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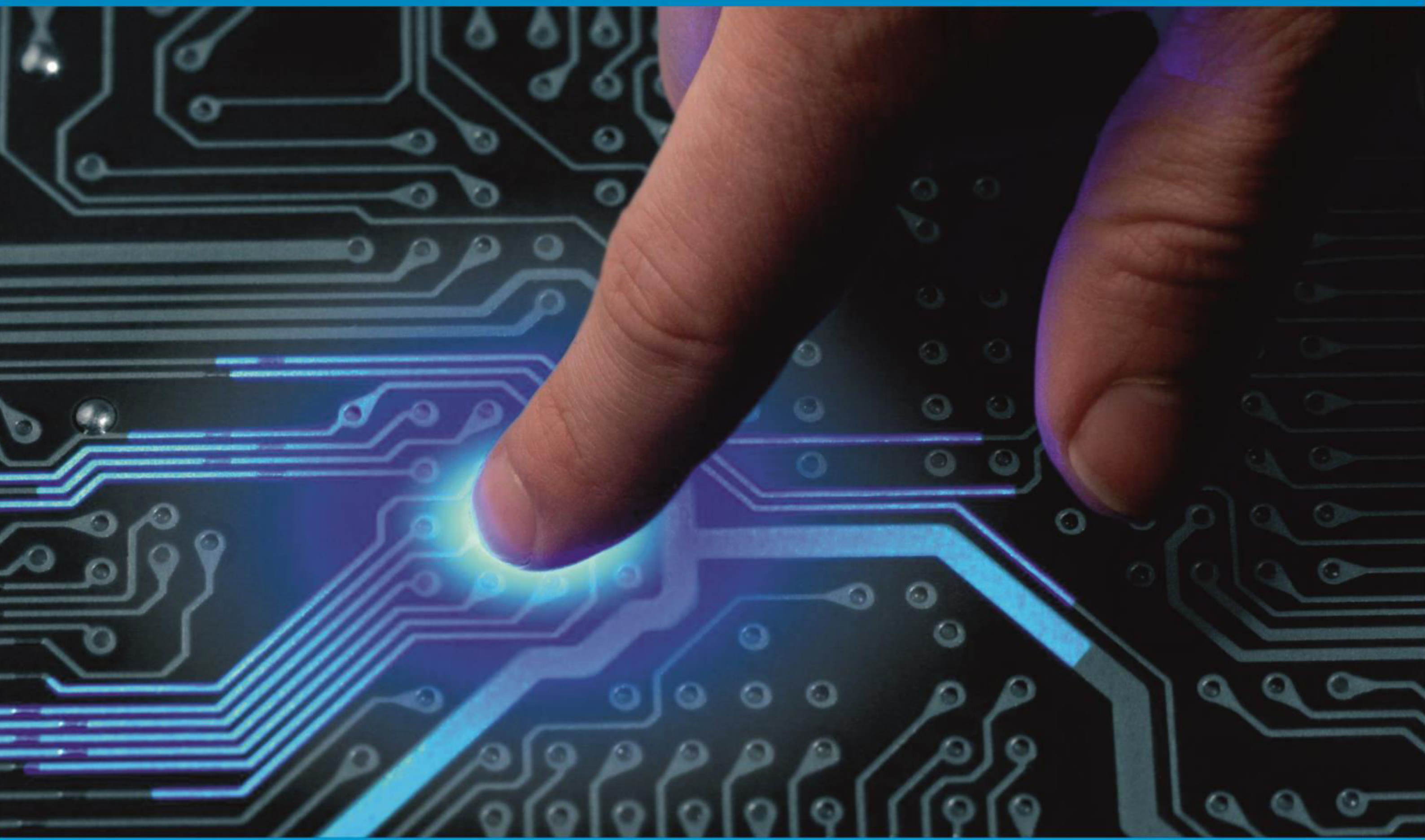

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Portable Water Quality Testing

