Real-Time River Water Quality Monitoring and Control System

PROJECT REPORT

Team ID	PNT2022TMID03537
Project Name	IOT Based Real-Time River Water Quality Monitoring and Control System

INTRODUCTION

Water is the primary need of all living beings and living without water is impossible. With the advancement of technology and industrialization, environmental pollutions have become a major concern. Water pollution is one of the most serious types of this environmental pollution. Our lives depend on the quality of water that we consume in different ways, from juices which are produced by the industries. Any imbalance in the quality of water would severely affect the humans health and at the same time it would affect the ecological balance among all species. Water quality refers to the chemical, biological, radiological, and biological parameters of the water.

The essential parameters of the water quality vary based on the application of water. For example, for aquariums, it is necessary to maintain the temperature, pH level, dissolved oxygen level, turbidity, and the level of the water in a certain normal range in order to ensure the safety of the fish inside the aquarium. For the industrial and household applications, however, some parameters of the water are more essential tobe monitored frequently than the others, depending on the usage of the water.

Project Overview

Real-time water quality monitoring uses **technologically advanced monitoring sensors** to collect in-stream water quality measurements and make data available for analysis and action in real time. Field teams deploy sensors strategically at designated points in a given surface water area to monitor waters within defined measurement parameters.

Purpose

Monitoring water quality is clearly important because in our seas, our rivers, on the surface and in our ports, for both companies and the public. It enables us to assess

LITERATURE SURVEY

1. **Water quality monitoring system based on Internet of Things Author**:

Chengcheng Zhang, Jian Wu, Jiancheng Liu Publication: IEEE 2020 Chengcheng et al presents a solution that integrates the design of STM32 single- chip microcomputer, sensors, WiFi wireless transmission and remote water quality management system. It monitors water quality turbidity, pH value, temperature and uploads the data to the management center through wireless communication.

2. IoT Based Real-time River Water Quality Monitoring System Author:

Mohammad Salah Uddin Chowdurya, Talha Bin Emran b, Subhasish Ghosha , Abhijit Pathak a, Mohd. Manjur Alama, Nurul Absar a, Karl Andersson c, Mohammad Shahadat Hossain d Publication: Science Direct 2019 Mohammad et al proposed a manual method for sensor based water quality monitoring system with high frequency, high mobility, and low power. Here the data collected at the site can be displayed in a visual format on a server PC with the help of Spark streaming analysis through Spark MLlib, Deep learning neural network models, Belief Rule Based (BRB) system and is also compared with standard value.

3. Efficient Cloud Based Real Time Water Quality Monitoring System Using Internet Of Things Author:

M.Usha Rani, Dr.R.Alageswaran, Sathish Kumar A Publication: JASC: Journal of Applied Science and Computations(2018) M.Usha Rani et al proposes water sampling system with required sensor. Whenever the water level in the lakes or ponds reaches the lower/upper level it is identified and notification is sent to the administrator. It can also predict overflow and water scarcity in future from the past results. The parameters like PH, calcium, sulphate and nitrate ions that is present in the water is also identified.

4. Water Quality Monitoring System Using IOT Author:

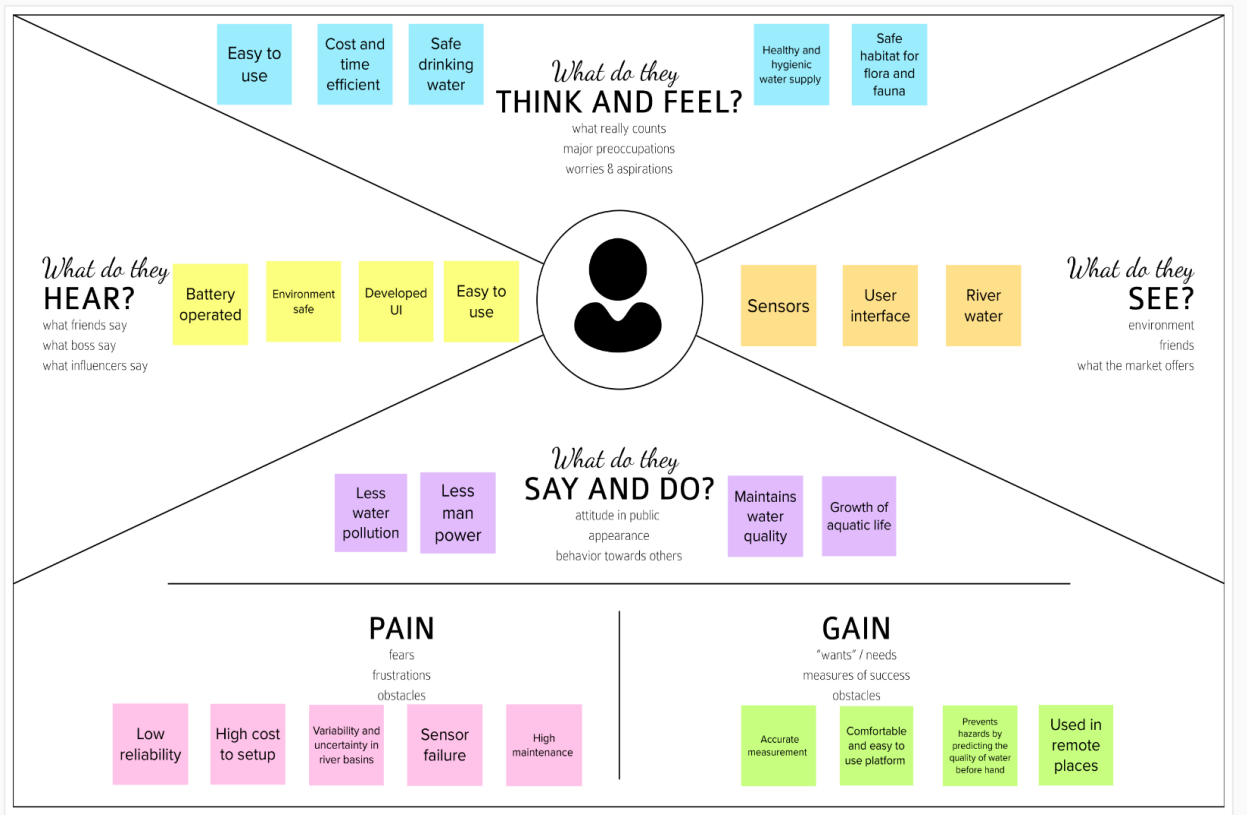
Dr. Nageswara Rao Moparthi, Ch. Mukesh, Dr. P. Vidya Sagar Publication: IEEE 2018 Dr. Nageswara Rao Moparthi et al implements Water Quality Monitoring System for municipal water tanks and drinking water reservoirs using an Arduino board and GSM module. This module can be easily implemented when a wireless oxygen sensor is used.

5. Real-Time Water Quality Monitoring System Author:

Jyotirmaya Ijaradar1, Subhasish- Chatterjee Publication:International Research Journal of Engineering and Technology (IRJET) (2018) Jyotirmaya et al proposed real-time water quality monitoring system for water health at residential places. It measure various chemical and physical properties of water like pH, temperature and particle density of water using sensors and send the data to cloud and trigger an alarm when discrepancies are found in water quality

