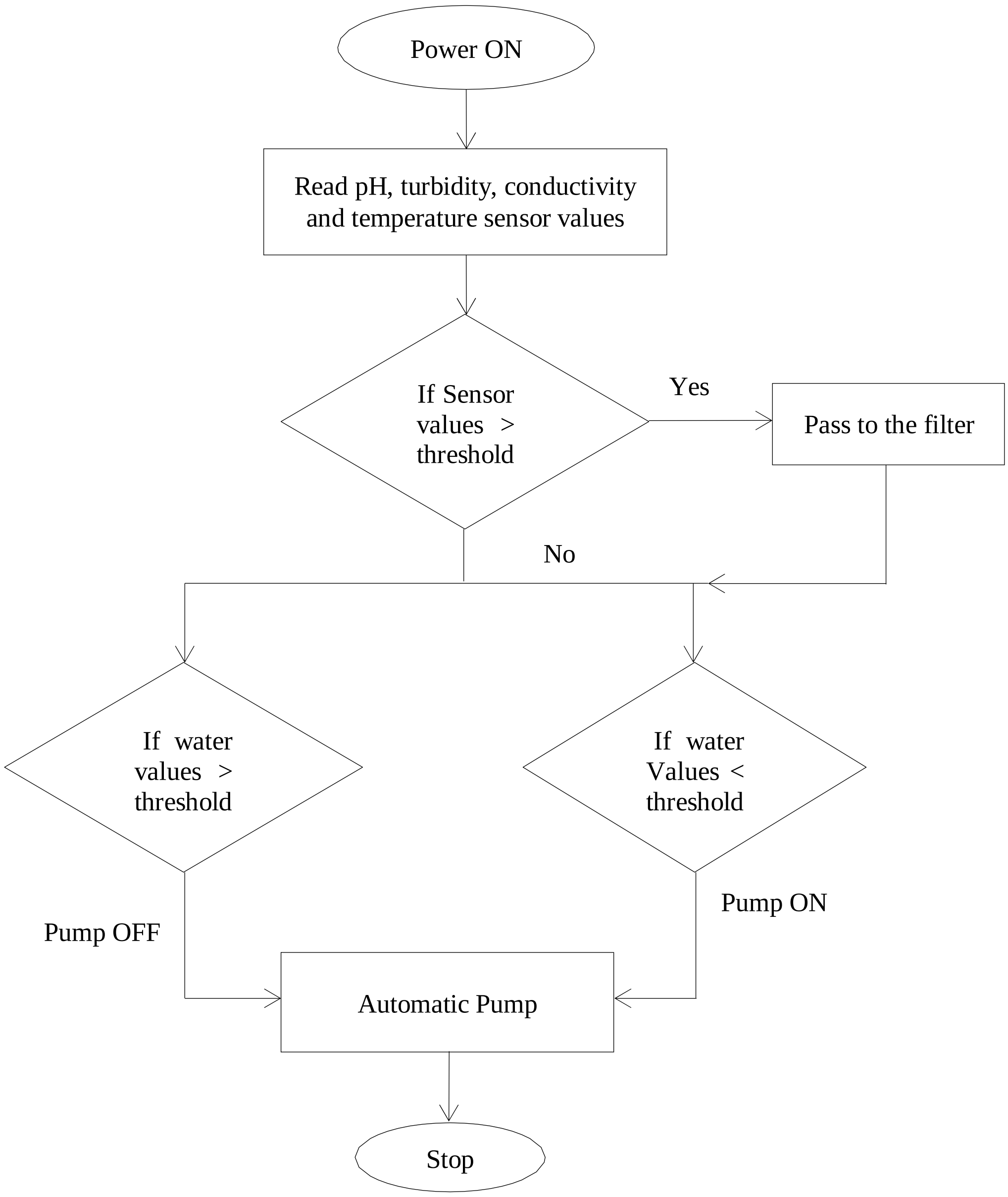

Figure 3.4: Flowchart of the working of automatic pump

Circuit Connection for the System

All the different sensors being used in this project are connected to the Arduino Uno microcontroller and the display system that is used to display the values that is the LCD is also connected to the Arduino Uno microcontroller. These circuit level connections are shown in figure 3.5. The components used in this circuit diagram are Arduino UNO, LCD for display of parameters, Wi-Fi module, cloud, relay, filter, pump and sensor network which consists of pH sensor, temperature sensor, turbidity sensor, conductivity and water level sensor.

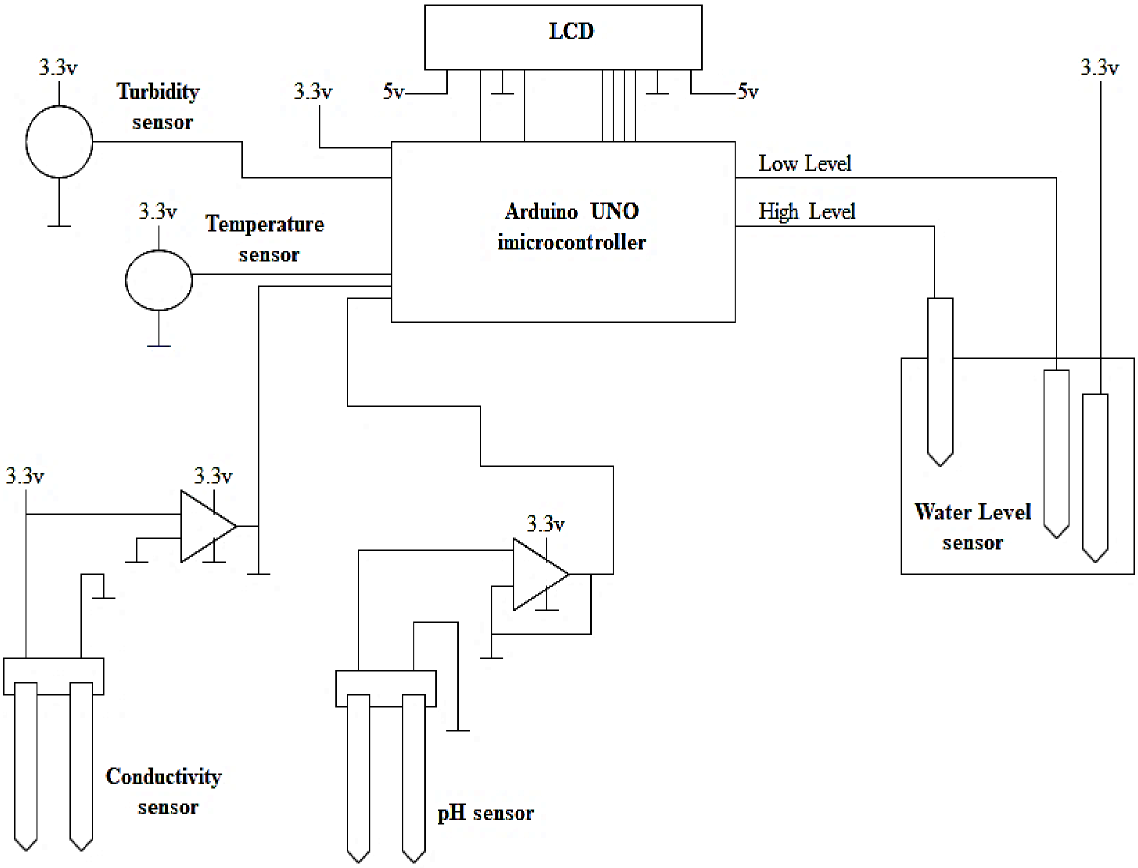

Figure 3.5: Circuit connections interfacing the sensors with Arduino

The whole design of the system is based mainly on IOT which is newly introduced concept in the world of development. There is basically two parts included, the first one is hardware & second one is software. The hardware part has sensors which help to measure the real time values, another one is Arduino. The hardware part consist sensors like turbidity, flow, pH, conductivity and temperature. Turbidity sensor is used to measure cloudiness of water. Cloudiness is caused by suspended solids (mainly soil particles) and plankton (microscopic plants and animals) that are suspended in the water column. Moderately low levels of turbidity may indicate a healthy. pH is the measure of hydrogen ion concentration. Temperature sensor used to monitor the temperature of water. The outputs of sensors are given to the ATmega 328 controllers; the controller used here is Arduino UNO. It converts the analog values to digital one, & LCD shows the displays output from sensors, Wi-Fi module gives the connection between hardware and software.

Data Transmission Method used in Present System

Figure 3.6 presents the current Information transmission framework where in, first all the information are gathered and are physically adjusted which builds the odds of manual blunders.