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ABSTRACT: The increase in the human activity over the past century is having a devastating impact on our environment, directly resulting in a cost to human health. To ensure environmental sustainability, it is important to have effective monitoring systems. Environmental monitoring systems have been developed for monitoring air quality, water quality, animal tracking and earthquake monitoring. Water Quality Monitoring (WQM) is of particular importance in environmental monitoring. Although water is abundant on earth, only 2.5% of the available water is fresh water, and approximately 20% of the world's population does not have access to safe drinking water. As a result, observing and detecting pollutants in water is vital. The parameters that are analysed in this project are pH, Turbidity and Temperature. The main advantage of this project is integration of all the parameters to a single portable embedded system which saves time and money. This water quality testing device is easy to handle and portable which make it more advantageous than the normal laboratory testing.

KEYWORDS: Smart, Portable, Quality Testing, Alert

I. INTRODUCTION

Clean water is one of the most essential 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 urban homes and water sources available in more remote areas, is not necessarily safe for consumption. Environment is disturbed everyday due to the unpredictable weather changes, many areas affected by flood and soil erosion which make the water ponderous.

Water quality monitoring can be achieved through physiochemical measurements as well as microbial measurements. Physiochemical parameters include electrical conductivity, pH, oxidation reduction potential (ORP), turbidity, temperature, chlorine content and flow. These parameters can be analyzed 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 proven that water parameters are affected by impurities in specific ways and can be detected and monitored using appropriate water quality sensors. In this project we present a water quality testing device which is more effective, affordable and portable. The water gets polluted and cannot be used by the people after massive disasters such as the floods. In this project various parameters regarding the water quality of the sample taken is analyzed. The main objective of this project is the integration of all the sensors to measure the parameters present in water to a single portable device which saves time and money. To compute the physical and chemical parameters of the water such as temperature, pH and turbidity several sensors were used. The centralized system receives the measured values. Through the Wi-Fi system, the sensor output data is sent to the observer using IoT. The developed water quality monitoring system consists of microcontroller, some simple sensors as well as a display unit which is very useful for detecting the appropriate pH, temperature, and turbidity of water. In addition, the implemented system is highly proficient, cost effective and consequently, the accuracy of the measuring device is in a convenient level.

II. RELATED WORK

The available water resources are getting exhausted and water quality is degraded due to the rapid increase in population and need to meet demands of human beings for industrial, agriculture, and personal use. The quality of

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ground water is also affected by insecticides and pesticides. The rivers in India are getting contaminated due to industrial waste and discharge of untreated sewage.

A microcontroller based water quality observance system with high degree of accuracy and likely to find parameters like temperature, muddiness and potential of gas (pH). In this project based analysis work, a simple microcontroller is employed as central process unit (CPU) and multiple sensors that observe varied parameters and send the information to microcontroller and eventually display provides the results. [1]

With a similar concept, work that has been done on the design and development of a water quality monitoring system, with the target of notifying the user about the real-time water quality parameters. The system is in a position to live physiochemical parameters of water quality. The sensors are connected to a microcontroller-based measuring node, which processes and analyses the data. The notification node shows the reading of the sensors and also it outputs an audio alert when the water quality parameters reach unsafe levels. The measurement node is in a position to transmit data via ZigBee to the notification node for audio and visual display. [2]

In this work a distributed system for measuring water quality is designed and implemented. The sensors are connected to field point, where the data is sent using a GSM network to land based station. The aim of the study is to process the sensor data using kohenen maps. [3]

The water monitoring system analyses and processes water quality parameters (pH, conductivity, dissolved oxygen and temperature), and also sounds an alarm when there's a water contamination, or change in water quality. The parameters are measured with off- the shelf sensors and data is sent to a base station via GPRS (general packet radio service). [4]

This work describes a low-cost turbidity sensor design for continuous on-line water quality monitoring applications. The measurement of turbidity by agricultural and environmental scientists is restricted by the present cost and functionality of obtainable commercial instruments. The proposed design is capable of measuring turbidity within the range of 0-1000 Nephelometric Turbidity Unit (NTU) with improved accuracy and robustness since it uses an 850-nm infrared LED, and dual orthogonal photo detectors. [5]