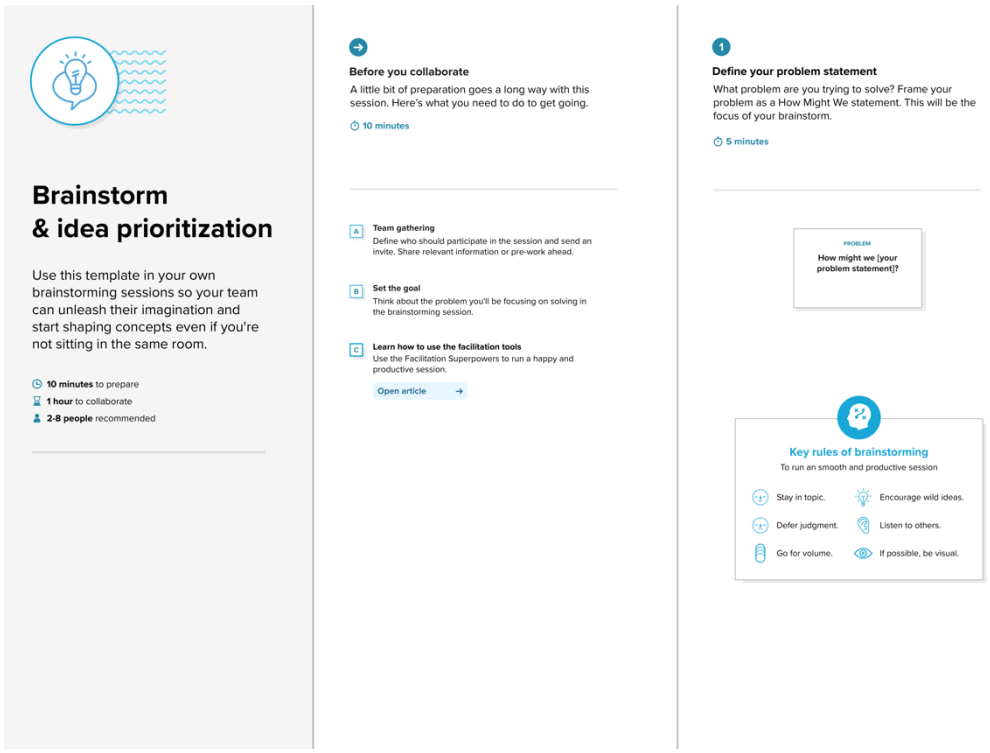
IDEATION & PROPOSED SOLUTION

Empathy map canvas

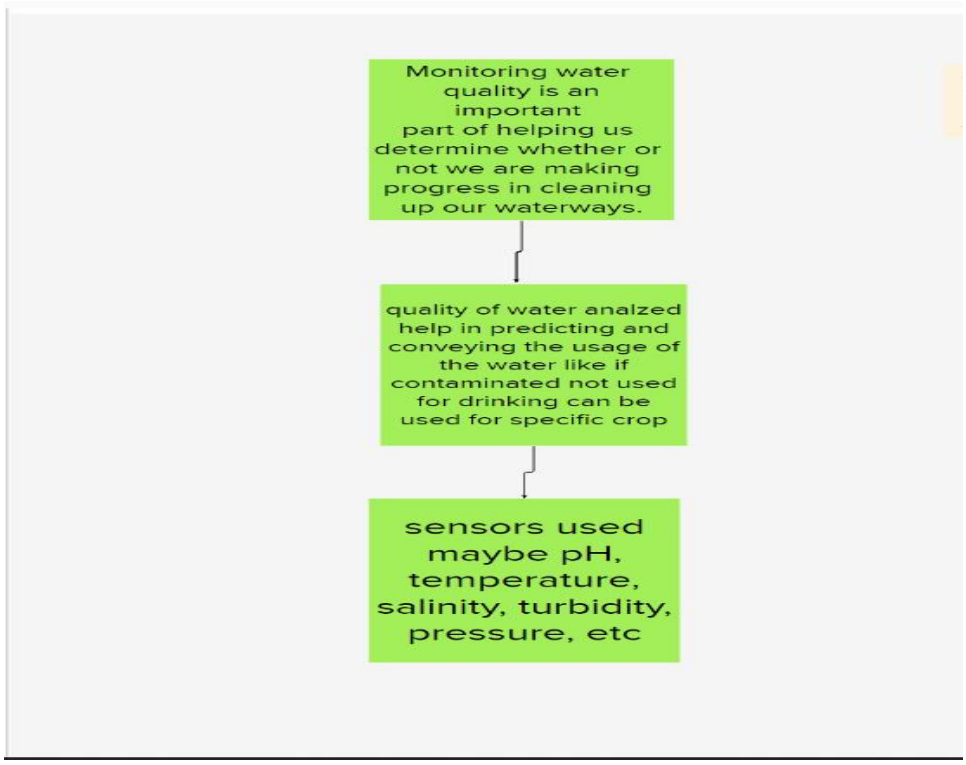


Ideation & Brainstorming

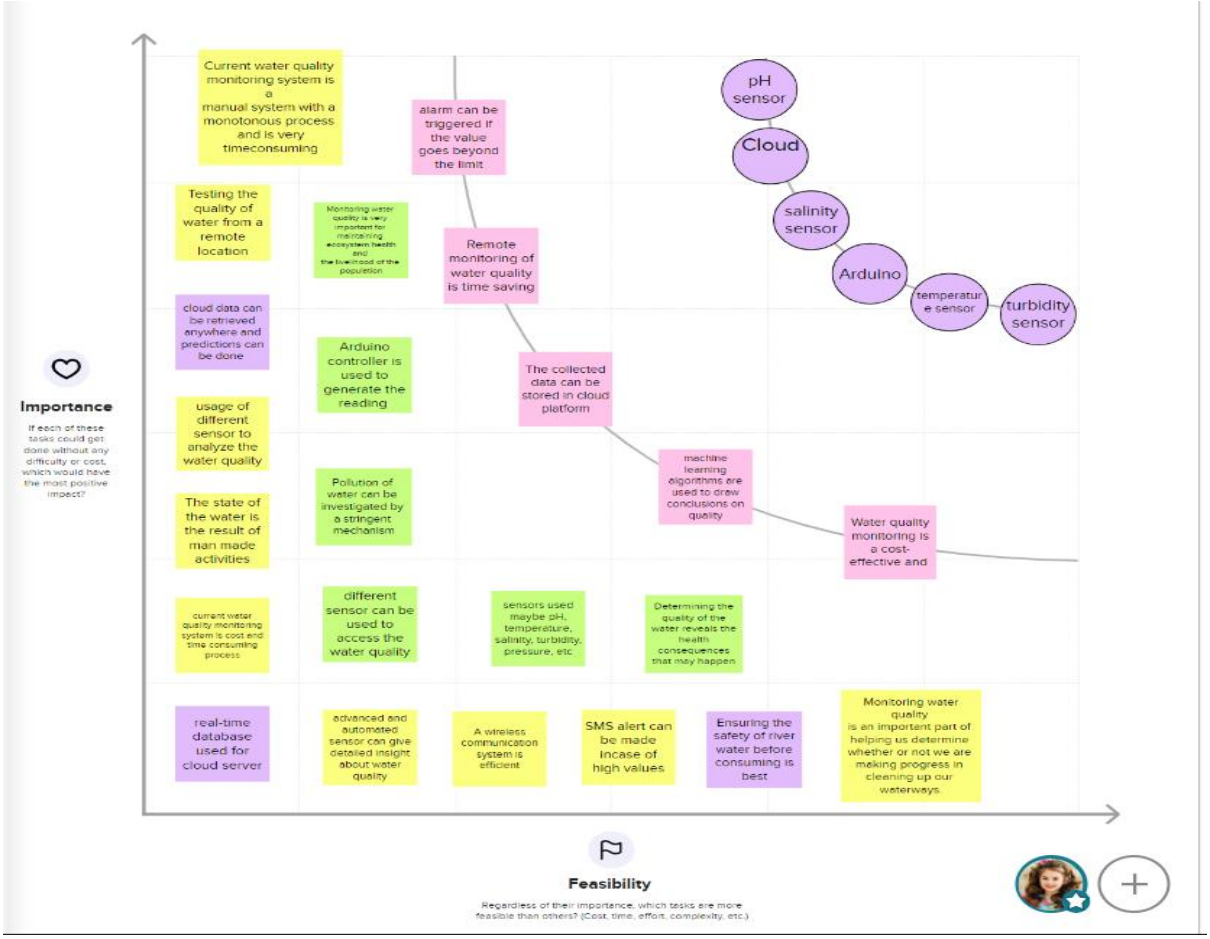
Step-1: Team Gathering, Collaboration and Select the Problem Statement



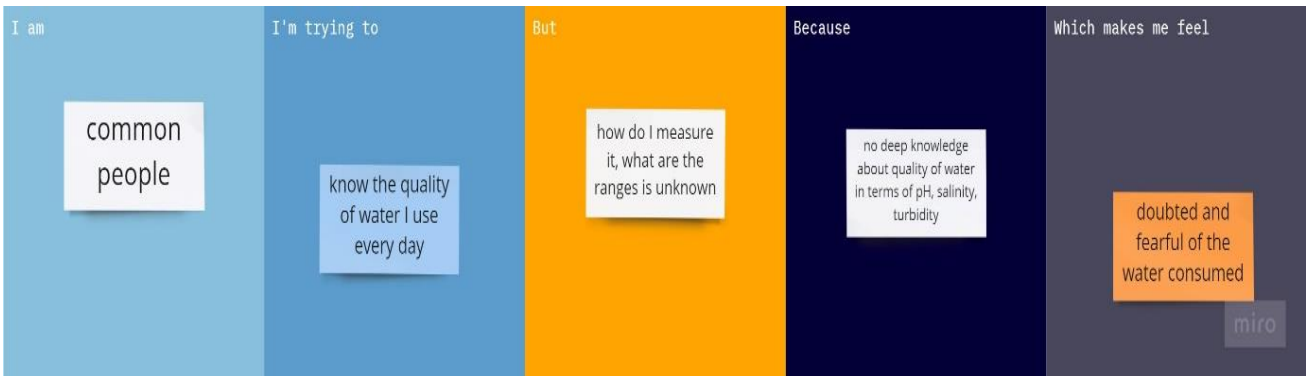
Step-2: Brainstorm, Idea Listing and Grouping