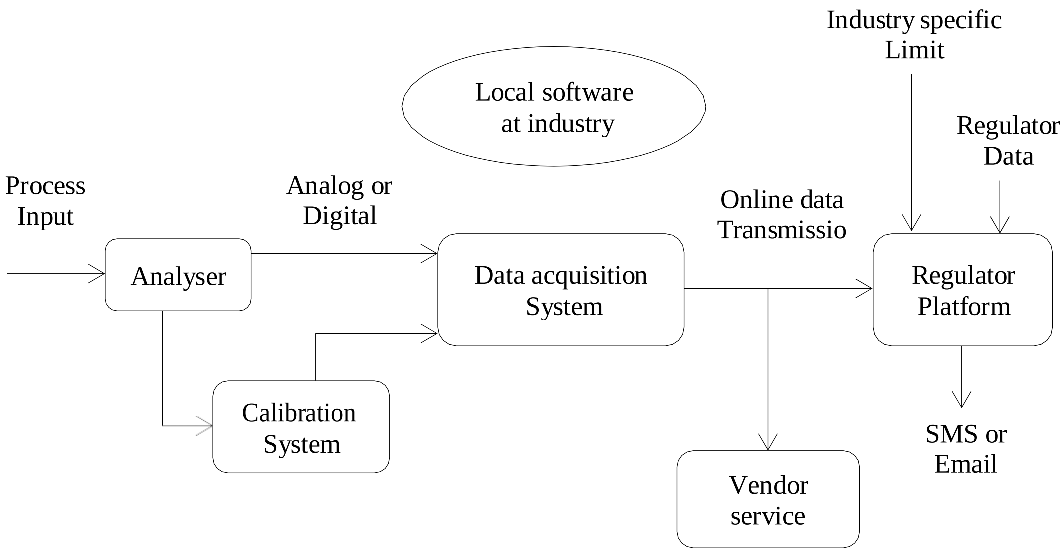

Figure 3.6: Block diagram of the existing Data transmission system

These are then put away in the information securing framework which is available in nearby programming of the business and are physically transmitted through online to the vendors and the administrative authorities such as the Local Contamination Control Board. From here further investigation is carried out. The online transmission will happen properly only if the internet connection is available. If not then that data collected at that particular time will be lost and there is no means of getting them back. The disadvantages of the existing system are:

- Setting Upper Clamp
- Changing Linearization Coefficient
- Changing Analyser Range
- File Based Data Transfer
- Non-Continuous Data

Data Transmission Method Used in our Project

The system in figure 3.7 has the analyser and the calibration system inside a single framework with the goal that no human intercession is permitted and that all the gathered information is adjusted naturally. This information is promptly sent to the cloud through internet to get stored and they can be accessed by the vendors or the authority whenever they need. This information can be accessed to through web access, mobile app or can be shown on the television or the computer.

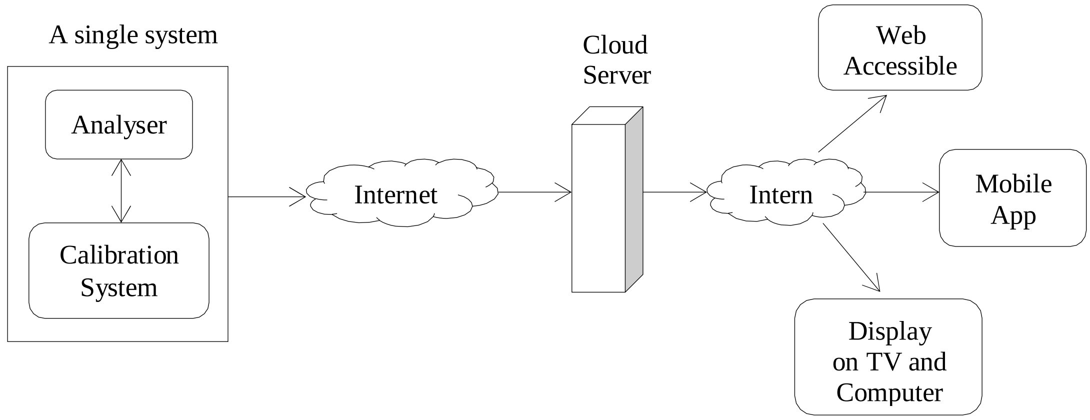

Figure 3.7: Block diagram of the Data transmission system used in our project

Chapter Summary

This chapter includes the complete working flow of our proposed model, here it provides the detailed discretion about the interconnection of various sensors with Arduino UNO and we have advanced features add on to our proposed work. Finally this chapter gives the complete overview of our model.

CHAPTER 4

IMPLEMENTATION of IoT BASED SMART WATER QUALITY MONITORING and FLOW CONTROL SYSTEM

The project requirements are divided into two categories. They are functional and non-functional requirements.

Hardware Requirements

The hardware components those are used for the project are as follows:

- Arduino Uno
- Turbidity Sensor
- PH Sensor
- Temperature Sensor
- Conductivity Sensor
- Water Level Sensor
- WiFi module
- Relay
- Power supply
- LCD
- Filter
- Alarm
- Pump

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 32-bit Arduino Due, based on the Atmel SAM3X8E was introduced in 2012.The boards use single or double-row pins or female headers that facilitate connections for programming and incorporation into other circuits. These may connect with add-on modules termed shields. Multiple and possibly stacked shields may be I/O pins are at the top, the 6 analogy input pins at the lower right, and the power connector at the lower left. Individually addressable via an I²C serial bus. The technical specifications are:

- MicrocontrollerATmega328P
- Operating Voltage:5v
- Input Voltage:7-20v
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins:6
- DC Current per I/O Pin: 20mA
- DC Current for 3.3V Pin: 50mA
- Flash Memory: 32 KB of which 0.5 KB used by boot loader
- SRAM: 2 KB
- EEPROM: 1 KB
- Clock Speed: 16MHz
- Length: 68.6mm
- Width: 53.4mm
- Weight: 25g

The General Pin functions are,

- LED: There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

- VIN: The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.

- 5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack(7-20V), the USB connector(5V), or the VIN pin ofthe board (7-20V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage the board.

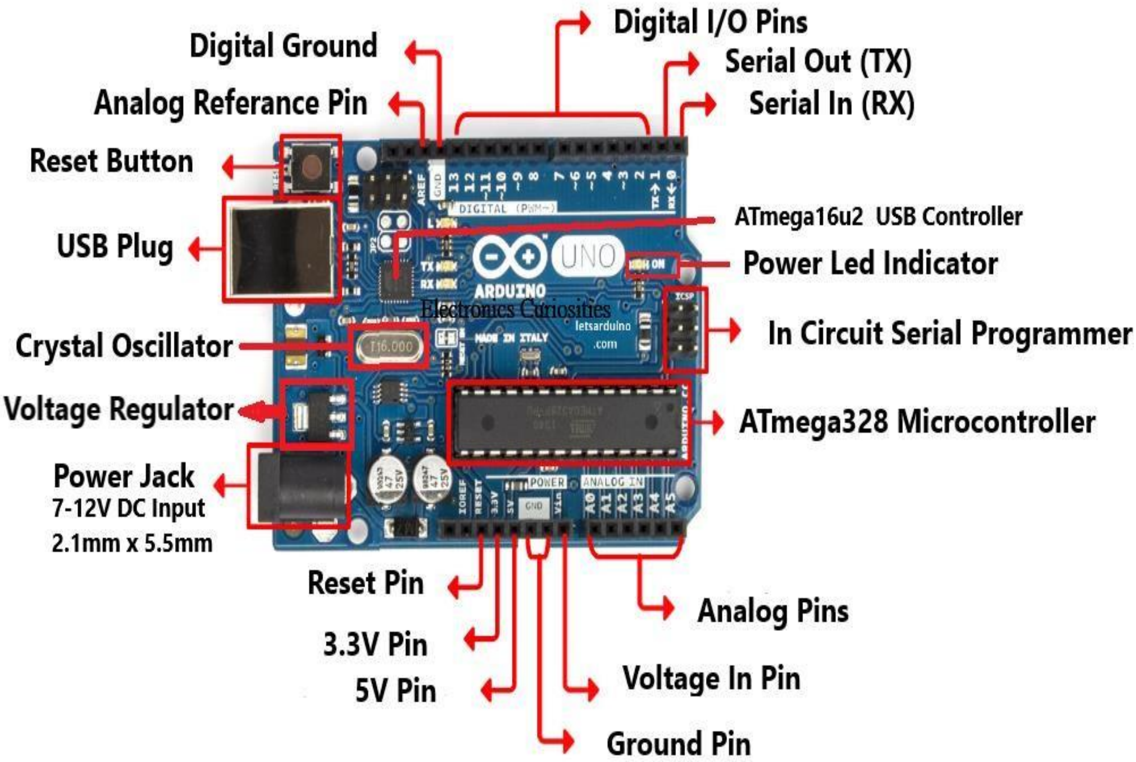

Figure 4.1: Arduino Uno

- **3.3 V and GND:** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50mA. GND: Ground pins.
- **IOREF:** This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or3.3V.
- **RESET:** Typically used to add a reset button to shields which block the one on the board. The Special Pin Functions are,

- Each of the 14 digital pins and 6 Analog pins on the Uno can be used as an input or output, using pin Mode (), digital Write(), and digital Read() functions. They operate at 5 volts. Each pin can provide or receive 20mA as recommended operating condition and has an internal pull-up resistor.
- A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. The Uno has 6 analog inputs, labelled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference function.