Another work projected a water quality measuring system; it consists with information communication unit, numerous sensors for water quality testing, data acquisition module with single chip microcontroller unit, monitoring center. Water quality is detected without human intervention under the control of single chip microcontroller using various parameters. [6]

III. SYSTEM IMPLEMENTATION

A. *Methodology:*

The Internet of things (IoT) is a system of reticulated computing devices, mechanical and digital machines having unique identifiers (UIDs) and the ability to transfer information over a network without requiring human-to-human or human-to-computer interaction. The definition of the Internet of things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Smart solutions for water quality monitoring have growing importance with advancement in communication technology. Also, a power efficient, simpler solution for water quality monitoring based on Internet of Things technology is conferred.

The model developed is employed for testing water samples and therefore the information uploaded over the Internet are analyzed. The system conjointly provides an alert to a remote user, once there is a deviation of water quality parameters from the pre-defined set of standard values. This is a low cost, less complex smart water quality monitoring system using a controller with inbuilt Wi-Fi module to monitor parameters such as pH, turbidity and temperature.

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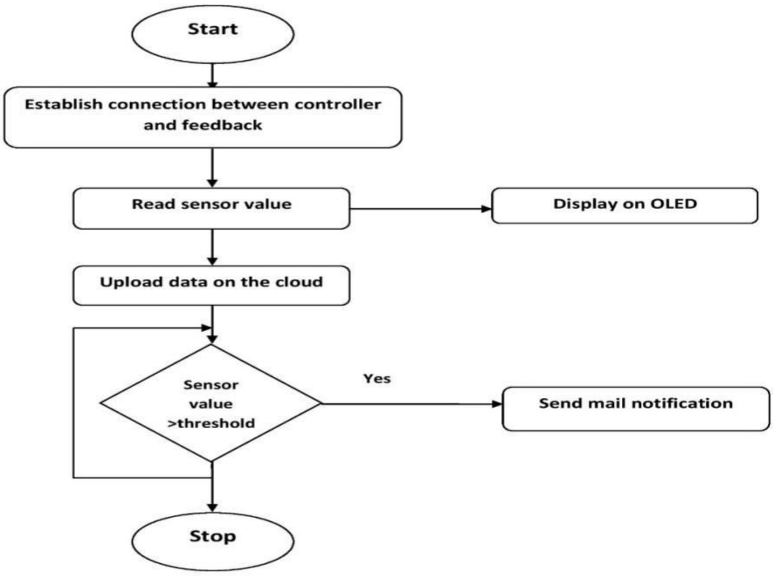

Fig. 1 Flow chart representing methodology

ThingSpeak

ThingSpeak software permits the Authorized users to access the measured data by logging on as shown in Fig. 2. By providing the registered user ID and password, the parameters are displayed in real-time in the form of graphical representation. ThingSpeak is an open-source Internet of Things application and API to store and retrieve information from things with the help of the HTTP protocol over the Internet or via a Local Area Network. It permits the creation of , location tracking applications, sensor logging applications, and a social network of things with status updates.

Getting started with ThingSpeak:

- Sign up to create a new account in ThingSpeak and create a new channel to store the data from sensors.
- Sending Status to the cloud where we have our cloudservice available and sensors capturing data locally.
- Next we design the user interface. First print screen show the visible and invisible elements.

