IoT based water quality assistant for Irrigation

Capstone Project Proposal

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BE Third Year- COE

CPG No. 101

Under the Mentorship of

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Mentor Consent Form

I hereby agree to be the mentor of the following Capstone Project Team

Project Title: IoT based water quality assistant for Irrigation		
Roll Number	**Name**	**Signature**
101983043	Umang Sharma	Umang 22/3/21
101983044	Suryansh Bhardwaj	22/03/2021
101983045	Prakhar Srivastava	Prakhar Srivastava 22/03/21

Name of Mentor: Dr. Karun Verma

Signature of Mentor:

Karun Verma

to me

Dear Umang,

I have gone through the proposal, the contents has been updated to my satisfaction. You can now proceed for submission to the coordinators.

Best wishes,

Dr. Karun Verma

1. Project Overview

Water quality illustrates the condition of the water, including its chemical, physical, and biological characteristics, usually with respect to its suitability for a particular purpose such as drinking, irrigation or swimming. The composition of water is dependent on various natural factors (geological, topographical, meteorological, hydrological and biological) and varies with seasonal differences, weather conditions and water levels. The quality of ground water used for irrigation, thus, varies with respect to geographical location, time of the year as well as weather conditions. This variation can result in unsuitable water, and consequently a lower yield for many crops.

The Project focuses on determining quality of water and classifying water as good quality or bad quality for the purpose of irrigation as well as automatically diverting bad-quality water to the treatment pump, before going to fields.

It is divided into three major segments:

A. Data Collection

Data related to the temperature, turbidity, Potential of Hydrogen (pH), and most importantly the Sodium Absorption Ratio (SAR) of the water will be collected by the Team [1,2]. This raw data will then be used to determine the water quality by using a model uploaded onto the Microcontroller.

B. Treatment of Water

Using the raw data collected in Segment A, a machine learning model uploaded onto the microcontroller will then determine whether the water quality is suitable for irrigation or not. Based on the quality of water, so determined, the Project will turn on the appropriate water pump, *i.e.*, treatment pump (in case of bad-quality water) or field water pump (in case of good-quality water).

C. Data Analysis and Visualization

The raw data will also be uploaded onto an online dashboard where it will be visualized and analysed on a long-term basis. This phase is an ‘add on’, in order to keep the local apparatus independent from the remote website.

2. Problem Statement

Ideally, water used for irrigation should be sufficiently clean and devoid of any harmful salt contents that could hinder the quality of crops.

According to paper on ‘Water Quality for Agriculture’ published by the Food and Agriculture Organization of the United Nations, water used for irrigation can vary greatly in quality depending upon type and quantity of dissolved salts [3]. The suitability of water for irrigation is determined by the total amount of salt present as well as by the kind of salt. Various soil and cropping problems may develop if the total salt content increases, and special management practices may be required to maintain acceptable crop yields.

Currently water quality is monitored through time consuming laboratory methods and with various costly sensors having low sensitivity which delays any action and is highly inefficient.

Our team proposes a cost effective and scalable solution where, with the help of machine learning models and sensors, water quality will be calculated and if it is unsuitable for irrigation, it would be redirected to a treatment facility.

This will ensure minimum wastage of water and provide the crops with a constant flow of suitable irrigation water, increasing the overall yield for the farmers. Moreover, better water quality will also help the soil’s pH levels to be stable, which may help the farmers by reducing their need for fertilisers.

3. Need Analysis

In present day water quality in general and microbial drinking and process water quality in particular, is monitored either through time consuming laboratory methods or various costly online sensors having low sensitivity. Water quality monitoring results are thus either delayed or insufficient to support proactive management action.

Our project aims to develop a monitoring system which aims to provide reliable sensors, an established IoT network to monitor water quality and a real time dashboard to analyse data and classify water as fit or unfit [4]. The monitoring system established by our project will be scalable and cost effective which will resolve the issue of non-scalable and costly monitoring methods.

Irrigation water quality is a critical aspect of crop production. There are many factors which determine water quality. Among the most important are alkalinity, pH and soluble salts. Poor quality of water is generally responsible for slow growth of the crop, poor aesthetic quality of the crop and, in some cases, can result in the gradual death of the plants. Poor water of quality leads to major losses for farmers and can also affect soil health.

