A

Mini Project

On

WATER QUALITY MONITORING AND FORECASTING SYSTEM

(Submitted in partial fulfillment of the requirements for the award of Degree)

BACHELOR OF TECHNOLOGY

in

COMPUTER SCIENCE AND ENGINEERING

by

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2020-2024

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

CERTIFICATE

This is to certify that the project entitled **"WATER QUALITY MONITORING AND FORECASTING SYSTEM"** being submitted by **KUSUMA VINAY KUMAR REDDY (207R1A0589), CHILUKA NARESH (207R1A0572), BEDUGOLLA VENKATA SAI (207R1A0568)** in partial fulfillment of the requirements for the award of the degree of B.Tech in Computer Science and Engineering to the Jawaharlal Nehru Technological University Hyderabad, is a record of bonafide work carried out by them under our guidance and supervision during the year 2022-23.

The results embodied in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

Water is a fundamental requirement for human, animal, and plant survival. Despite its importance, quality water is not always for drinking, domestic and/or industrial use. Numerous factors such as industrialization, mining, pollution, and natural occurrences impact the quality of water, as they introduce or alter various parameters present therein, thus, affecting its suitability for human consumption or general use. The World Health Organization has guidelines which stipulate the threshold levels of various parameters present in water samples intended for consumption or irrigation. The Water Quality Index (WQI) and Irrigation WQI (IWQI) are metrics used to express the level of these parameters to determine the overall water quality. Collecting water samples from different sources, measuring the various parameters present, and bench-marking these measurements against pre-set standards, while adhering to various guidelines during transportation and measurement can be extremely daunting. To this end this study proposes a network architecture to collect data on water parameters in real-time and use Machine Learning (ML) tools to automatically determine suitability of water samples for drinking and irrigation purposes. The developed monitoring network is based on LoRa and takes the land topology into consideration. Results of simulations done in Radio Mobile revealed a partial mesh network topology as the most adequate.

Due to the absence of large and open datasets on drinking and irrigation water, datasets usable for training ML models were developed. Three ML models - Random Forest (RF), Logistic Regression (LR) and Support Vector Machine (SVM) were considered for the water classification process and results obtained showed that LR performed best for drinking water, while SVM was better suited for irrigation water. Recursive feature elimination was then combined with the three ML models to reveal which of the water parameters had the greatest influence on the classification accuracies of the respective model.

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1. INTRODUCTION

1.INTRODUCTION

1.1 PROJECT SCOPE

The project aims to develop a real-time water quality monitoring network utilizing LPWAN technology, particularly LoRa, to collect data on various water parameters. This data will be processed using machine learning models to assess water suitability for drinking and irrigation. Recursive feature elimination will identify key parameters influencing classification accuracy. The network's topology will be designed to optimize data transmission, and genetic algorithms will aid in optimal monitoring station placement. Performance assessments of LPWAN technologies will be conducted through simulation and real-world testing. The project will provide valuable insights into water quality and offer a scalable, ethical, and cost-effective solution for monitoring and ensuring safe water resources.

1.2 PROJECT PURPOSE

The purpose of this project is to address the critical need for efficient and accurate water quality monitoring. By developing a real-time monitoring network, integrating machine learning for automated assessment, and optimizing station placement, the project aims to enhance access to safe drinking water and improve irrigation quality. Through the use of LPWAN technology like LoRa, the project seeks to establish a cost-effective and scalable solution capable of transmitting data over long distances. This initiative aligns with the broader goal of safeguarding water resources, mitigating the impact of pollution, and ensuring compliance with established quality standards, ultimately contributing to the well-being of communities and the environment.

1.3 PROJECT FEATURE

This project features real-time water quality monitoring through LPWAN technology, employing machine learning for automated assessment. It optimizes network topology based on land topology, identifies key water parameters, and benchmarks against standards for reliable data. Genetic algorithms aid in optimal station placement, and both simulation and real-world testing assess communication technology performance. Scalability and ethical considerations ensure a robust, responsible, and adaptable solution for safeguarding water resources.