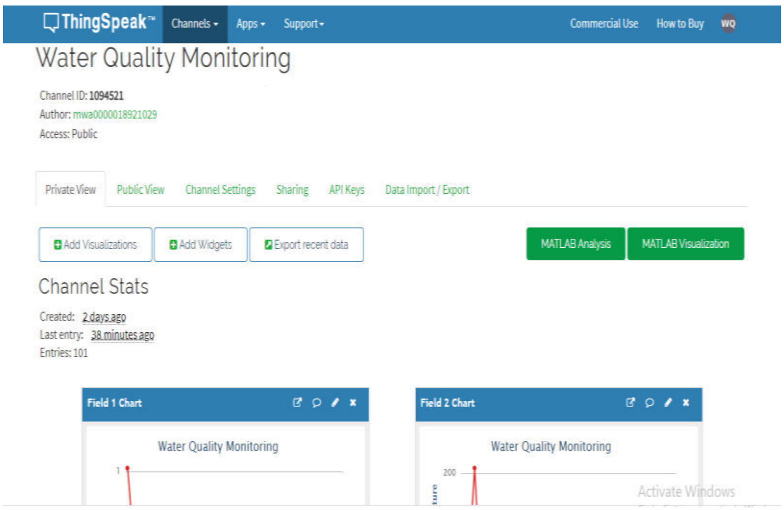

Fig.2 ThingSpeak page

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B. *Block Diagram and Description:*

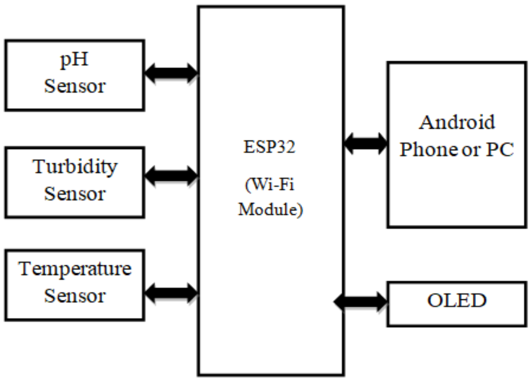

Fig. 3 Block Diagram

a) *pH Sensor*: The pH scale is logarithmic and the value goes from 0 to 14. It is low for acidic and high for alkaline solutions. The pH of natural water is approximately 7. pH 0 is an indication of strong acid whereas pH 14 is an indication of strong base.
b) *Turbidity Sensor*: It has the ability to detect the pendant particles in the water.If the sample has a high turbidity the amount of light from the laser that reaches the sensor will be lower. So, the LDR sensor measures the change in light intensity that shines on the sensor. It proves that clean water contains low turbidity.
c) *Temperature Sensor*: The DS18B20 waterproof stainless-steel Temperature detector may be a pre-wired and rainproof version of the DS18B20 detector. Its distinctive 1-wire interface makes it straightforward to speak with devices. It will convert temperature to a 12-bit digital word in 750ms (max).
d) Wi-Fi Module- ESP32: ESP32 could be a series of affordable, low power system on Chip microcontrollers with integrated Wi-Fi and dual mode Bluetooth. ESP32 has Xtensa Dual Core 32-bit LX6 microprocessors, that runs up to 600 DMIPS. The ESP32 can run on jailbreak boards and modules from 160 MHz upto 240 MHz.
e) SSD 1306 OLED Display: SSD 1306 could be a single-chip CMOS OLED/PLED driver with controller for organic/ chemical compound light weight emitting diode dot-matrix graphic show system. It consists of 128 segments and 64 commons.

C. *Circuit Explanatin*

pH indicates the samples acidity but is actually a measurement of the potential activity of the Hydrogen ions (H+) in the sample. Before setting up the circuit, the pH probe must be activated. The activation is done by dipping the probe in 0.1 Molar HCl for about 2-3 hours. Soon after the probe is activated the probe must be calibrated. This pH sensor has been calibrated by the manufacturers at 24 degree centigrade room temperature.The pH sensor circuit consists of the pH sensor module, a glass electrode (probe), ESP32, and 9V battery. The pH sensor module is powered by using a 9V battery. The module has a +ve and –ve pins in it. The +ve pin of the module is connected to the analog pin of the ESP32 whereas the –ve pin of the module is connected to the ground of the. The glass electrode is connected to the pH sensor module. For the output to be displayed, an OLED display is used. The OLED display is interfaced with the pH sensor circuit.

A waterproof probe, DS18B20 is used to measure temperature. It measures temperature from -55 degree C to 125 Degree C. It has 0.5°C accuracy from -10°C to +85°C. It has a programmable resolution from 9 Bits to 12 Bits. It does not require any external components. Its unique one wire interface requires only one port for communication. The connections are fairly simple. Start by connecting Red stripe to 5V, Black connects to ground and Yellow Stripe is data that goes to analog pin of ESP32. Then place a 4.7k pull-up resistor between the data and 5V to keep the data transfer stable. Place the DS18B20 the right way around. If you put it the wrong way around, it will get hot and then break.