Our project apart from making a monitoring system to determine the presence of unwanted elements in water will include an automated segregation element which will direct poor-quality water into treatment plant and the treated good-quality water into the field. Hence, the project will stop the poor-quality water from entering the fields, channelise it to treatment plant for making available good-quality water for the fields. The whole system developed will be automated, thereby facilitating not-so-technical savvy farmers to operate it with ease.

Water monitoring nano sensors have an increasing market to the extent that these nano sensors have a share of about 30% of the whole nano sensors market. In general, there is growing potential for investment in manufacturing of water monitoring nano sensors, and they will prove to be attractive investment for companies in future.

Since our project includes water monitoring sensors and a cost-effective IoT network, this stands in parallel to the technologies being developed by many start-ups and hence, is very much in demand.

4. Literature Survey

Signs of deteriorating water quality can be seen all over the world, in both developed and developing countries. The types, magnitudes and extents of water quality problems differ from one country to another, and even from one part of a country to another part. A number of private and public enterprises have been working in the field of assessment and management of water quality. Moreover, a few people have also tried to implement systems to keep the water quality in check, such as Brinda Das, P.C. Jain with *Real-*

Time Water Quality Monitoring System using Internet of Things [5], Joy Shah with *An Internet of Things Based Model for Smart Water Distribution with Quality Monitoring* [6] and Jeevan Jyoti Mohindru and Umesh Kumar Garg with *Hydro-Chemical and Physico-Chemical Monitoring of Groundwater in North-West Region of Punjab, India-A Study Involving Analysis of Major Ions, Heavy Metal Ions and other Related Parameters* [7]. An international journal, *Environmental Monitoring and Assessment,* also devotes itself in the progress of use of Monitoring Data in Assessing Environmental Risks to Man and the Environment [8].

Indices used for Water Quality Monitoring and Assessment:

i. **Chemical oxygen demand (COD):** This is the equivalent amount of oxygen consumed (measured in mg/l) in the chemical oxidation of all organic and oxidisable inorganic matter contained in a water sample.

ii. **Biochemical oxygen demand (BOD):** This is the oxygen requirement of all the organic content in water during the stabilisation of organic matter usually over period of three or five days

iii. **pH**: This is the measure of the acidity or alkalinity of water. It is neutral (at 7) for clean water and ranges from 1 to 14.

iv. **Dissolved oxygen (DO):** This is the amount of oxygen dissolved in a water sample (measured in mg/l).

v. **Turbidity:** This is the scattering of light in water caused by the presence of suspended solids. It can also be referred to as the extent of cloudiness in water measured in nephelometric turbidity units (NTU).

vi. **Electrical conductivity (EC):** This is the amount of electricity that can flow through water (measured in Siemens), and it is used to determine the extent of soluble salts in the water.

vii. **Temperature:** The is the degree of hotness or coldness of the water and usually measured in degrees Celsius (°C) or Kelvin (K).

viii. **Oxidation-reduction potential (ORP):** This is the potential required to transfer electrons from the oxidant to the reductant, and it is used as a qualitative measure of the state of oxidation in water.

ix. **Salinity:** This is the salt content of the water (measured in parts per million).

x. **Total Nitrogen (TN):** This is the total amount of nitrogen in the water (in mg/l) and is a measure of its potential to sustain and eutrophication or algal bloom.

xi. **Total phosphorus (TP):** This is the total amount of phosphorus in the water (in mg/l) and is a measure of its potential to sustain and eutrophication or algal bloom.

Analysis of specific studies

Table 1 : Review of certain studies related to our Project

Place/Name	Features Monitored	Technology used	Miscellaneous
Wang et al, Xinglin Bay in Xiamen, China [9].			Their system was divided into three subsystems- Data acquisition Digital data Data processing
Shafi et al. investigated the of surface water across 11 locations in Pakistan [10].	pH, Turbidity and Temperature	The algorithms considered were Support Vector Machine (SVM), k Nearest Neighbour (kNN), single-layer neural network and Deep neural network.	It was observed from the learning process on the 667 lines of data that deep neural network had the highest accuracy (at about 93%). The model could accurately predict water quality in the future six months.
Saravanan et al , Tamilnadu, India [11].	Monitored the turbidity, temperature and colour	Technology was usable in real-time and employed a GSM module for wireless data transfer.	Using a Supervisory Control and Data Acquisition Internet of Things for Water

			Quality Monitoring … 253 (SCADA) system that is enabled by IoT.
Liu et al. pumping station along the Yangtze river in Yangzhou, China [12].	Temperature, pH, DO, Conductivity, Turbidity, COD and NH3	IoT enabled but incorporated a Long Short-Term Memory (LSTM) deep learning neural network.	
Zin et al. Curtin Lake, northern Sarawak in the Borneo island [13].	pH, Turbidity, Temperature, Water level and Carbon dioxide	Wireless sensor network enabled by IoT system consisted of Zigbee wireless communication, protocol, FPGA and a personal computer.	