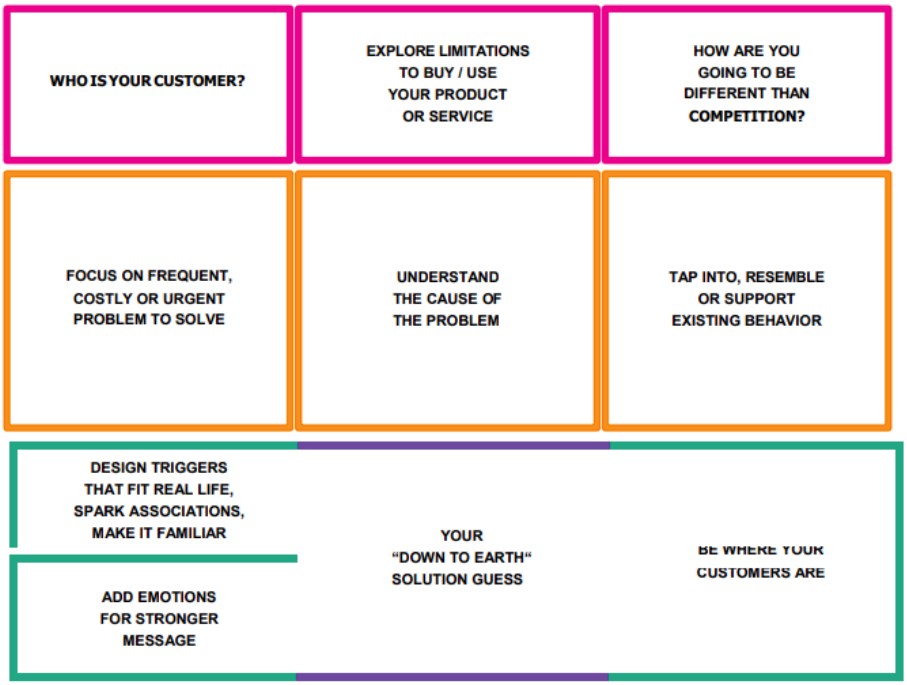
Step-3: Prioritize



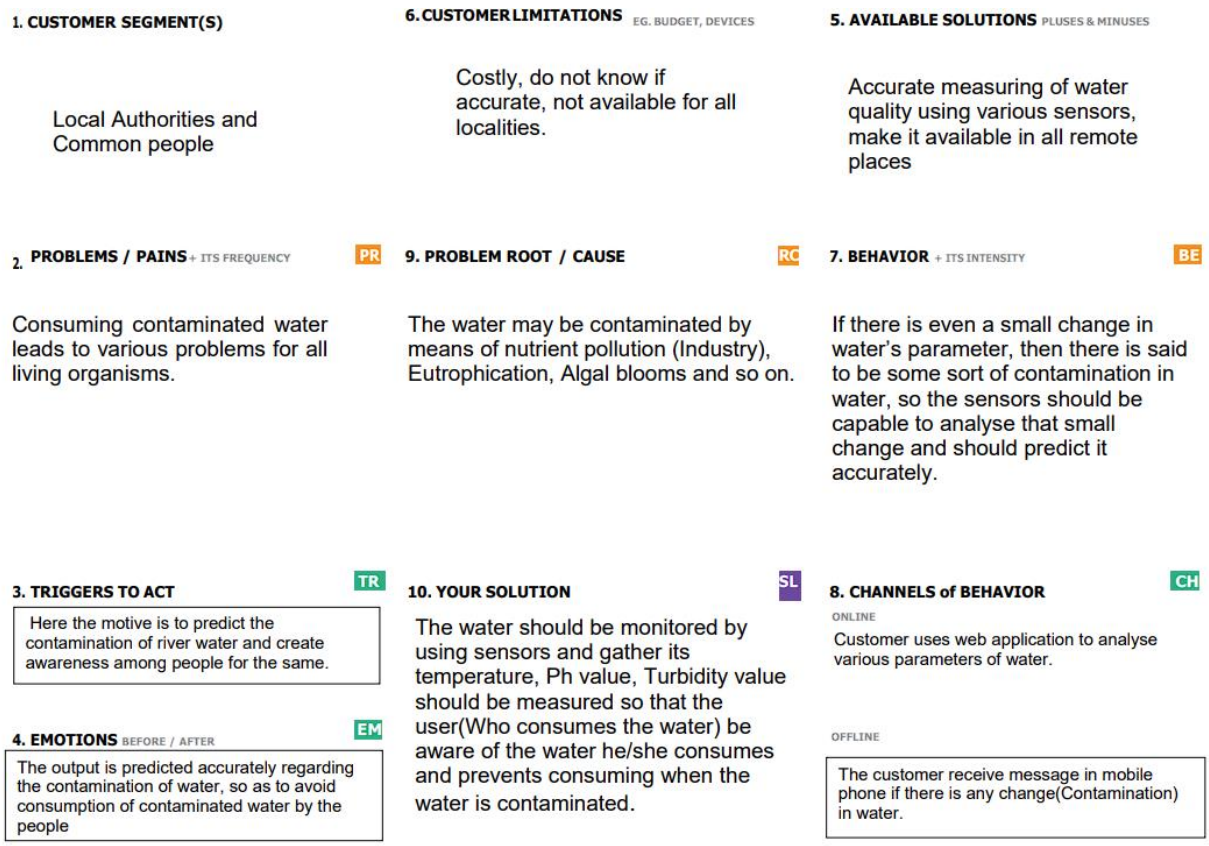
Problem Statement Definition



I am	Common people living a normal life on Earth	Common people living on Earth who consume water in their day-to-day life for Living, domestic works, letc.,
I’m trying to	Monitor the quality of the water	Wants to monitor the water consumed everyday whether the water is contaminated or in pure form, pH, temperature, salinity in it
but	Do not know to monitor the quality of water	Time consuming process for manual testing
because	Lack of required knowledge	Common people lack knowledge of this type of testing, sensors etc.
Which makes me feel	Doubted and fearful of the consumed water	Decline of pure water, increasing viral diseases



Problem solution fit



Proposed Solution

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	IOT Based Real Time River Water Quality Monitoring and Control System
2.	Idea / Solution description	1. To monitor the quality of water using sensors like temperature, potentiometer(pH), turbidity, salinity and so on. 2. Collecting those data and storing it in cloud and perform analyse to check if the water is contaminated or not for drinking. 3. If the water is contaminated an alert is made to the user/ local authority through SMS or can be viewed through web application anytime.
3.	Novelty / Uniqueness	1.Based on the collected data prediction is made whether the water can be used for cultivation of specific crops and suitable for the aquatic animals.
4.	Social Impact / Customer Satisfaction	Algal growth, fertilizers, pesticides cause river pollution which can impact all living beings. Better monitoring and control measures can impact health and vegetation massively.
5.	Business Model (Revenue Model)	Service based product is developed to serve the local people to know the quality of water before consuming it or using it for any purpose. This prevents health issues or at most loss of living being.
6.	Scalability of the Solution	Developing the product as both web and mobile application it is portable, and data can be accessed from anywhere anytime. provide a real-time monitoring and a feasible solution for remote or distant places where water quality laboratory is not present.

REQUIREMENT ANALYSIS

Functional Requirements:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Login	Confirmation through verified password
FR-2	View Water Details	View current water details in website View traditional water eligibility in website
FR-3	Logout	Logs out the user successfully

Non-functional Requirements:

Following are the non-functional requirements of the proposed solution

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	Load time for user interface screens shall not be more than 2 seconds and which is adaptable to the System.
NFR-2	**Security**	User account is password protected Account creation done only after email verification and it is a two step verification process.
NFR-3	**Reliability**	Users can access their account 98% of the time without failure
NFR-4	**Performance**	Load time for user interface screens shall not be more than 2 seconds. Login info verified within 10 seconds.
NFR-5	**Availability**	Maximum down time will be about 4 hours
NFR-6	**Scalability**	System can handle about 1000 users at any given time

PROJECT DESIGN

Water quality monitoring (WQM) is crucial for managing and protecting riverine ecosystems. Current WQM network design practices often rely on unsubstantiated criteria rather than accountable algorithms. Water managers face difficulties to relate the impact of local boundary conditions on the choice of appropriate WQM network design methods. After reviewing the commonly used design methods and their resulting monitoring setups, it was evident that multivariate statistical analysis is the most frequently used method for designing WQM networks in rivers.

Turbidity sensor:

The turbidity sensor **detects water quality** by measuring level of turbidity. It is able 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.