The turbidity sensor output is obtained in range of brightness. This value is converted to percentage of brightness. Clearer the water, smaller will be the percentage of brightness. One end of the LDR is connected to the 3.3V port in the ESP32, whereas the other end is connected to a 4.7k resistor connected to the ground. The junction between the resistor and LDR is connected to the analog pin.

The setup is quite simple. The setup is placed in a box. The box will prevent the light from the surrounding which will be shining on the LDR sensor, so that the measurements will be more accurate. A laser beam is passed through the sample. A sample is placed in a small glass between the laser and the sensor. Depending on the glass used, the laser bends by the angle of the glass. The use of a glass with straight walls will prevent this. The whole setup is placed in a 3D printed holder with laser in one side and the LDR at the other. This ensures that the circuit becomes uninterrupted

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and the value obtained is precise. The turbidity range is calculated every second. The average of all the values at the end of 20 seconds is updated to the ThingSpeak field. Thus a precise and accurate value is obtained The user gets notified through an Email directly from the ThingSpeak account using IFTTT platform. The ThingSpeak values are mailed to the users for further use. Thus this system can be the best alternative to the conventional laboratory testing of water. The system can further be improved for other applications also.

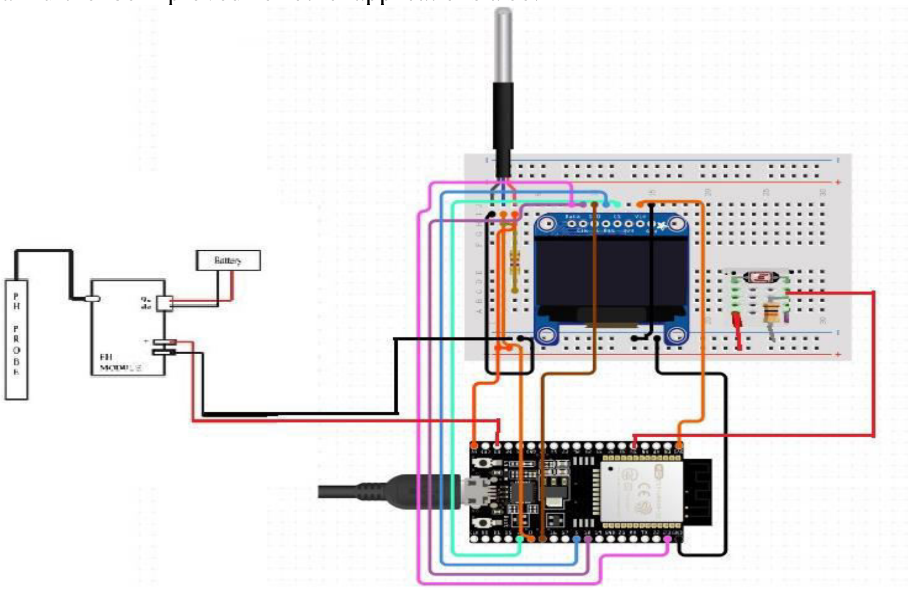

Fig. 4 Complete Circuit Diagram of the System

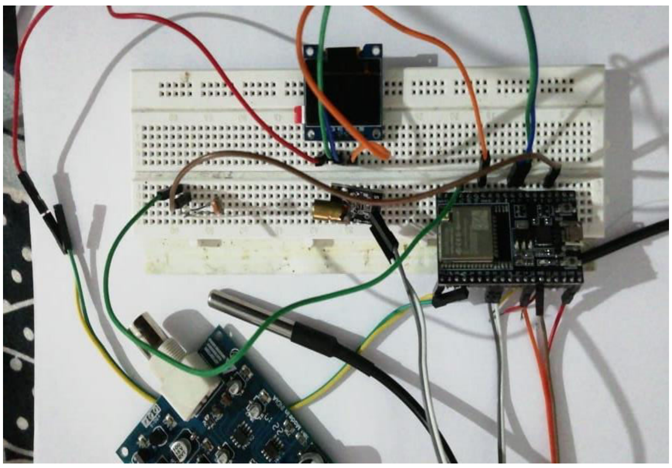

Fig. 5 Hardware Implementation

D. *Product Assembly*

Fig. 6 depicts the 3D model of the product that involves various sections in its assembly design. Whole of the system is divided into prime 3 parts- tray section, body and display.