The above table contains information from *'Internet of Things for Water Quality Monitoring and Assessment: A Comprehensive Review'* in a simplified manner.

Existing Systems and Solutions

SWA1 [14]– Smart Water Analyzer, a highly sensitive, affordable spectrum sensor for continuous online monitoring and rapid detection of microbial contamination in water.

The water from the water source pipe is passed into the SWA-1 sensor, and flows through the sensor's inner channel. Two LED sources are installed at one end of the channel and emit light at various wavelengths, 260-300 nm and 750-900 nm respectively. A special sensitive receiver is installed at the opposite end of the channel. Emitted light beams pass through the water medium in the channel and encounter particles of various origin. As a result, light energy is absorbed by the particles, and the receiver identifies reduction in the energy power, as compared to that measured when the "baseline" water quality reference was established (which may be referred to as a "reference light energy" level).

VWM Solutions [15]**-** ColiMinder technology is based on direct measurement of specific metabolic (enzymatic) activity of target organisms present in the sample. The enzymatic approach directly measures the specific enzymatic activity present in the sample. The measured enzymatic activity per sample volume is used as a measure of the contamination.

The enzymatic measurement approach is the only rapid measurement approach that allows:

->Technology independent determination of contamination limits

->Calibration of devices independent of their measurement technology

5. Objectives

- To integrate different sensors and Wi-Fi module with an IoT device and build a cost-effective hardware setup [16].
- To process data from different sensors like SAR sensor, pH sensor humidity sensor etc. calibrate the readings and send it to web portal using the IoT device.
- To develop an interactive web dashboard to tabulate live readings from the sensors for the user.
- To perform analysis of data gathered from different sensors to determine quality of water and to classify water as good quality or bad quality and to generate a corresponding signal to IoT device to turn on the appropriate water pump, *i.e.,* treatment pump (in case of bad-quality water) or field water pump (in case of good-quality water).

6. Methodology

As discussed in the Project Overview, the project will be divided into three segments or phases.

Initially the field component will collect the temperature, pH value, turbidity and flow of water. Moreover, it will also be collecting data on the SAR value of the water.

$$SAR = \frac{Na^{+1}}{\sqrt{\frac{Ca^{+2} + Mg^{+2}}{2}}}$$

The SAR value will be specifically calibrated in conjunction with the Electronics (ECE) and Chemistry (CHE) departments of TIET, wherein the ECE department will be helping in the creation of the sensor, while the CHE department will be helping to analysis samples of water to calibrate the sensor.

This data will be collected by the sensors being connected to transmitting LORA modules which transmit data wirelessly through a WAN network, with a receiver connected to a microcontroller.

Moving onto the next phase, this data will be analysed with the help of a Machine Learning model uploaded directly onto the Microcontroller.

Using this analysis, the water can be directed to a treatment facility if it is unsuitable for irrigation, or any other intended use.

The data will also be uploaded online in the next phase and this data will be accessible by other Users online.