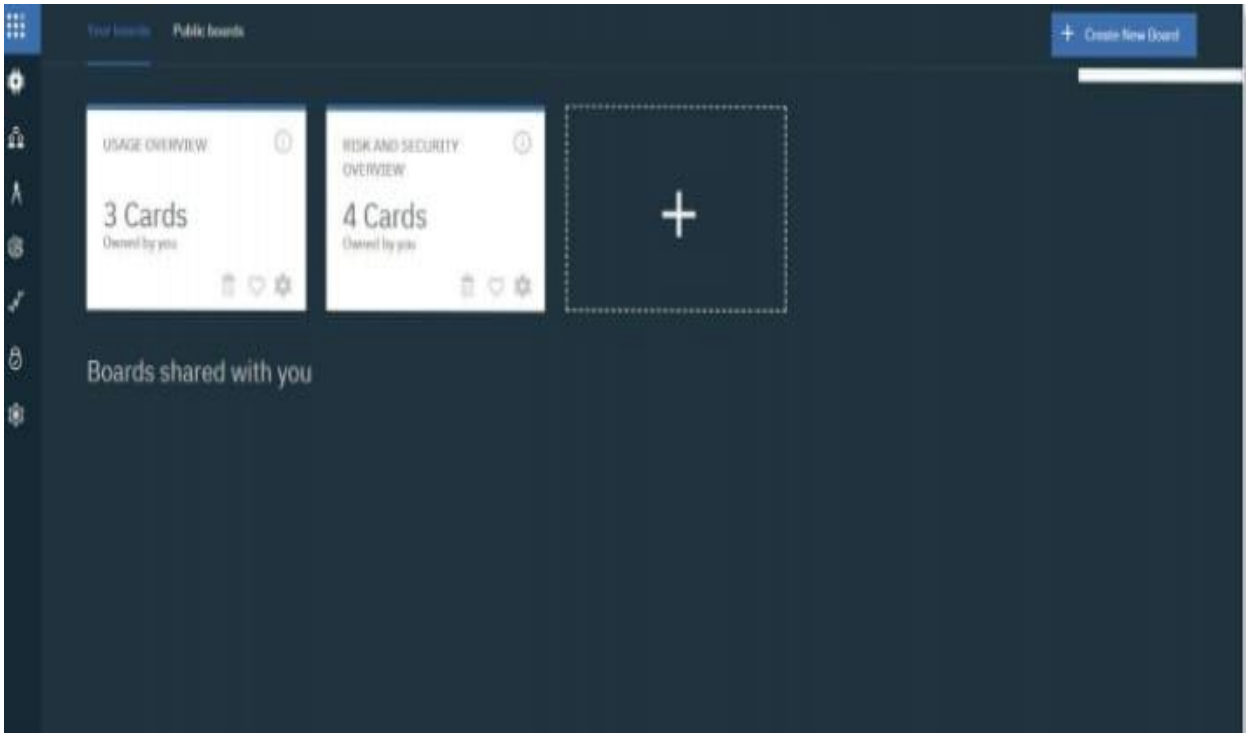
LED Display:

LED Display (light-emitting diode display) is a screen display technology that uses a panel of LEDs as the light source. Currently, a large number of electronic devices, both small and large, use LED display as a screen and as an interaction medium between the user and the system. Modern electronic devices such as mobile phones, TVs, tablets, computer monitors, laptops screens, etc., use a LED display to display their output.

Ph level sensor:

A pH sensor is a **scientific device used to accurately measure acidity and alkalinity in water and other liquid substances**. It is an important device used in most industries, including power plants, pharmaceuticals, food & beverage, primaries, chemicals, oil gas, and wastewaters.

IBM Watson cloud:



Watson is an AI from IBM. Created to form your business more intelligent and every worker your best worker. Watson features a range of advanced APIs, specialized tooling, and Software as a Service application. This implies that Watson is made for complex use cases and designed to integrate with platforms that experts utilize in their daily work. Ensuring seamless access to the knowledge you would like to form the right decisions

Uses of IBM Watson:

- Watson gives you complete control of what is important to you and therefore the foundation of your competitive advantage, your data, models, learning, and API.
- Watson learns more from less because of its high learning power.
- Watson was initially available only on IBM Cloud but is now portable across any cloud-powered business. This prevents customers from being locked into one vendor and enables them to start out deploying AI wherever their data resides.

Arduino-UNO:

The Arduino UNO is a standard board of Arduino. Here UNO means 'one' in Italian. It was named as UNO to label the first release of Arduino Software. It was also the first USB board released by Arduino. It is considered as the powerful board used in various projects. Arduino.cc developed the Arduino UNO board.

Arduino UNO is based on an ATmega328P microcontroller. It is easy to use compared to other boards, such as the Arduino Mega board, etc.

Node-Red process:

Node-RED is a **flow-based development tool for visual programming** developed originally by IBM for wiring together hardware devices, APIs and online services as part of the Internet of Things. Node-RED provides a web browser -based flow editor, which can be used to create JavaScript functions.

License: Apache License 2.0
Operating system: Cross-platform
Stable release: 3.0, / July 14, 2022; 3 months ago
Written in: JavaScript

Working Principle:

Monitoring consists of a systematic and planned series of measurements or observations that are appropriately analysed and reported, to generate information and knowledge about a water body.

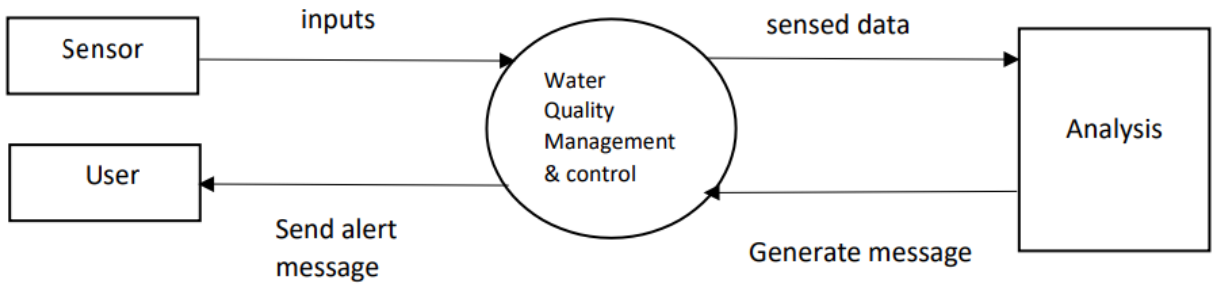
Water quality monitoring provides us with information on the health of waterways and for the management of catchments, water resources and the environment. Monitoring may be required for single studies and to focus on particular issues or knowledge gaps, or it may be part of a more regular ongoing operation.

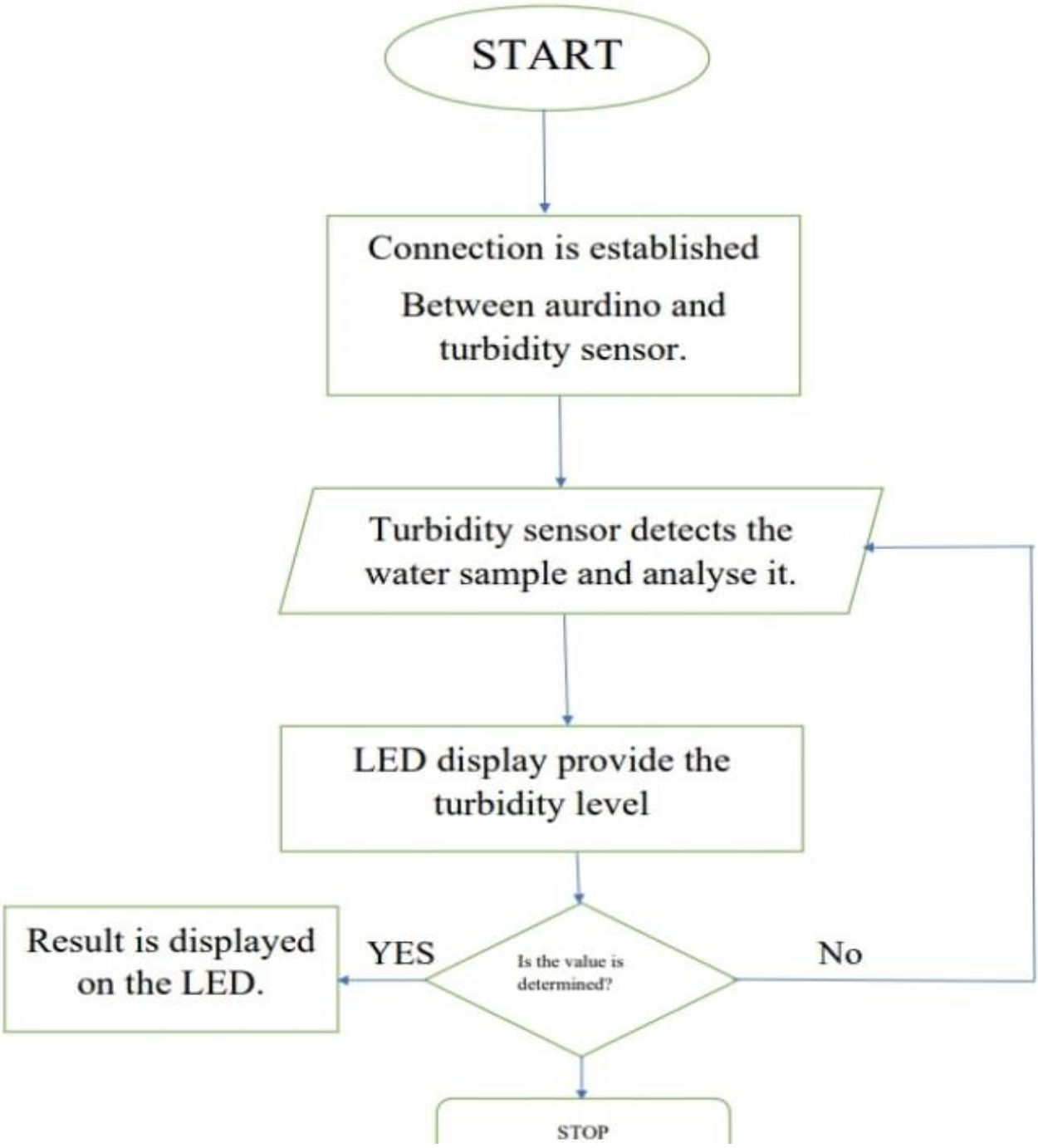
Monitoring data are essential for people involved in planning, licensing and approval processes and natural resource management, as well as agencies, consultants, researchers and community groups interested in monitoring, assessment and reporting.