In addition, some pins have specialized functions:

- **Serial:** pins 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts:** pins 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- **PWM (Pulse Width Modulation):** 3, 5, 6, 9, 10, and 11 Can provide 8-bit PWM output with the analog Write () function.
- **SPI (Serial Peripheral Interface):** 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.

Turbidity Sensor

Turbidity sensor detects water transparency in case water is not clear due to mud or the solvents present in the water then controller will raise the alarm and stops water to pump. pH sensor is used to detect whether water is acidic or alkaline or neutral and to measure number of solvents or metallic particles dissolved in water conductivity sensor is used when metallic ions are more than conductivity is more .This water is not fit for drinking. Controller will raise the alarm when conductivity is more. It 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.

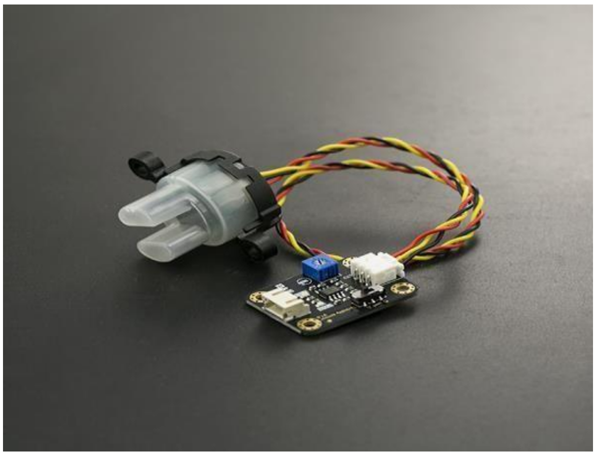

Figure 4.2: Turbidity Sensors

Turbidity sensors are used to measure water quality in rivers and streams, wastewater and effluent measurements, control instrumentation for settling ponds, sediment transport research and laboratory measurements. This liquid sensor provides analog and digital signal output modes. The threshold is adjustable when in digital signal mode. You can select the mode according to your MCU. Measure the amount of light that is scattered by the suspended solids in water. As the amount of total suspended solids (TSS) in water increases, the water's turbidity level (and cloudiness or haziness) increases.

Specification:

- Operating Voltage: 5VDC
- Operating Current: 40mA(MAX)
- Response Time :<500ms
- Insulation Resistance: 100M(Min)

Output Method:

- Analog output:0-4.5V
- Digital Output: High/Low level signal (you can adjust the threshold value by adjusting the potentiometer) Operating Temperature:5℃~90℃
- Storage Temperature:-10℃~90℃
- Weight:30g
- Adapter Dimensions: 38mm*28mm*10mm/1.5inches*1.1inches*0.4inches

pH Sensor

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). For this study the pH sensor will consist of a conventional glass electrode as these electrodes are more reliable and economical for long term monitoring. The glass membrane at the bottom is doped to be ion- selective and is only sensitive to a specific ion (in most cases the hydrogen ion).

Figure 4.3: pH Sensor

The pH electrode acts like a single cell battery and there is a direct correlation between the voltage output of the electrode and the pH of the measured water commonly used for water measurements, is a measure of acidity and alkalinity, or the caustic and base present in a given solution. The pH value is also equal to the negative logarithm of the hydrogen-ion concentration or hydrogen-ion activity. 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 using the Nernst equation and displays the pH as output.

To calculate the pH of an aqueous solution you need to know the concentration of the hydronium ion in moles per liter (molarity). The pH can be calculated using the expression: $pH = -\log[H_3O^+]$ pH is important because substances such as our stomach acids tend to be at a certain pH in order to work properly. pH is also important because it must be at certain levels in order for living organisms to survive. Create a large pH scale (two or three meterslon). The pH of pure water is 7. In general, water with a pH lower than 7 is considered acidic, and with a pH greater than 7 is considered basic. The normal range for pH in surface water systems is 6.5 to

8.5, and the pH range for groundwater systems is between 6 and 8.5.

Table 4.1: pH sensor values

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Acidic						**Neutral**							**Alkaline**

Common pH scale runs from 0 to 14 with 0 being strongly acidic and 14 being strongly alkaline. In the middle of the scale there is neutral 7 which represents ideally pure water. This scale is shown in table 4.1.

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.

Figure 4.4: Temperature Sensor

Operates from 400µA to 5mA at 10 mV/°K. With less than 1-Ω dynamic impedance, the device operates over a current range of 400µA to less than 1-Ω Dynamic Impedance 5mA with virtually no change in performance. When Easily Calibrated at 25°C, the LM135 has typically less than Wide Operating Temperature Range 1°C error over a 100°C temperature range. Unlike other sensors, the LM135 has a linear output. 200° Cover range Low Cost Applications for the LM135 include almost any type of temperature sensing over a −55°C to 150°C temperature range. The low impedance and linear2 Applications output make interfacing to readout or control circuitry Power Supplies are especially easy. Battery Management the LM135 operates over a −55°C to 150°C HVAC temperature range while the LM235 operates over a Appliances −40°C to 125°C temperature range. The LM335 operates from −40°C to 100°C. The LMx35 devices are available packaged in hermetic TO transistor packages while the LM335 is also available in plastic TO-92packages.

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.

Figure 4.5: Water Conductivity sensor

How the Sensor Works: 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. Distilled water has a conductivity ranging from 0.5 to 3µS/cm, while most streams range between 50 to 1500µS/cm. Freshwater streams ideally should have conductivity between 150 to 500 µS/cm to support diverse aquatic life. Water conductivity sensors are 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.

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. Level sensors are used to detect the level of substances that can flow. Such substances include liquids, slurries, granular material and powders. Such measurements can be used to determine the amount of materials within a closed container or the flow of water in open channels. Principle of Water Level Indicator the working principle of a water level indicator is actually quite simple.

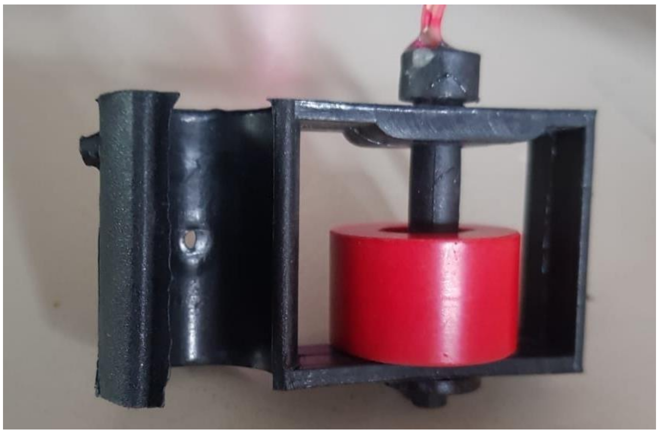

Figure 4.6: Water Level Indicator

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. The water level indicator is defined as a system which gets the information about the water level in reservoirs or in tanks which is used in homes. By using the water level indicator we can overcome the overflow of water from the tankers

ESP8266 Wi-Fi Module

The ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack andmicro-controller capability produced by Shanghai-based Chinese manufacturer. This small module allows micro-controllers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes- style commands. However, at the time there was almost no English-language documentation on the chip and the commands it accepted. The very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation. The ESP8285 is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi. The successor to these micro-controller chips is the ESP32.

Memory:

- 32 KiB instruction RAM
- 32 KiB instruction cache RAM
- 80 KiB user-data RAM
- 16 KiB ETS system-data RAM
- External QSPI flash: up to 16 MiB is supported (512 KiB to 4 MiB typically included).