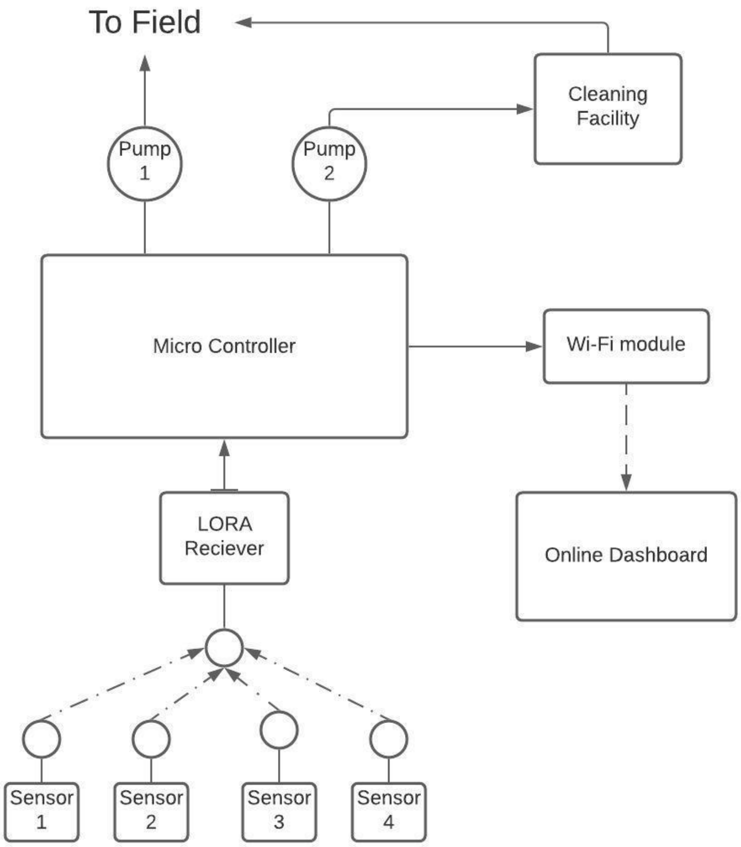

Figure 1: Block Diagram of architecture

As can be seen, Figure 1 is showing the simple block diagram of the project architecture.

The sensors will communicate with the Microcontroller via the LORAWAN which will activate either Pump 1 or Pump 2 depending on the water quality and all the data will be sent to the online Dashboard [17].

7. Project Outcomes

- Using concepts of machine learning, data regarding the quality of given water would be collected.
- A working online dashboard would be designed where the data can be uploaded and accessed by the user as and when required
- The capstone project is intended to help determine if the water quality is good enough to be used for irrigation, thus, leading to increase in yield of crops quantitatively as well as qualitatively.

8. Individual Roles

Umang Sharma (Team Leader): Implementation of the backend and collaborating the different technologies used in the project as well as the hardware and sensors used.

Suryansh Bhardwaj: Exploration and Implementation of the various Machine Learning algorithms that can be used and applied onto the data collected.

Prakhar Srivastava: Exploration and creation of the User Interface for the online Dashboard.

9. Workplan

Table 2: Predicted Distribution of Capstone Work

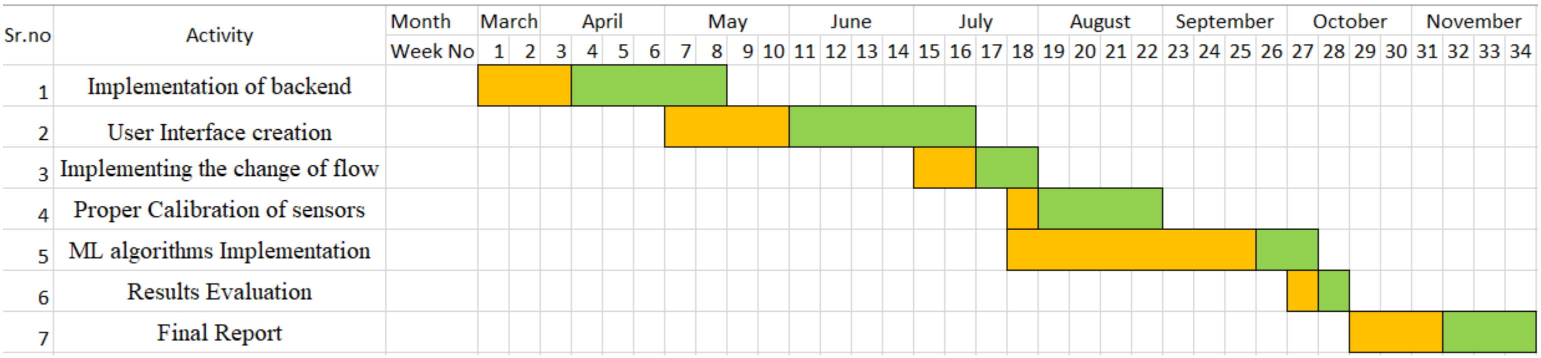

Table 2 shows the predicted workplan for the Capstone project with the Yellow bars indicating exploration of the activity, and the green one as the Implementation of said activity.