- Define the information requirements and monitoring program objectives.
- Design a monitoring study, including its type, scale, measurement parameters and sampling programs, including preferred methods for sampling.
- Determine the preferred approach for field sampling (field sampling design), including how to prepare, collect and preserve samples of waters, sediments and biota efficiently and safely.
- Design a program for laboratory processing and analyses of water, sediment and biota samples that provides accurate results in an efficient and safe manner.
- Analyse and interpret the data collected with respect to the monitoring program objectives and the underpinning conceptual models of the study area.

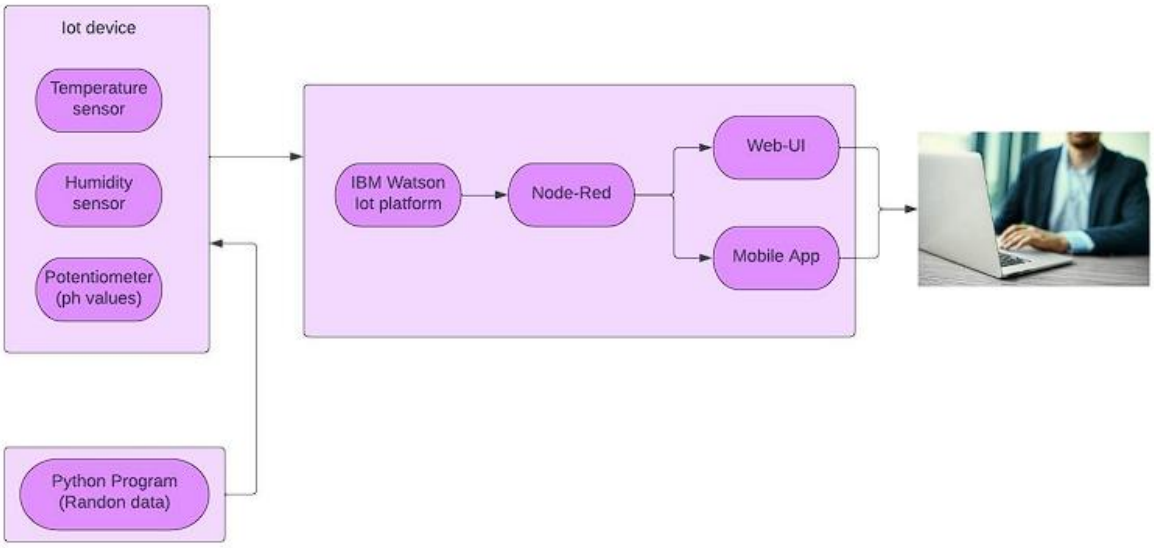
Report and disseminate information and results from the monitoring program in ways that address different stakeholder needs and backgrounds.

Data Flow Diagrams




START
Connection is established
Between aurdino and
turbidity sensor.
Turbidity sensor detects the
water sample and analyse it.
LED display provide the
turbidity level
Is the value is
determined?
YES
No
Result is displayed
on the LED.
STOP

Solution & Technical Architecture



User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
	Check water parameters	USN-2	User can check the level of water parameters like temperature, humidity, PH level etc.	User can check the level of water parameters	High	Sprint-1

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
User(Mobile user)	Check Notification	USN-1	User can check the notification of the alert message.	User can check the notification	High	Sprint-1

PROJECT PLANNING & SCHEDULING

SPRINT PLANNING AND ESTIMATION

Taking the proper steps to set up a sound water quality monitoring plan is an excellent way for students to learn about their watershed, how their home or school fits into it, and how scientists approach their work. As we work toward our capstone site study, the steps we take in investigating our water quality are very important. The data we obtain for our suite of parameters (pH, DO, turbidity and temperature) are only as good as the method or plan we use to collect it. Recognizing the limitations of field methods and additional factors that may affect our data will be key steps in arriving at an accurate conclusion to our testable question and developing any plans for further action and reporting.

When using the World Water Monitoring Day test kits, there are some strengths and weaknesses in the quality of the data collected. On the positive side, the kits are easy to use, provide quick results and are comparable to the thousands of other study sites using them

Sprint delivery schedule

The project must be planned to do in 2-3 months. According to our scheduling process of the working, the project is done in these following weeks and completed by our team-mates successfully.

These are the following schedule that proceed by our team to complete the project successfully.

Budget:

The process in done by the following permitted budget

- Turbidity sensor
- LED display
- Arduino UNO
- Connecting wires

Total budget of the project is Rs.6,000-10,000(approx.).

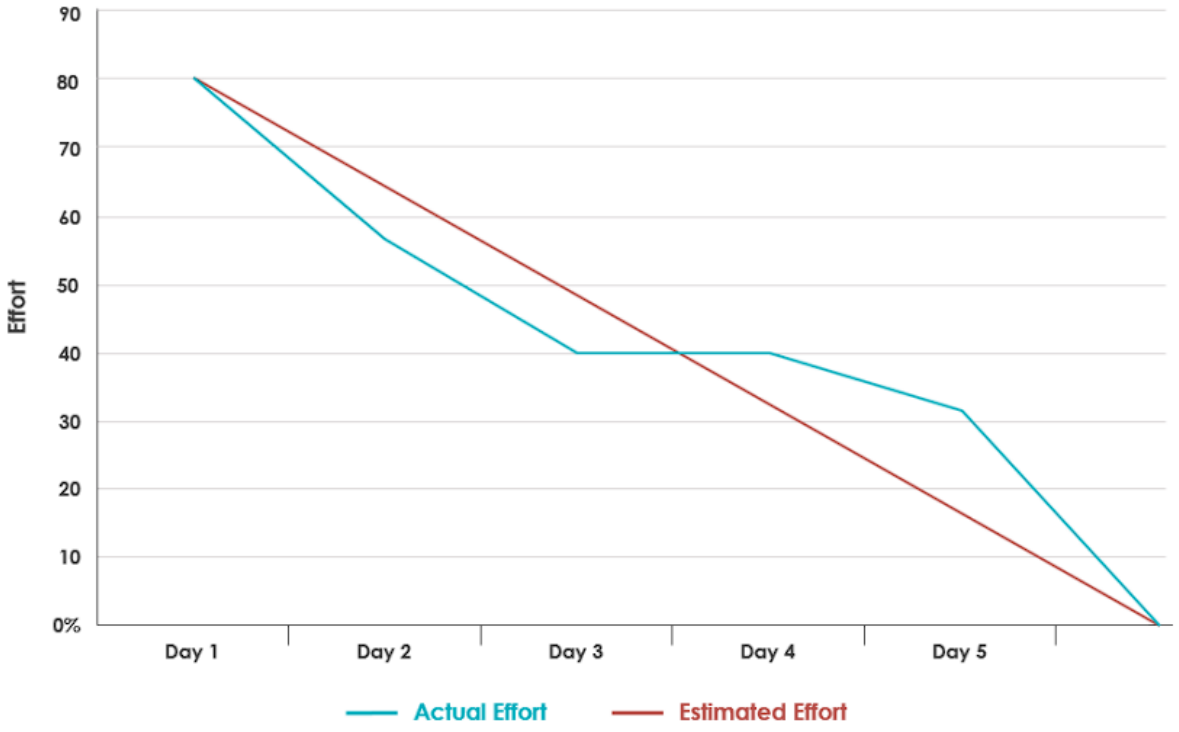
Velocity:

Imagine we have a 10-day sprint duration, and the velocity of the team is 20 (points per sprint). Let's calculate the team's average velocity (AV) per iteration unit (story points per day)