i. *Tray section*- There is a long and short tray on right and left side respectively which is capable of holding components. Short tray is used to hold the LDR and the long tray for placing the 650nm laser. Both are placed in line of sight and acts like receiver and transmitter respectively. Specifically matched components are placed at same height and maintain exact order and alignment. These trays redefine product's whole structure maintaining complexity to medium. Two sided handle like structure made of PLA is 3D printed.

ii. *Body*- Transparent, strong glass material forms the body of the product which acts like a reservoir where water to be tested is placed. Both pH and temperature sensor probe is dipped inside the beaker placed inside the body. Probe ends are connected to external circuitry that comes under next section. The glass material is strong, durable and cost effective. Water is filled upto an optimum level to prevent overflow. Measurements are labelled for accurate results.

iii. *Display*- It is a square lid like structure with a screen like display over it to show the measured readings. Under the lid cover, we fix batteries, pH sensor module, OLED embedded in breadboard circuit to accompany the parts of other sections. External circuitry connections provided here prevents damage due to water overflow. It provides protective shield for the components so an uninterrupted working is promoted. User prompts to see transparent screen over shield to note down the measurements.

Different views of product are depicted here. To make it portable components and outline materials are made from light weight materials. This makes device efficient and handy. It is high temperature compatible and prevents toxic gas degradation. Safely placed and kept standby wherever necessary. It is highly chemical resistant which keeps the system to tolerate toxic gas attack.

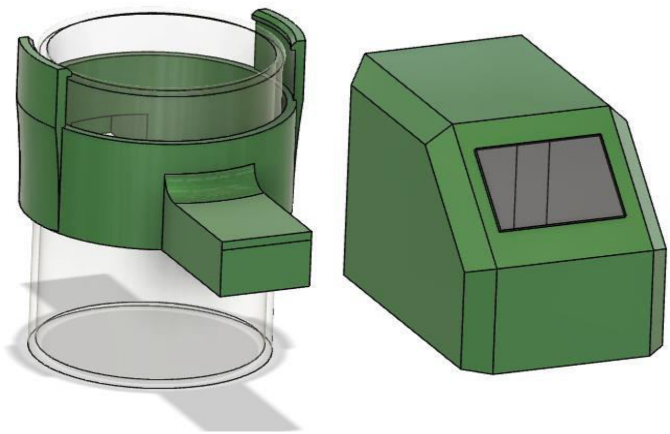

Fig. 6 The 3D Printed Product Casing Model

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IV. EXPERIMENTAL RESULTS

a) Result of pH sensor

Table 1: Error calculation of pH sensor

Name of the Substance	pH reading from Laboratory	Voltage reading from sensor	pH reading from sensor	Error in value
0.1 M HCl	3.28	0.76	2.66	0.62
Lime+water	4.34	1.07	3.74	0.60
Lemon	3.65	0.87	3.04	0.61
Water	7.79	2.05	7.17	0.62
Soap water	8.85	2.36	8.26	0.59
pH4 Buffer	5.23	1.32	4.62	0.61
pH7 Buffer	7.42	1.95	6.82	0.60
pH9 Buffer	8.97	2.38	8.33	0.64

Average of the error values gives 0.611 which is taken as the offset value of our program. The offset value is added with the observed value to obtain the output, thereby reducing the percentage of error in the output value.