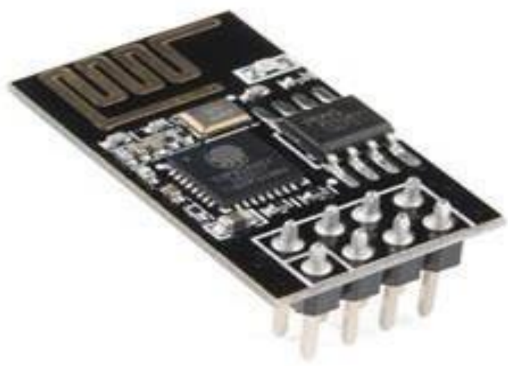

Figure 4.7: ESP8266 Wi-Fi Module

The overview of ESP8266 is listed below:

- **High Durability**

  ESP8266EX is capable of functioning consistently in industrial environments, due to its wide operating temperature range. With highly-integrated on-chip features and minimal external discrete component count, the chip offers reliability, compactness and robustness.

- **Compactness**

  ESP8266EX is integrated with a 32-bit Ten silica processor, standard digital peripheral interfaces, antenna switches, RF balun, power amplifier, low noise receive amplifier, filters and power management modules. All of them are included in one small package, our ESP8266EX.

- **Power-Saving Architecture**

  Engineered for mobile devices, wearable electronics and IoT applications, ESP8266EX achieves low power consumption with a combination of several proprietary technologies. The power-saving architecture features three modes of operation: active mode, sleep mode and deep sleep mode. This allows battery-powered designs to run longer.

- **32-bit Ten silica Processor**

  The ESP8266EX microcontroller integrates a Ten silica L106 32-bit RISC processor, which achieves extra-low power consumption and reaches a maximum clock speed of 160MHz.

The Real-Time Operating System (RTOS) and Wi-Fi stack allow about 80% of the processing power to be available for user application programming and development. The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers. The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community. This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interfaces; it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts. In the Documents section below you will find many resources to aid you in using the ESP8266, even instructions on how to transforming this module into an IoT (Internet of Things) solution.

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.

The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and retransmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations. Relay Driver Circuit is a part of the Fire Detection circuit. It is used to send a signal when it there is sudden variation in the temperature. The sudden change in the temperature may occur due to the fire break out under any circumstances, and under these conditions the fire detection circuit consists of relay drive that enables the transmitter to respond with certain action to the fire caused and also sends a message to the owner and also to the neighbor.

Figure 4.8: Relay

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. The electric power is shut down when a fire accident is reported to the thermistor which in-turn informs the micro-controller about the fire. Now the microcontroller sends a signal back to fire detection circuit which again passes on to the relay driver circuit causing the electrical connection to shut down. By shutting down the electrical connections the further damage that can be caused by fire can be reduced and safety can be ensured through this security system. The relay subsystem is an electrically-operated switch. The relay switches when the signal coming into the driver is high. It must be connected to a transducer driver subsystem. The relay circuit uses a DPDT (double-pole, double-throw) relay. When switched, the centre terminal block is connected to the normally open (NO) upper terminal block. The relay coil is connected between the supply rail and the input signal. This acts as load on the driver. When the input signal coming into the relay subsystem is low, a potential difference across the relay coil causes current to flow. It is this flow of current that causes contacts to switch.

Power Supply

Main building block of any electronic system is the power supply to provide required power for their operation. For the micro-controller, audio amplifier, keyboard, edge connector +5V is required. The power supply provides regulated output voltage of +5V, and non-regulated output voltage +12V. Three terminal IC 7805 meets the requirement of +5V regulated. The secondary voltage from the main transformer is rectified by diodes D1-D4 and is filtered by capacitor C1. This unregulated dc voltage is supplied to input pin of regulator IC. C2 is an input bypass capacitor and C3 is to improve ripple rejection. The IC used are fixed regulator with internal short circuit current limiting and thermal shut down capability. A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from as our ceto the correct voltage, current and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters. Some power supplies are separate standalone pieces of equipment, while others are built into the load appliances that they power.

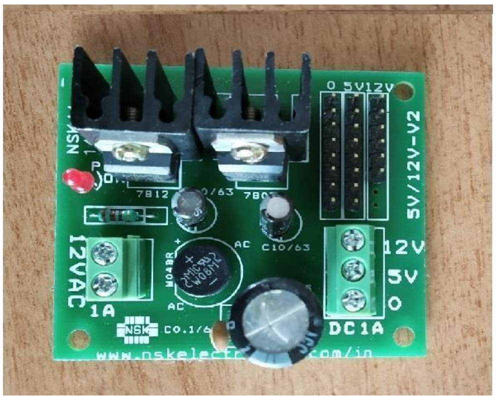

Figure 4.9: Power Supply Board

Other functions that power supplies may perform include limiting the current drawn by the load to safe levels, shutting off the current in the event of an electrical fault, power conditioning to prevent electronic noise or voltage surges on the input from reaching the load, power-factor correction, and storing energy so it can continue to power the load in the event of a temporary interruption in the source power (uninterruptible power supply). Adjustable power supplies allow the output voltage or current to be programmed by mechanical controls (e.g., knobs on the power supply front panel), or by means of a control input, or both. An adjustable regulated power supply is one that is both adjustable and regulated. An isolated power supply has a power output that is electrically independent of its power input; this is in contrast to other power supplies that share a common connection between power input and output.

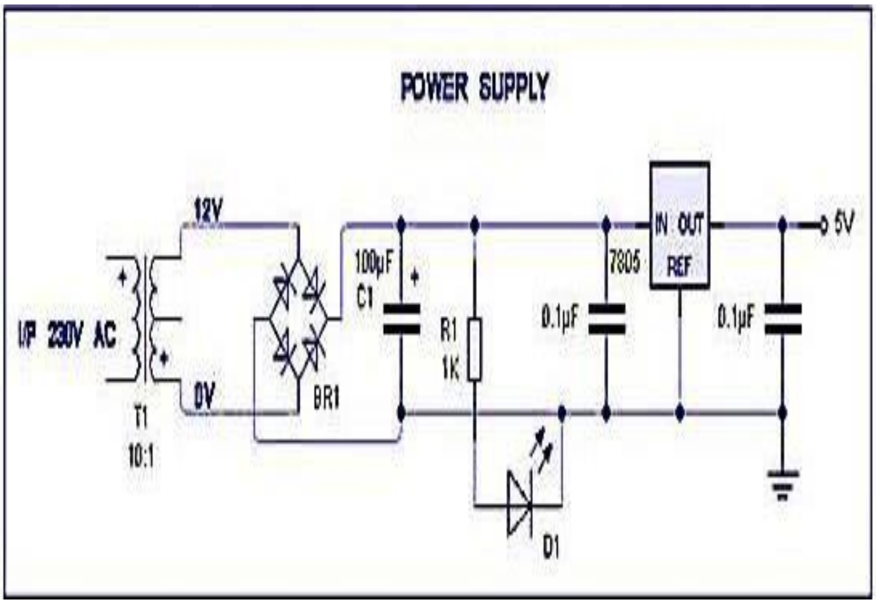

Figure 4.10: Power supply circuit

Power supply required for the micro controller 89C52 is 5 volts. The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. Initially a step down transformer is used to step down the input voltage to be given to the rectifier, which converts A.C voltage to D.C voltage. The transformer produces 12 volts D.C. This is given to the 7805-voltage regulator to produce 5 volts D.C. The voltage ranges of different 78XX series like LM7805C used for 5V.

LCD (Liquid Crystal Display)

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. For an 8 bit bus, the display requires a +5v supply plus 11 I/O lines. For a 4bit data bus it only requires the supply line plus seven extra lines. When the LCD display is not enabled, data lines are in tri-state which means they are in static of high impedance and this means they do not interface with the operation of ARM when the display is not being addressed. The LCD requires 3 control lines from the ARM. The enable line (E) allows access to the display through R/W and RS lines.