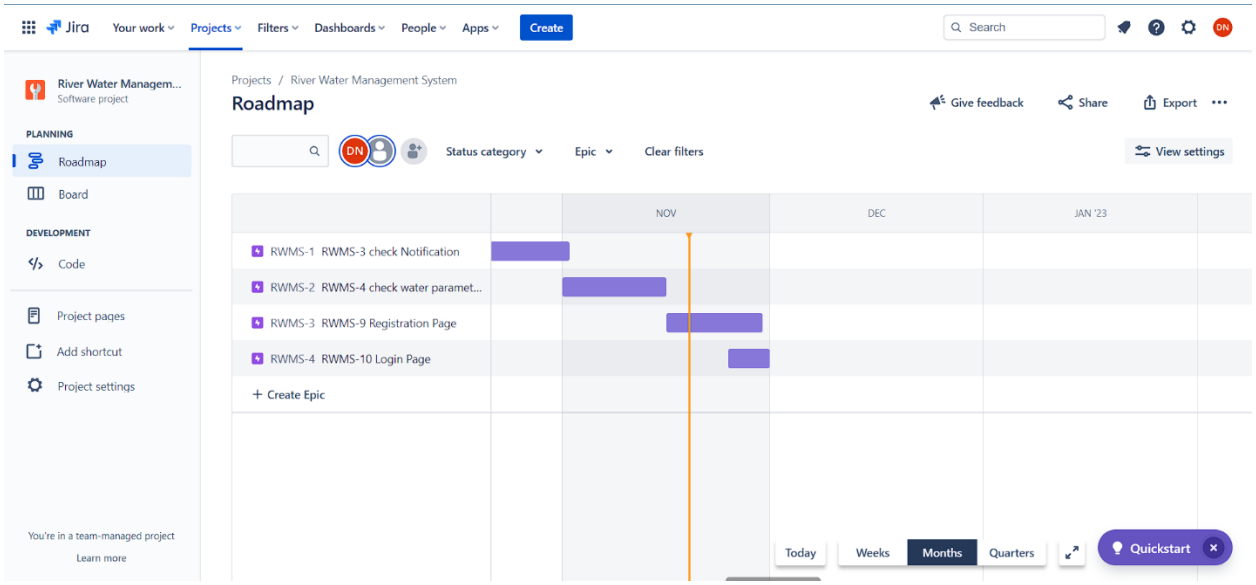
$$AV = \frac{sprint\ duration}{velocity} = \frac{20}{10} = 2$$

Burndown Chart:

A burn down chart is a graphical representation of work left to do versus time. It is often used in agile software development methodologies such as Scrum. However, burn down charts can be applied to any project containing measurable progress over time.



Reports from JIRA



TESTING

Water quality assessment provides the base line information on water safety. Since water quality in any source of water and at the point of use, can change with time and other factors, continuous monitoring of water is essential. WHO guidelines provide values for 96 substances (out of 128 chemicals initially reviewed). It is very expensive, time consuming, difficult and largely unnecessary to test for all these parameters. The list of parameters to be selected from the guidelines and included in any water assessment and monitoring program will vary according to the local conditions. This Technical Bulletin aims at providing parameters that are basic and generally considered priorities in any water quality assessment programme. It also presents the testing kits that have been identified so far by UNICEF for assessment and monitoring programmes.

The following basic parameters should be included:

1. Microbiological parameters: basic microbiological tests should cover thermo- tolerant coliforms (a group of bacteria that grow at 44°C) and faecal streptococci. In addition, physical and chemical parameters, such as disinfectant residuals, pH and turbidity, affect the microbiological quality of water.

2. Physical parameters: in addition to turbidity, mentioned above, conductivity, colour, taste and odour might cause rejection of water.

3. Harmful chemicals: nitrate, iron, arsenic, fluoride, lead, cyanide, metals (aluminium, cadmium, chromium, copper, manganese, mercury), selenium, organics (including pesticides and disinfectant by-products), alkalinity and corrosivity.

Testing methods

1. Physical parameters

Colour:

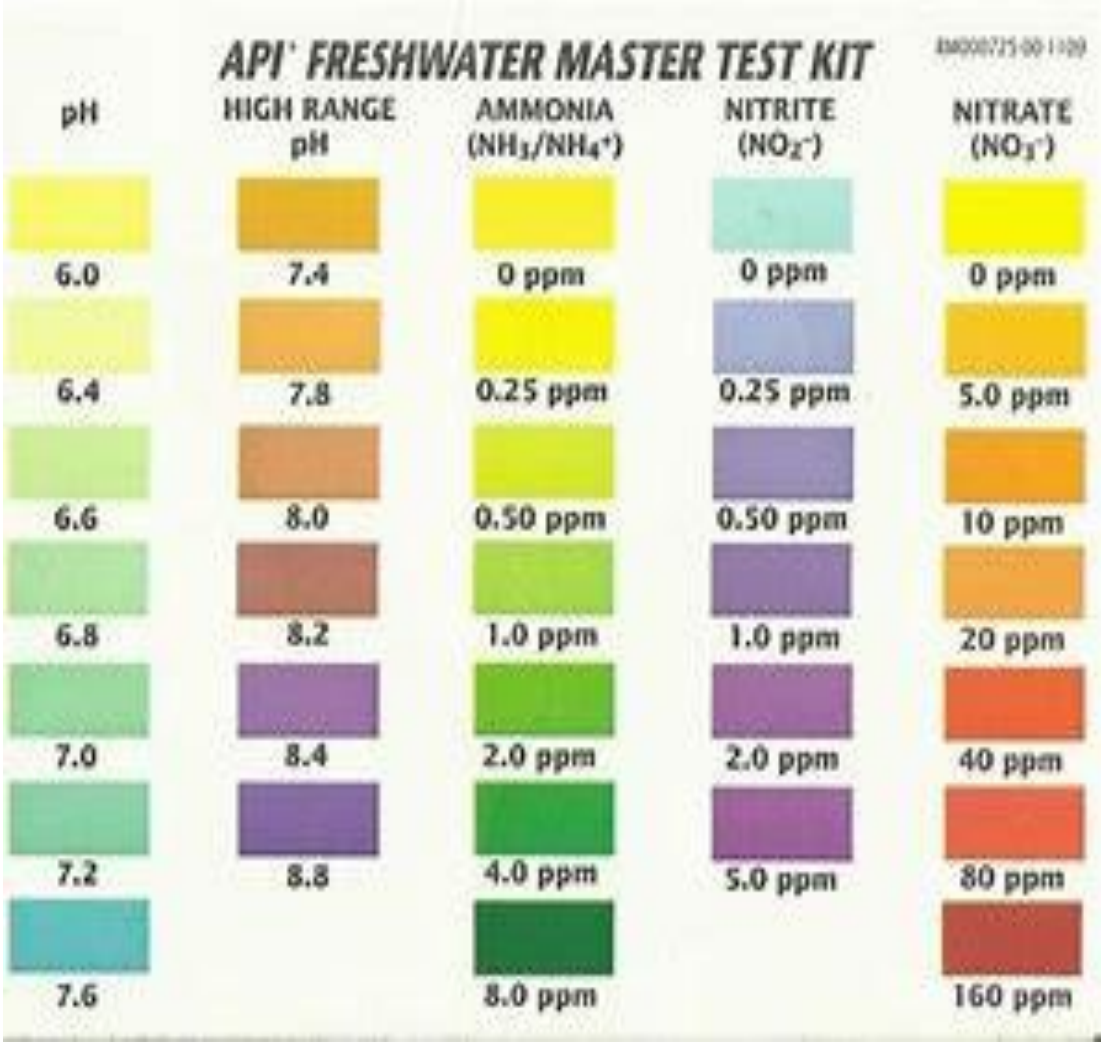
This is usually monitored through visual observation only. It is simple and cost free. However, for quantitative assessments, a light box or a spectrophotometer should be used.