10. Course Subjects

The following subjects would be used for execution of Capstone project:

- For Pre-processing: Concepts of machine learning (regression analysis) will be used. (UCS409, UCS538, UML501)
- Computer programming will be used to write an efficient and neat code and basic html code will be used for the web interface. (UTA003, UTA018)

- The whole project will be put into a proper structure using the concepts of Software Engineering (UCS503)
- Arduino programming and microcontroller would be used for the sensors which will be designed in the capstone. The concept of IoT introduced in Engineering Design would be used. (UTA014)

References

[1] Sophia Karastogianni, Stella T. Girousi. pH: Principles and Measurement. December 2016. Available https://www.researchgate.net/publication/301702485_pH_Principles_and_Measurement

[2] E. J. Williamson, Frank Wiersma ,L. O. Fine. A Study of the Sodium Adsorption Ratio and Residual Sodium Carbonate Concepts of Irrigation Waters as They Affect Exchangeable Sodium of Soil Under Semiarid Conditions. Available

https://acsess.onlinelibrary.wiley.com/doi/abs/10.2136/sssaj1959.03615995002300040011x

[] D. W. R.S. Ayers, "WATER QUALITY EVALUATION: Food and Agriculture Organization of the United Nations," 1994. [Online]. Available: http://www.fao.org/3/t0234e/T0234E00.htm#TOC.

[4] IEEE Internet of Things Journal. Issue 6, March15,-2021.Available https://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=6488907

[5] B. Das, P. Jain. Real-time water quality monitoring system using internet of things, in 2017 International Conference on Computer, Communications and Electronics (Comptelix), Jaipur, Rajasthan India, 1–2 July 2017. IEEE

[6] J. Shah, An internet of things based model for smart water distribution with quality monitoring. Int. J. Innov. Res. Sci. Eng. Technol. 6(3), 3446–3451 (2017). Available http://dx.doi.org/10.15680/IJI RSET.2017.0603074

[7] Jeevan Jyoti Mohindru, Umesh Kumar Garg. Hydro-Chemical and Physico-Chemical Monitoring of Groundwater in North-West Region of Punjab, India- A Study Involving Analysis of Major Ions, Heavy Metal Ions and other Related Parameters, Vol. 33, No. 3.

[8] G. Bruce Wiersma (2021). Environmental Monitoring and Assessment Vol.193. Available https://www.springer.com/journal/10661

[9] S. Wang, Z. Zhang, Z. Ye, X. Wang, X. Lin, S. Chen, Application of environmental internet of things on water quality management of urban scenic river. Int. J. Sustain. Dev. World Ecology. 20(3), 216–222 (2013). https://doi.org/10.1080/13504509.2013.785040

[10] U. Shafi, R. Mumtaz, H. Anwar, A.M.Qamar, H. Khurshid, Surface water pollution detection using internet of things, in 2018 15th International Conference on Smart Cities: Improving Quality of Life Using ICT & IoT (HONET-ICT), Islamabad, Pakistan, 8–10h Oct 2018). IEEE

[11] K. Saravanan, E. Anusuya, R. Kumar, Real-time water quality monitoring using Internet of Things in SCADA. Environ. Monit. Assess. 190(9), 556 (2018). https://doi.org/10.1007/s10 661-018-6914-x

[12] P. Liu, J. Wang, A.K. Sangaiah, Y. Xie, X. Yin, Analysis and prediction of water quality using LSTM deep neural networks in IoT environment. Sustainability 11(7), 2058 (2019). https:// doi.org/10.3390/su11072058/

[13] M.C. Zin, G. Lenin, L.H.Chong, M. Prassana, Real-time water quality system in internet of things, in IOP Conference Series: Materials Science and Engineering, vol 495, no 1, p. 012021 (2019). http://dx.doi.org/10.1088/1757-899X/495/1/012021

[14] Alex Keinan , New equipment allows for sampling, testing water in real time(2017).Available https://www.foodengineeringmag.com/articles/96511-new-equipment-allows-for-sampling-testing-water-in-real-time

[15] VWM Vienna Water Monitoring Solutions. Source: www.vienna-water-monitoring.com

[16] IEEE Wireless Communications. Issue 1, February-2021.Available https://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=77422

[17] Ismail Butun, Nuno Pereira, Mikael Gidlund. Analysis of LoRaWAN v1.1 security: research paper (2018). Available https://www.researchgate.net/publication/325493576_Analysis_of_LoRaWAN_v11_security_research_paper