Figure 4.11: LCD

When this line is low, the LCD is disabling and ignores signals from R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly. The R/W determines the direction of data between LCD and ARM. When it is low, data is written to the LCD. When it is high, data is read from the LCD. With the help of the register select (RS) line, the LCD interprets the type of data on data lines. When it is low, an instruction is being written to the LCD. When it is high, a character is being written to the LCD. Displays for a small number of individual digits and/or fixed symbols (as in digital watches, pocket calculators etc) can be implemented with independent electrodes for each segment. In contrast full alphanumeric and/or variable graphics displays are usually implemented with pixels arranged as a matrix consisting of electrically connected rows on one side of the LC layer and columns on the other side, which makes it possible to address each pixel at the intersections. The general method of matrix addressing consists of sequentially addressing one side of the matrix. LCDs are more energy efficient and offer safer disposal than CRTs. Its low electrical power consumption enables it to be used in battery-powered electronic equipment. The most flexible ones use an array of small pixels. The earliest discovery leading to the development of LCD technology, the discovery of liquid crystals, dates from 1888. By 2008, worldwide sales of televisions with LCD screens had surpassed the sale of CRT units.

Features of LCD as follows:

- 5×8 and 5×10 dot matrix possible.
- Low power operation support 2.7 to 5.5V.
- Wide range of liquid crystal display driver power.
- Liquid crystal drives waveform.
- A (One line frequency AC waveform).
- Correspond to high speed MPU bus interface.
- 4-bit or 8-bit MPU interface enabled.

- 80 × 8-bit display RAM (80 characters max.).
- Automatic reset circuit that initializes the controller/driver after power on.
- Internal oscillator with external resistors.
- Low power consumption.

RS- Register Select

There are 2 very important registers in LCD

- Command Code register
- Data Register

If RS=0: Instruction command Code register is selected, allowing user to send command
If RS=1: Data register is selected allowing to send data that has to be displayed.

R\W- Read\Write

R\W input allows the user to write information to LCD or read information from it. How do we read data from LCD? The data that is being currently displayed will be stored in a buffer memory DDRAM. This data could be read if necessary.
If R\W=1: Reading
If R\W=0: Writing

E- Enable

The enable Pin is used by the LCD to latch information at its data pins. When data is supplied to data pins, a high to low pulse must be applied to this pin in order for the LCD to latch the data present in the data pins.

Pin Description:

16×2 LCD is a 32 digits display screen for all kinds of CMOS/TTL devices. In Liquid crystal display 16×2, there are 2 rows and 16 columns. Besides, 5×8 pixel makes a single digit. Any digit from ASCII code is viewable on the module. This display module has too much use in most of the commercial projects and there is almost a library in every programming language about it. The premade libraries made it easy to interface with other devices. Table 4.2 explains the pins of LED.

Table 4.2: LCD pin description

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when High	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

Pin Diagram:

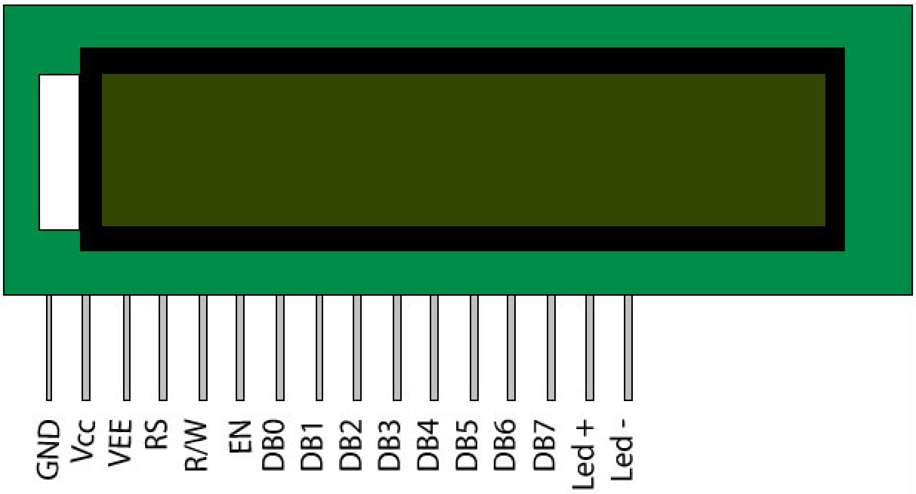

Figure 4.12: LCD pin description

There are two sections pins on the whole 16×2 LCD module. Some of them are data pins and some are command pin. Somehow, every pin has a role in controlling a single pixel on the display. Additionally, all the input/output pins of this module are shown in the above pinout diagram.

Sediment 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

Software Requirements

The software components those are used for the project are as follows:

- Arduino IDE
- Embedded C
- Thing Speak Cloud

Arduino Ide

The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It originated from the IDE for the languages Processing and Wiring.

Figure 4.13: Arduino IDE

It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program argued to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

- Sketch: A program written with the Arduino IDE is called a sketch. Sketches are saved on the development computer as text files with the file extension. Arduino Software (IDE) pre-1.0 saved sketches with the extension.
- Minimal Arduino C/C++ programs consist of only two functions.
- Setup (): This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.
- Loop (): After setup () has been called, function loop () is executed repeatedly in the main pro- gram. It controls the board until the board is powered off or is reset
- Library: The open-source nature of the Arduino project has facilitated the publication of many free software libraries that other developers use to augment their projects.

Importance of Arduino: Inexpensive Arduino boards are relatively inexpensive compared to other micro-controller plat-forms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than $50 Cross-platform The Arduino Software (IDE) runs on Windows, Macintosh OSX, and Linux operating systems. Most micro-controller systems are limited to Windows. Simple, clear programming environment The Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with how the Arduino IDE works. Open source and extensible software - The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based.

Embedded C

During infancy years of microprocessor based systems, programs were developed using assemblers and fused into the EPROMs. There used to be no mechanism to find what the program was doing. LEDs, switches, etc. were used to check correct execution of the program. Some ‘very fortunate’ developers had In-circuit Simulators (ICEs), but they were too costly and were not quite reliable as well. As time progressed, use of microprocessor-specific assembly-only as the programming language reduced and embedded systems moved onto C as the embedded programming language of choice. C is the most widely used programming language for embedded processors/controllers. Assembly is also used but mainly to implement those portions of the code where very high timing accuracy, code size efficiency, etc. are prime requirements. Initially C was developed by Kernighan and Ritchie to fit into the space of 8K and to write (portable) operating systems. Originally it was implemented on UNIX operating systems. As it was intended for operating systems development, it can manipulate memory addresses. Also, it allowed programmers to write very compact codes. This has given it the reputation as the language of choice for hackers too. As assembly language programs are specific to a processor, assembly language didn’t offer portability across systems. To overcome this disadvantage, several high level languages, including C, came up. Some other languages like PLM, Modula-2, Pascal, etc. also came but couldn’t find wide acceptance. Amongst those, C got wide acceptance for not only embedded systems, but also for desktop applications. Even though C might have lost its sheen as mainstream language for general purpose applications, it still is having a strong-hold in embedded programming. Due to the wide acceptance of C in the embedded systems, various kinds of support tools like compilers & cross-compilers, ICE, etc. came up and all this facilitated development of embedded systems using C.

The characteristics are:

- Register Definitions, Initialization and Startup Code – C is a high level programming language that is portable across many hardware architectures. This means that architecture specific features such as register definitions, initialization and startup code must be made available to your program via the use of libraries and include files.
- Basic C program structure – all the programs you will write will have this basic structure. All variables must be declared at the start of a code block.
- Programming memory models The keil C compiler has two main C programming memory models, SMALL and LARGE which are related to this two types of memory. In the SMALL memory model the default storage location is the bytes of internal memory while in the LARGE memory model the default storage location is the externally addressed memory.
- Special function registers –. The value in the declaration specifies the memory location of the register. Extensions of the LPC2148 often have the low byte of a bit register preceding the high byte. In this scenario it is possible to declare a bit special function register, SFR, giving the addresses of the low byte the memory location of the register used in the declaration must be a constant rather that a variable are expression.
- Memory model used for a function – The memory model used for a function can override the default memory model with the use of the small, compact are large keywords.

Features of Embedded Programming

- Code Speed
  Code speed is governed by the processing power, timing constraints.
- Code Size
  Code size is governed by available program memory and use of programming language. Goal of embedded system programming is to get maximum features in minimum space and minimum time.

Embedded systems are programmed using different type of Languages

- Machine Code.
- Low level language, i.e., assembly.

- High level language like C, C++, Java, Ada etc.
- Application level language like Visual Basic, scripts, Access, etc.

Assembly language maps mnemonic words with the binary machine codes that the processor uses to code the instructions. Assembly language seems to be an obvious choice for programming embedded devices.

ThingSpeak Cloud

Thing Speak is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud Thing Speak is often used for prototyping and proof of concept IoT systems that require analytics. Thing Speak is an open data platform for the Internet of Things. Your device or application can communicate with Thing Speak using a REST ful API, and you can either keep your data private, or make it public. In addition, use ThingSpeak to analyze and act on your data. Thing Speak is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. Thing Speak provides instant visualizations of data posted by your devices to Thing Speak. Thing Speak is often used for prototyping and proof of concept IoT systems that require analytics. Thing Speak server is an open data platform and API for the Internet of Things that enables you to collect, store, analyze, visualize, and act on data from sensors.