Odour:

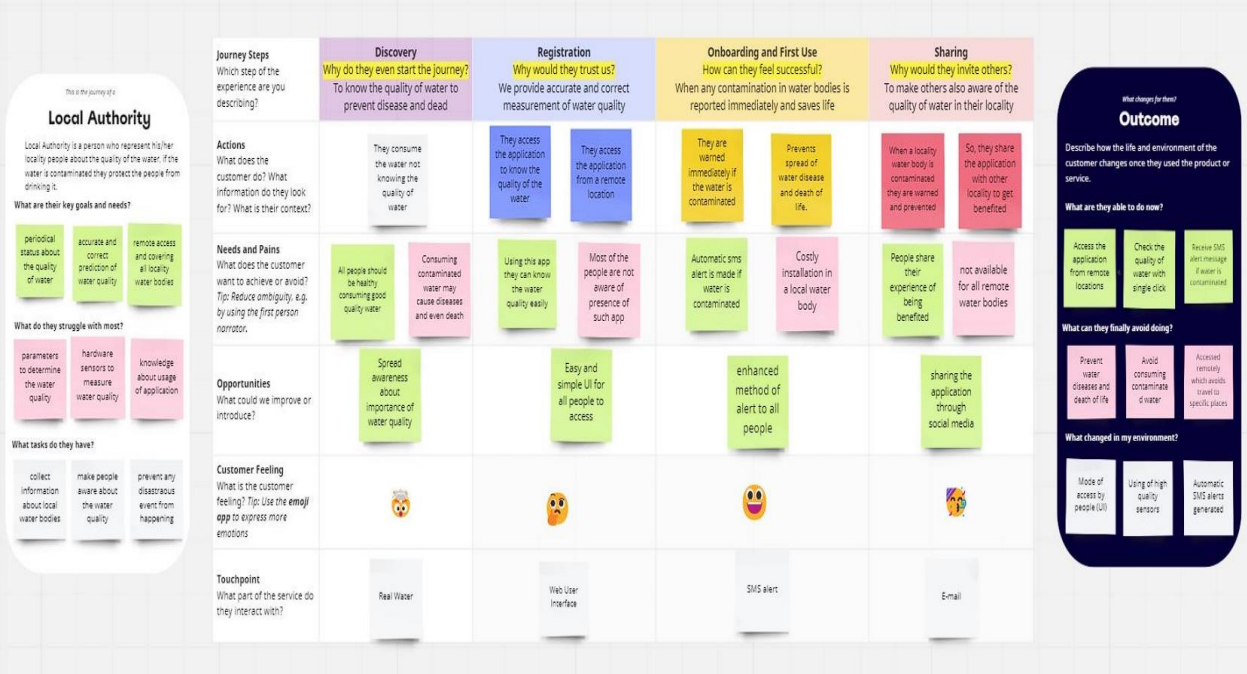
Assessment of odour is usually not included in the water quality assessment. If a change in odour is detected, it might indicate a water quality problem that requires further investigation.

2. Chemical parameters

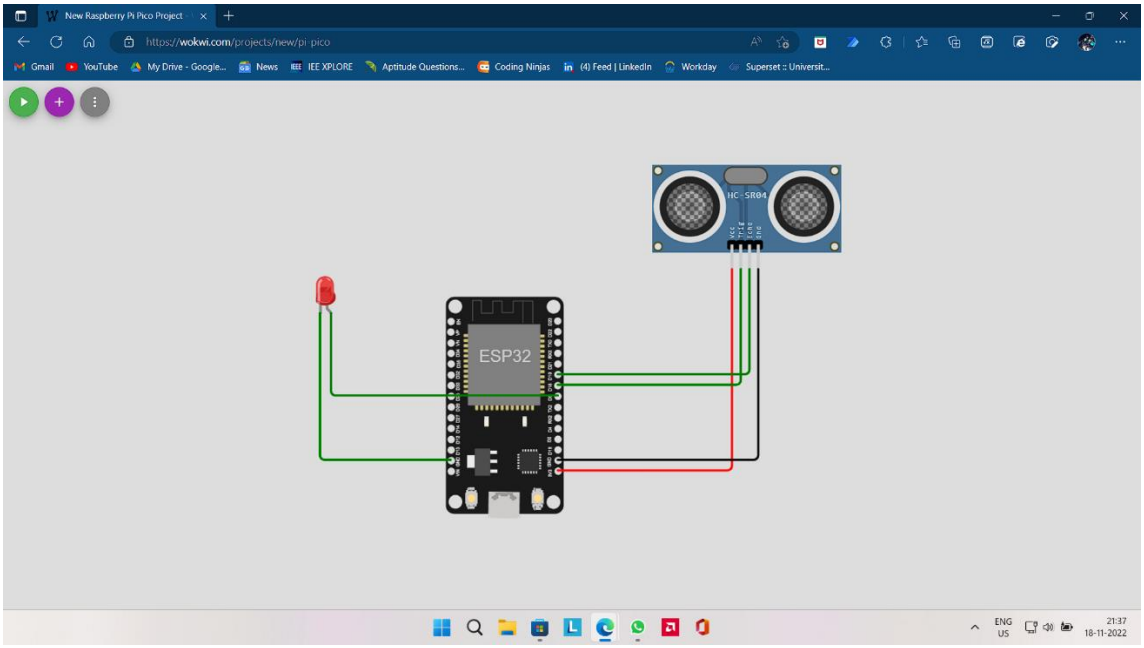
The basic chemical parameters that are generally included in water assessment and monitoring programmes are shown in the table below. They were determined at the Rapid Water Quality Assessment Meeting held by WHO, UNICEF and the Water, Engineering and Development Centre (Loughborough University) in Bangkok on 5-7 May 2002. Local conditions could lead to some variations in the parameters selected.



Customer control journey map:



wokwi raspberry pi simulator



CODE:

```
#include <WiFi.h>//library for wifi
#include <WiFiClient.h>
#include <PubSubClient.h>//library for MQtt
// creating the instance by passing pin and typr of dht connected
 float distance;
#define sound_speed 0.034
 int trigpin=18;
 int echopin=19;
 int led=5;
 int LED=9;
 long duration;
 String message;// creating the instance by passing pin and typr of dht connected

void callback(char* subscribetopic, byte* payload, unsigned int payloadLength);

//-------credentials of IBM Accounts------

#define ORG "f5rl2v"//IBM ORGANITION ID
#define DEVICE_TYPE "IOT_Device_1"//Device type mentioned in ibm watson IOT Platform
#define DEVICE_ID "shiruv12"//Device ID mentioned in ibm watson IOT Platform
#define TOKEN "_fV(SmaZ9SnRwFdt0O"     //Token
String data3;
float h, t;


//-------- Customise the above values --------
char server[] = ORG ".messaging.internetofthings.ibmcloud.com";// Server Name
char publishTopic[] = "iot-2/evt/Data/fmt/json";// topic name and type of event perform and
format in which data to be send
char subscribetopic[] = "iot-2/cmd/command/fmt/String";// cmd  REPRESENT command type
AND COMMAND IS TEST OF FORMAT STRING
char authMethod[] = "use-token-auth";// authentication method
char token[] = TOKEN;
char clientId[] = "d:" ORG ":" DEVICE_TYPE ":" DEVICE_ID;//client id


//-----------------------------------------
WiFiClient wifiClient; // creating the instance for wificlient
PubSubClient client(server, 1883, callback ,wifiClient); //calling the predefined client id by
passing parameter like server id,portand wificredential
void setup()// configureing the ESP32
{
  Serial.begin(115200);
```

```
pinMode(trigpin,OUTPUT);
pinMode(echopin,INPUT);
pinMode(led,OUTPUT);
  delay(10);
  Serial.println();
  wificonnect();
  mqttconnect();
}

void loop()// Recursive Function
{

digitalWrite(trigpin,LOW);
digitalWrite(trigpin,HIGH);
delay(1000);
digitalWrite(trigpin,LOW);
duration=pulseIn(echopin,HIGH);
distance=duration*sound_speed/2;
Serial.println("distance"+String(distance)+"cm");
 if(distance<100)
 {
   message="Alert";
   digitalWrite(led,HIGH);
   } else
{
  message="No problem";
  digitalWrite(led,LOW);
  }
  delay(1000);
  PublishData(distance,message);
  // if (!client.loop()) {
  //   mqttconnect();
  // }
}



/*.....retrieving to Cloud.....*/

void PublishData(float d, String a) {
  mqttconnect();//function call for connecting to ibm
  /*
     creating the String in in form JSon to update the data to ibm cloud
  */
  String payload = "{\"distance\":";
```

```
  payload += d; payload += "}";
  payload += "," "{\"message\":";
  payload += a;
  payload += "}";


  Serial.print("Sending payload: ");
  Serial.println(payload);


  if (client.publish(publishTopic, (char*) payload.c_str())) {
    Serial.println("Publish ok");// if it sucessfully upload data on the cloud then it will print
publish ok in Serial monitor or else it will print publish failed
  } else {
    Serial.println("Publish failed");
  }

}
void mqttconnect() {
  if (!client.connected()) {
    Serial.print("Reconnecting client to ");
    Serial.println(server);
    while (!!!client.connect(clientId, authMethod, token)) {
      Serial.print(".");
      delay(500);
    }

     initManagedDevice();
     Serial.println();
  }
}
void wificonnect() //function defination for wificonnect
{
  Serial.println();
  Serial.print("Connecting to ");

  WiFi.begin("Wokwi-GUEST", "", 6);//passing the wifi credentials to establish the connection
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());
```