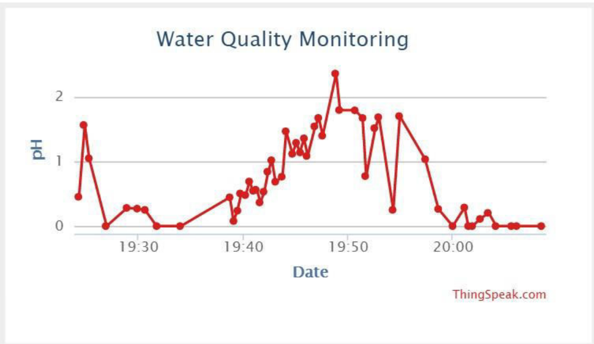

Fig. 8 Updation of pH field in ThingSpeak Channel

b) Result of Temperature Sensor:

Table 2: Error calculation of temperature sensor

No. of Observations	Probe Reading (°C)	Thermometer Reading (°C)	Percentage Error (%)
1	58	61.5	5.69
2	58	60	3.33
3	56	57	1.75
4	52	53	1.88
5	48	49	2.04

Average percentage of error =2.93%

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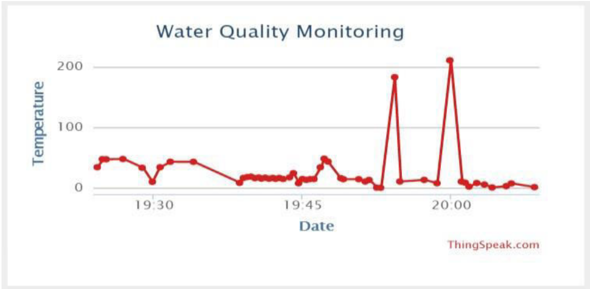

Fig. 9 Updation of Temperature field in ThingSpeak Channel

c) Result of Turbidity Sensor:

Table 3: Error calculation of turbidity sensor

No. of Obs.	Sample used	Turbidity Value	Inference
1	Purified Water	43.5	Clear
2	Tap Water	35.8	Clear
3	Soap Water	19.1	Misty
4	Mud Water	3.4	Cloudy

For quantitative analysis the unit of turbidity can be converted to their respective unit.

Fig. 10 Updation of Turbidity field in ThingSpeak Channel

V. APPLICATION

It can be used as a portable water quality detecting device. Domestic water is intended for human consumption like drinking and it can detect the suitability of water to other commercial purposes. Smart water quality technique is regarded for lake and sea water applications. Water quality monitoring is essential for healthy growth of aquatic creatures. With the growing water issues, the contamination of water remains to be the biggest crisis today. The conventional water quality testing at the laboratories is not always a perfect solution the problem. It takes time to get the results from such laboratory. Being the simplest and cheapest, this project is the best alternative to the above problem. The values are noted continuously. Thus more accurate results are provided. The product is made up of PLA material. Thus this product is environmental friendly. Making the casing with any metal can increase the weight of the product, thereby making it less handy. This product is in every way a better solution to the conventional techniques.

VI. CONCLUSION AND FUTURE WORK

The polluted water might be liable for our death or other dangerous diseases. For this reason, pure water detection becomes crying need in our life to avoid illness or unnecessary death. This implemented device is cost effective and therefore the accuracy of this device isn't such a lot high, but remains in convenient levels. A system is developed in which we evaluate three parameters of the water (Temperature, Turbidity and pH). The system is with maximum precision so as to provide accurate results. The data is uploaded every second. The average of all the values in every 20

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second is uploaded as the Field value in ThingSpeak. Thus precise and clearer valuesare obtained. In case of pH, the best 6 values are chosen and the average of these values is updated. The detection of water parameters could reduce the speed of illness and unnecessary death and also creates consciousness to people for healthier life. Testing ofpH, Temperature, Turbidity of water makes use of various water detection sensors with unique advantages and existing GSM network. This water quality testing is probably going to be more convenient, economical and fast. The system is embedded in a 3D printed box to make it more compact and easy to handle. The material used for 3D printing is PLA which is a biodegradable product. The product has least effect on environment due to its non-toxicity. The system has good flexibility.

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