Procedure to get the data from Thing speaks:

- On the ThingSpeak.com website, select Channels > My Channels.
- Under the channel that you created for this target hardware, click Settings.
- Click the API Keys tab.
- Copy the key from Read API Key parameter.
- Open the Thing Speak Read block in your model and paste the copied API key into the Read API key parameter.

Chapter Summary

This chapter provides the list of Hardware and software components which is required for our proposed model. Then we have provided the functionality and description of each components which have been used, further we have listed the outcomes that are obtained from our proposed work.

CHAPTER 5

RESULTS AND DISCUSSIONS

Five parameters namely conductivity, pH, turbidity, temperature and water level are measured using the experimental setup. The setup is connected to the cloud platform to analyse the data in graphical format.

Results

The final integration and the obtained results are shown through various images and values collected during the testing of the system. Figure 5.1 shows complete connection of our project interfacing the different sensors and the Wi-Fi module and the LCD.

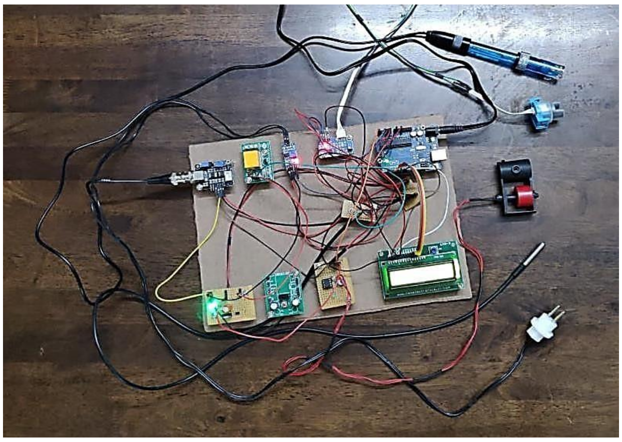

Figure 5.1: Interfacing all the sensors with Arduino UNO

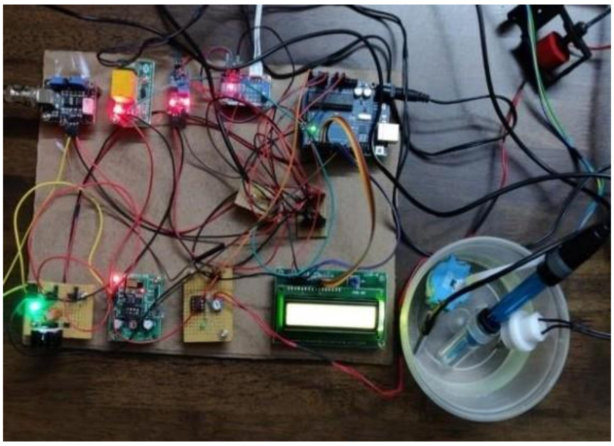

Figure 5.2: Sensor framework has been turned on

Figure 5.2 represents the components such as water level sensor, pH sensor, turbidity sensor, conductivity sensor, and Wi-Fi module are turned on and pH, water conductivity, turbidity are dipped in water.

Table 5.1: Range for all sensors used

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

The table 5.1 shows the safe and acceptable range of the turbidity sensor, pH sensor, conductivity sensor and temperature sensor according to the WHO standards.

Figure 5.3: LCD displaying the project title

Figure 5.4: LCD displaying the status of Wi-Fi connectivity

After all the connections are done and after the power supply is given, the LCD starts to display a few messages. Figure 5.3 shows the title of our project as soon as the system is turned on. Figure 5.4 we can see WiFi module getting initiated.

Figure 5.5: LCD displaying that the system is connected to the W-Fi

Figure 5.6: LCD displaying the values of various components

Figure 5.5 shows that the WiFi is connected that is the arduino board gets connected to the registered WiFi through the WiFi module. And figure 5.6 displays all the water parameter being measured such as temperature, pH, turbidity, conductivity and the level of water present on the tank.

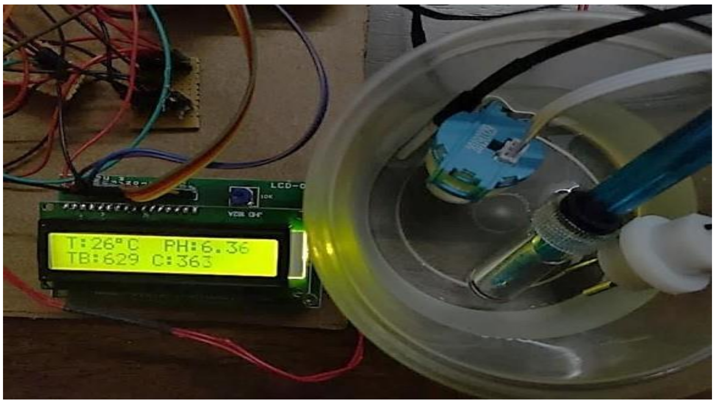

Figure 5.7: LCD displaying the different parameter values of drinking water

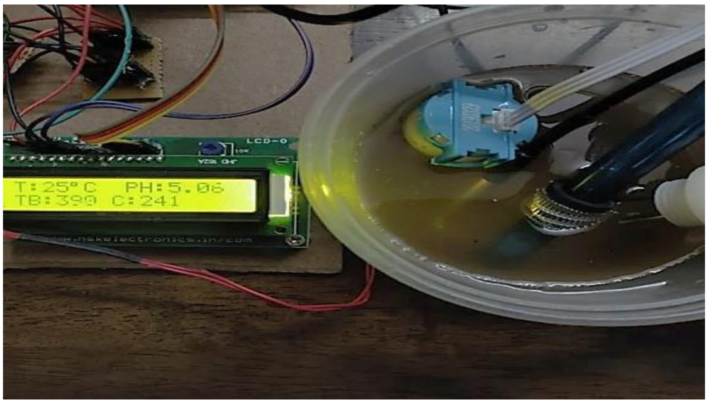

Figure 5.8: LCD displaying the different parameter values of mud water

In Figure 5.7 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. In Figure 5.8 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.

Table 5.2: The values of different parameters as observed for different water samples different parameters as observed for different water samples

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

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 5.2.

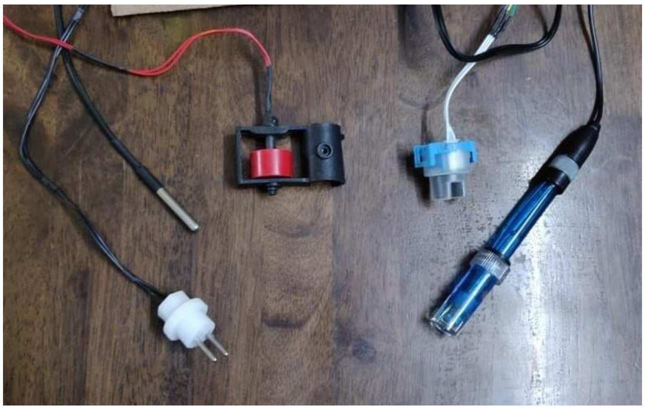

Figure 5.9: All sensors used

Figure 5.9 shows the sensors which we have used in our project that are, (from left) the conductivity sensor, temperature sensor, water level sensor, turbidity sensor and the pH sensor.

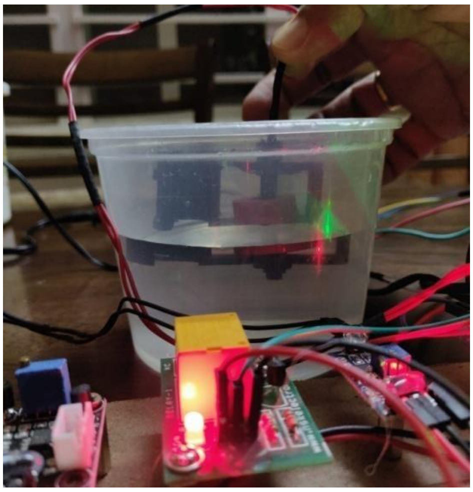

Figure 5.10: LED of the pump is turned-on when the water level sensor is down

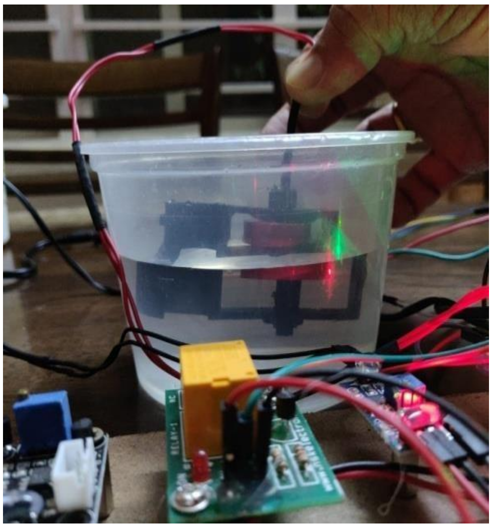

Figure 5.11: LED of the pump is turned-off when the water level sensor is up

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 5.10. 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 5.11.