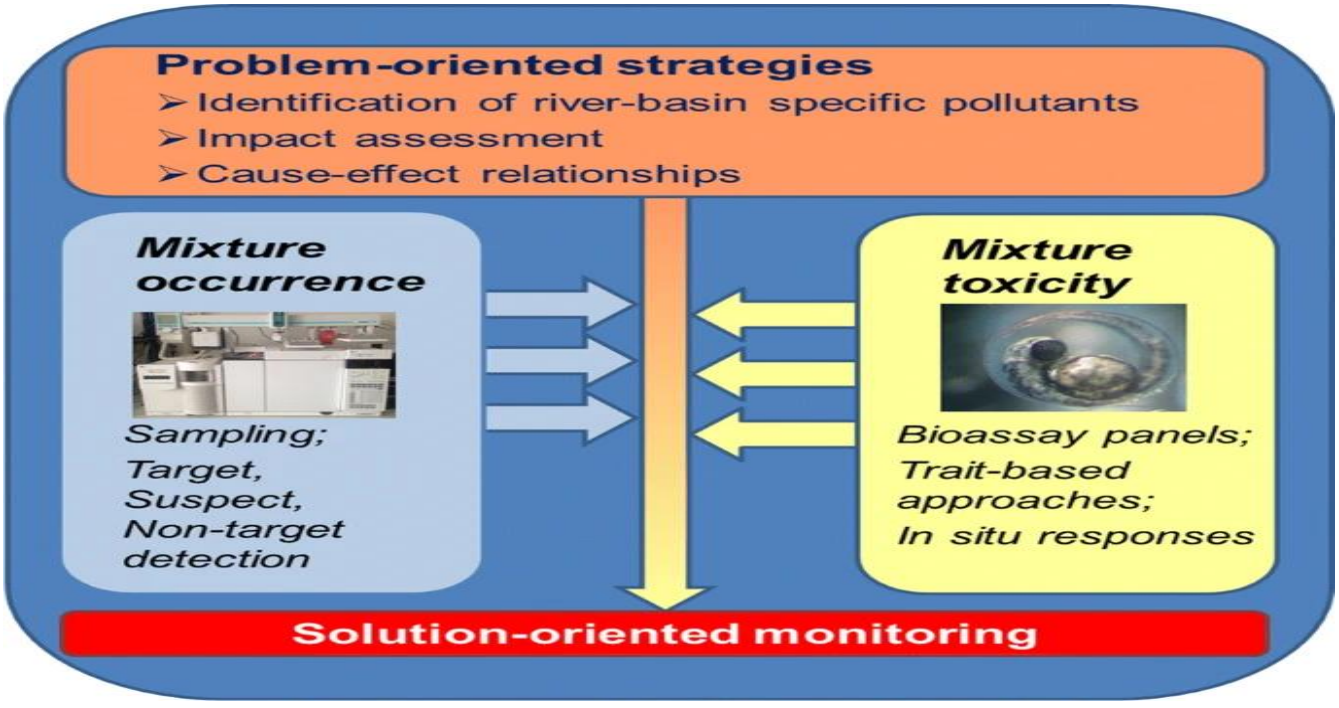
```
}

void initManagedDevice() {
  if (client.subscribe(subscribetopic)) {
    Serial.println((subscribetopic));
    Serial.println("subscribe to cmd OK");
  } else {
    Serial.println("subscribe to cmd FAILED");
  }
}

void callback(char* subscribetopic, byte* payload, unsigned int payloadLength)
{

  Serial.print("callback invoked for topic: ");
  Serial.println(subscribetopic);
  for (int i = 0; i < payloadLength; i++) {
    //Serial.print((char)payload[i]);
    data3 += (char)payload[i];
  }
  Serial.println("data: "+ data3);
  if(data3=="lighton")
  {
Serial.println(data3);
digitalWrite(LED,HIGH);
  }
  else
  {
Serial.println(data3);
digitalWrite(LED,LOW);
  }
data3="";
}
```

RESULT

The result of our work can be shown in a curve that is generated in the ThingSpeak, that is calculated and monitored from a different sensor like pH, turbidity, and temperature sensor and uploaded in it. Different curves and widgets are used to show the results of different sensors respectively. The curve is made as the sensors calculate the input data for different dates and times. Also used ThingSpeak mobile app, fig 13. for getting the results of the sensor in mobile phones, fig 14. Then IFTTT applets within the webhook services and the services provided by ThingSpeak like ThingHTTP and ThingSpeak React by using the URL of IFTTT applets to send the notification or push message to the owner's registered number. Results in ThingSpeak Asian Journal of Convergence in Technology ISSN NO: 2350-1146 I.F-5.11 Volume VII and Issue II 4.

Future work planning:

In future the process will get a progress and used to analyse the chemical properties also, The future plan is been reviewed as the following diagram.



ADVANTAGES AND DISADVANTAGES

Advantages:

- **Leads to Better Health:**
  Water quality monitoring system will help us to know the healthiest water in the plant, and it can lead to better health too. Quality water helps prevent waterborne illness.

- **Leads to Better Water Treatment:**
  In general, water treatment is one of the most important and sometimes the only thing that needs be done in a business because if there is any problem with water, it will affect the productivity of a company.
- **Cost Effective:**

- Quality water monitoring system can save a lot of money for you. This is because if you have a big company and it takes more than 5,000 liters of water in your plant per day, then your monthly bill will be more than 1 crore if you are using untreated water.

Performance:
Quality water monitoring system can help you to check your performance with water quality testing methods. This is because you can use those testing results and compare them with the performance of your plant and adjust that points where you are lacking.

Disadvantages:

- **Labor Intensive For Installation And Operation:**
  Quality water monitoring system requires a lot of man hours for its installation and operation. This is because water quality monitoring system consists of multiple instruments and they all are very time consuming.
- **Maintenance Costs:**
  Because of high labor intensive and high initial costs, quality water monitoring system has a high maintenance cost which is why after some time you will have to replace your entire system.

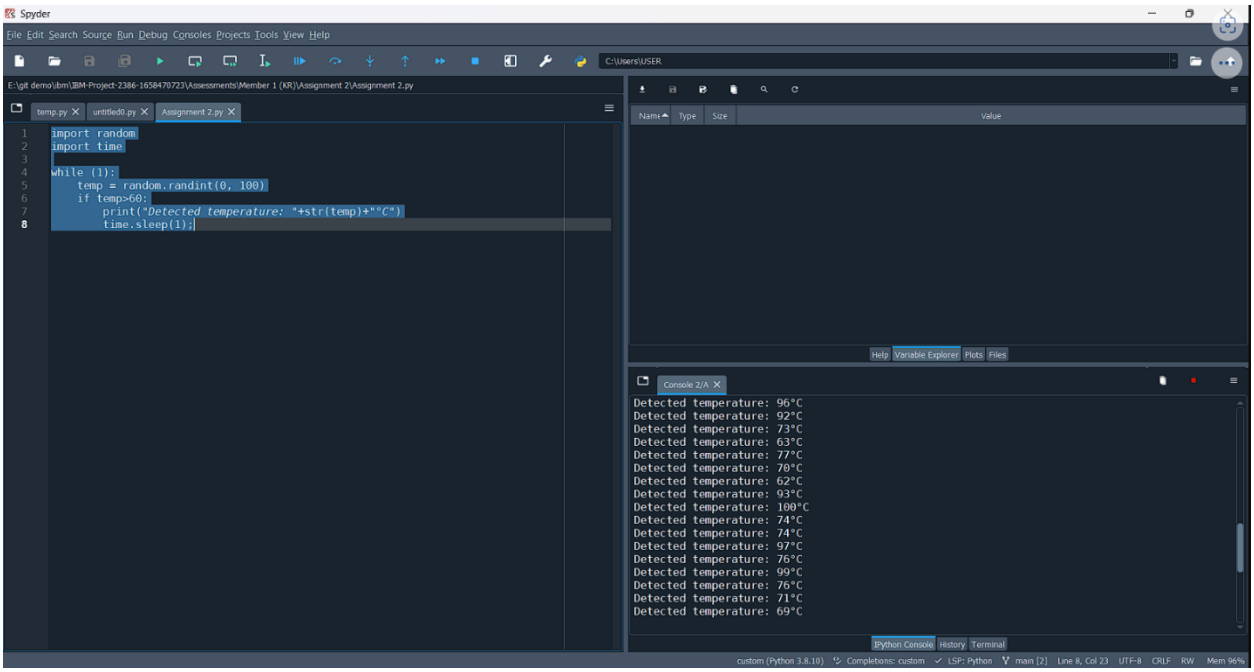
- **Time Consuming:**
  Quality water monitoring system is very time consuming and the whole procedure is not reliable. This is because with water quality monitoring

system you will have to change your test report every month, but some companies will ask for test reports every week or even daily.

APPENDIX

GitHub code

```
import random

import time


while (1):
    temp = random.randint(0, 100)
    humidity = random.randint(0, 100)
    if temp>60:
        print("ALERT!! Detected temperature: "+str(temp)+"°C")
        time.sleep(1)
```



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