Figure 5.12: Graphs for different sensor values

The above Figure 5.12 is 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 analyze. These real-time values can be accessed by the pollution control board and the other authorities from any other location.

Advantages and Disadvantages

The advantages and limitations or drawbacks of this project are mentioned below. And these drawbacks can be overcome while doing the future advancements according to the requirements.

Advantages

- Gives real time access to data.
- Cost efficient and easily portable.
- Can be implemented in all water purifiers and water monitoring systems.
- It can be applied industries like pharmaceutical, milk and food industry.
- To monitor river water and other water bodies.
- Data are secure as there is no human intervention after measuring the data.
- Needed in rapidly changing systems as this project is flexible to fit any type of need.

Disadvantages

- Corrosion might occur on the hardware components or sensors due to environmental factors.
- Setting the ideal value for the turbidity sensor is difficult as the sensor requires a complete dark environment to measure accurate values.

Chapter Summary

This chapter describes the overall results obtained from our working model. And then we have provided the detailed description of each stage. And it also defines the interaction between cloud and Arduino UNO.

CHAPTER 6

CONCLUSION AND FUTURE SCOPE

Conclusion

Consecutive follow up of water contamination status in remote area can be accomplished by checking the nature of water and gathering exhaustive information. This framework gives exhaustive assessment of water condition as well as can rapidly find earnest water contamination mishaps or catastrophic events, moving the irregular water quality data to checking focus by faster correspondence arrange and give graphical references to the dynamic office to fathom the status of the water. The report contains the details of the sensors and microcontrollers in the beginning after the description of the flow chart of the Water Quality Measuring Station (WQMS) followed by the circuit design and the specifications. This project clarifies the process of measurement of PH, Turbidity, conductivity, water level and Temperature measurement of water. This project also has the overall information about the hardware and software needed for the device to be ready. This project will be helpful for the future references for measuring pH, turbidity and temperature of water. These devices are low cost, more efficient and capable of processing, analysing, sending and viewing the data on cloud and also through WI-FI to mobile device. This can implement is suitable for environment monitoring, ecosystem monitoring, etc. and the data can be viewed anywhere in the world.

Future Scope

The future extension of the present work is immense. There is scope for improvement in this project based on the advancement in technology.

- The future extent of this project is to check the natural conditions, drinking water quality, treatment and sterilization of waste water and so forth. This framework could likewise be actualized in different mechanical procedures. The framework can be adjusted by the requirements of the client and can be actualized alongside lab view to screen information on PCs.
- Identifying the more parameters for most secure reason and increment the parameters by expansion of different sensors. By interfacing transfer we can control the stockpile of water.

- In future, it very well may be executed to screen the nature of water in family unit as well as for the entire city or a town or a dam, from where the water supply happens.
- With blend of different sensors, crossover quality checking frameworks can be structured sooner rather than later for the entire city or town.
- In the future, we plan to implement biological parameter of the water and install the system in several location of pond and also in water distribution network to collect water quality data and send to water board.

All these ideas can be implemented in the future to enhance the working of the project.

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IoT based Smart Water Quality Monitoring and Flow Control System

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***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.

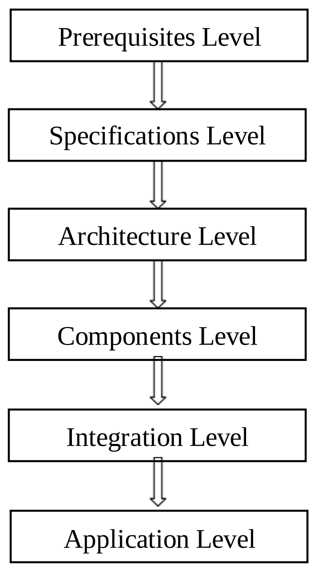

Figure 1: Sequence of flow of the proposed system

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.

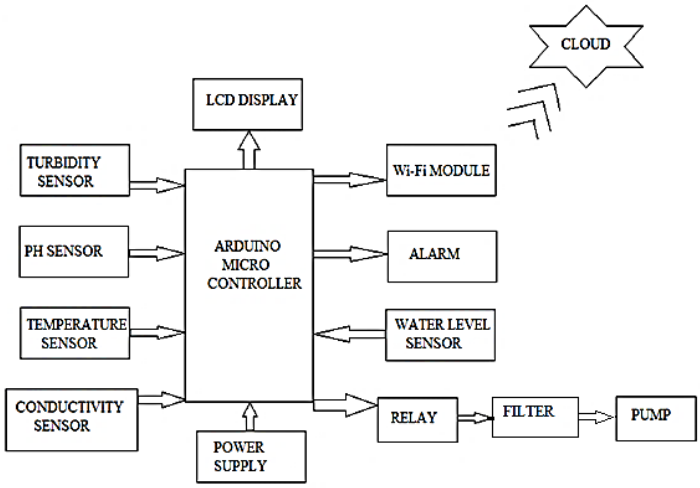

Figure 2: Block diagram of the proposed system

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

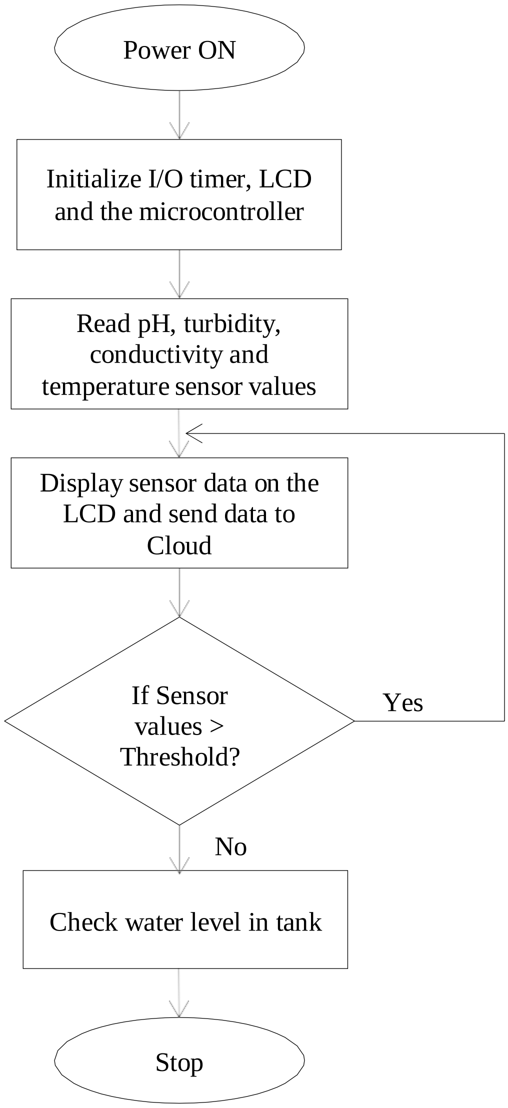

Figure 3: Flowchart for the interfacing of sensors

- 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

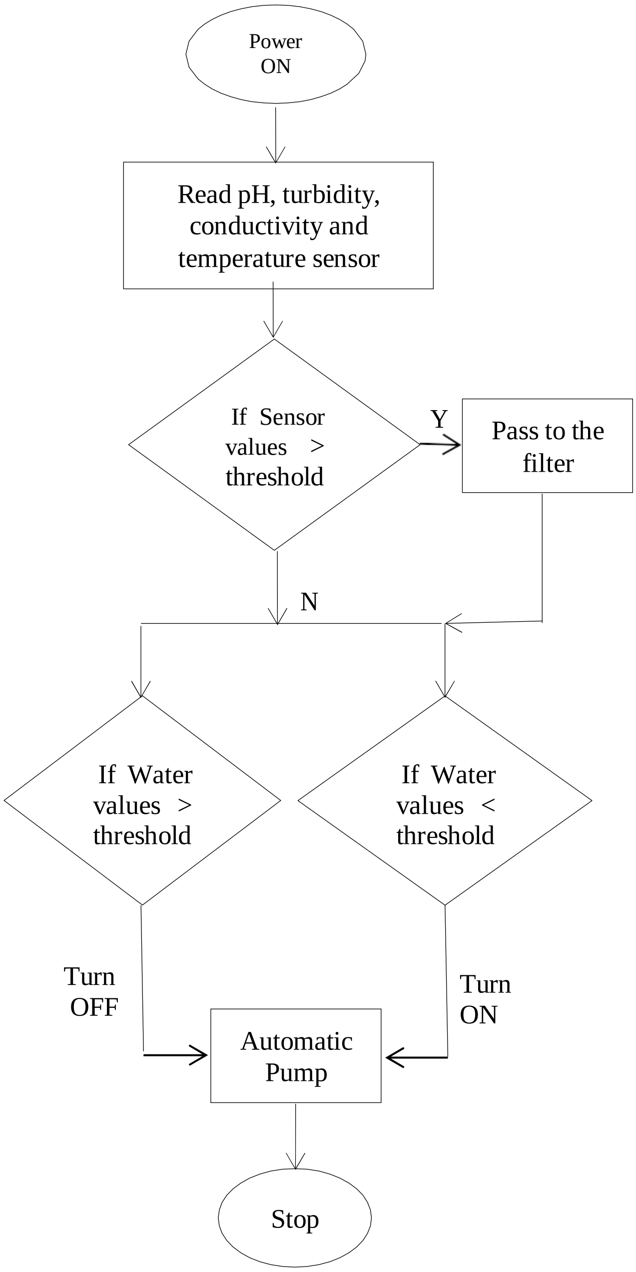

Figure 4: Flowchart for the operation of automatic pump

- 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

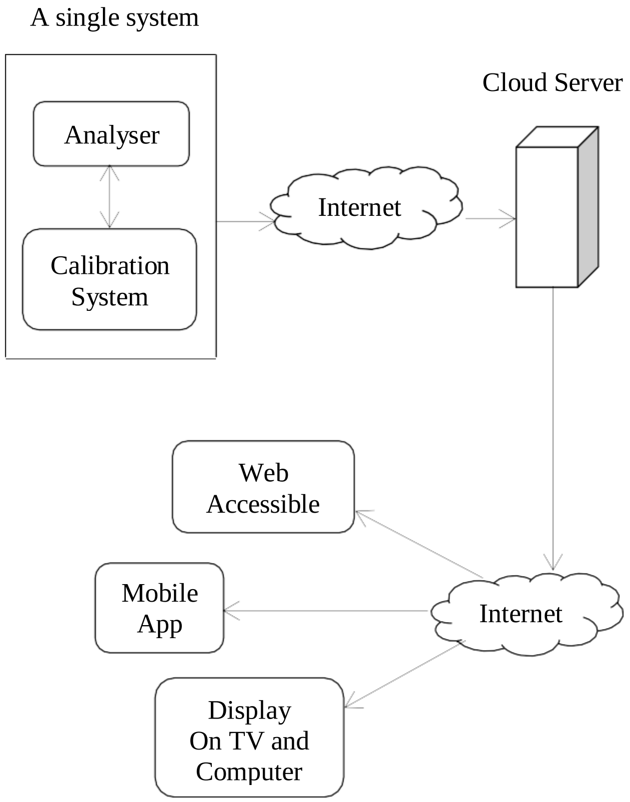

Figure 5: Flowchart of the process of sending data from Arduino UNO to the Cloud

- 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.

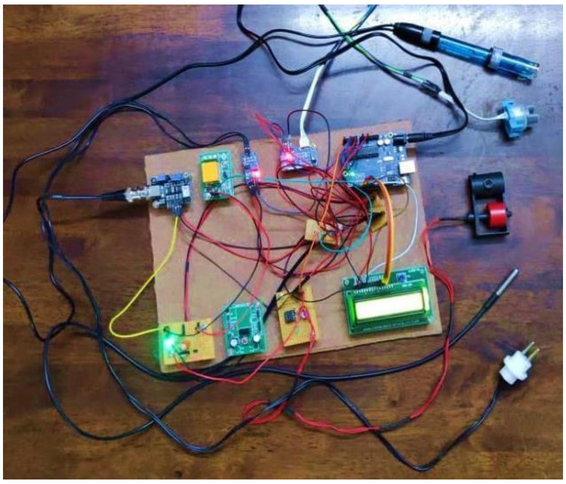

Figure 6: Interfacing all the sensors with the microcontroller

Figure 7: LCD displaying the project title

Figure 8: LCD displaying the Wi-Fi status

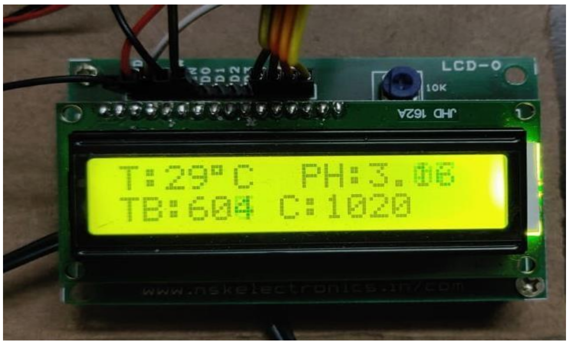

Figure 9: LCD displaying the different parameters measured by the sensors

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.

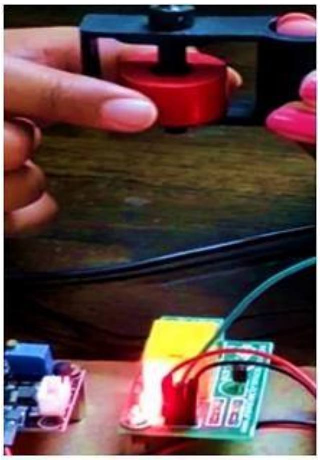

Figure 10: LED is on indicating that the pump is turned on as the water level sensor is down

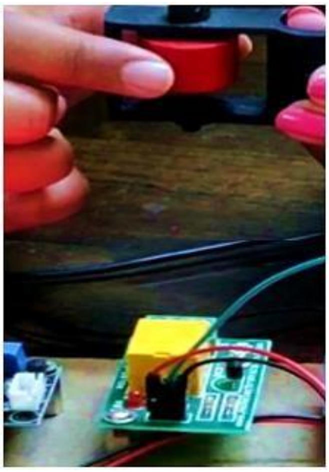

Figure 11: LED is off indicating that the pump is turned off as the water level sensor rises up

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

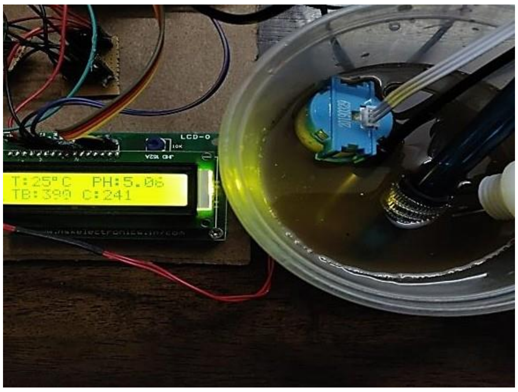

Figure 13: LCD displaying the different parameter values of mud water

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.

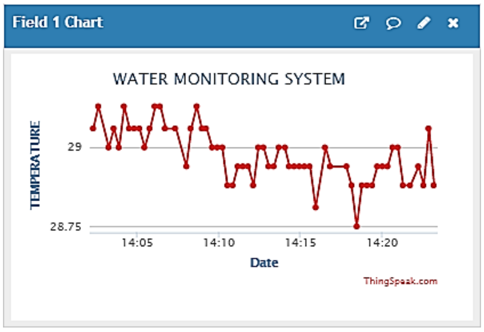

Figure 14: Graphical representation of temperature

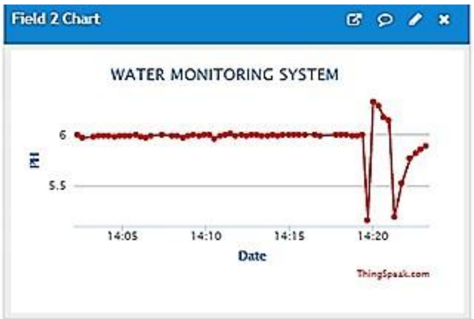

Figure 15: Graphical representation of pH

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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