2.SYSTEM ANALYSIS

2. SYSTEM ANALYSIS

System analysis is the important phase in the system development process. The System is studied to the minute details and analyzed. The system analyst plays an important role of an interrogator and dwells deep into the working of the present system.

In analysis, a detailed study of these operations performed by the system and their relationships within and outside the system is done. A key question considered here is, “what must be done to solve the problem?”

2.1 PROBLEM DEFINITION

The problem addressed by this project is the lack of a comprehensive and efficient water quality monitoring system, leading to challenges in ensuring safe drinking water and high-quality irrigation. Existing systems are often limited in real-time data collection, lack automation for assessment, and face difficulties in optimal station placement and communication technology selection. This project aims to overcome these issues by developing a holistic solution that integrates real-time monitoring, machine learning assessment, optimal station placement, and reliable communication technology to ensure water quality compliance and sustainability.

2.2 EXISTING SYSTEM

In , a network for measuring and monitoring water parameters in a metal producing city in Brazil was developed. Twelve water monitoring stations were setup to measure several physico-chemical water parameters, including pH, dissolved solids, Zinc, Lead etc. Finally, obtained results were analysed using principal component analysis. In a similar manner, developed a system to monitor water quality in Limpopo River Basin in Mozambique and set up 23 monitoring stations to measure physico-chemical and microbiological parameters, and ultimately assess the quality of water in the river basin.

Monitoring water parameters often entails periodically sampling a body of water to capture relevant metrics. These metrics might include physico-chemical and microbiological measurements, such as potential of hydrogen (pH), temperature, sodium levels etc. In a water monitoring network, measured parameters need to be transferred to a base station where relevant decision(s) would be taken. Due to the sparse nature of transmitted data, light weight communication protocols capable of transmitting relatively small data over long distance are required for water monitoring networks. From literature, Low Power Wide Area Network (LPWAN) technologies have been favoured for such applications. An extensive discussion on LPWAN technologies was done in . The work compared a few sub-GHz solutions including Sig-Fox, LoRa, Ingenu and Telensa, with respect to their range transmission rate, and channel count. Ingenu was reported to have the longest range in city settings at 15 km, followed by SigFox at 10 km and 50 km (irural areas); then LoRa at 5 km (in cities), and 15 km in rural settings.

Regarding the assessment of communication technologies, there has been a long-drawn debate over the efficacy of software simulations versus real-world testing. Though this debate still rages, several researchers have shown that simulation results are often at par with real-world tests. For instance, using LoRa, the authors in compared simulation results with real world test for intervehicle communication. They used NS3 as a simulation platform and an Arduino UNO C Dragino LoRa module for the real-world tests, while Propagation loss, coverage Packet Inter-reception (PIR), Packet Delivery Ratio (PDR) and Received Signal Strength Indicator (RSSI) level were used as benchmark metrics. They concluded that the results of the simulator were consistent with those of the real-world tests.

Hassan also compared the efficacy of simulation results (from Radio Mobile simulator) with real-world tests (using micro controllers C LoRa modules) when using LoRa as a bridge for Wi-Fi. Unlike , did not give a side-byside comparison of simulated vs. real-world results for each metric considered but concluded that the simulator performed well. set up seven pairs of XBee modules and compared communication performance using both the 800/900MHz and 2.4GHz frequencies. They concluded that simulation results from the Radio Mobile simulator corroborated with those of real-world tests.

2.2.1 DISADVANTAGES OF EXISTING SYSTEM

- An existing methodology doesn't implement DATA PRE-PROCESSING & LABELLING method.
- The system not implemented Calculating WQI for Irrigation Water for prediction in the datasets.

2. 3 PROPOSED SYSTEM

The water monitoring network proposed in this work is to be deployed in the City of Cape Town in Western Cape, South Africa, with the intention of monitoring water parameters in water storage dams and/or water treatment plants across the city. Data gathered by the monitoring network are then passed through Machine Learning (ML) models to determine their suitability for consumption or irrigation purposes.

- Build a network for real-time collection and monitoring of water quality across water storage dams in the city of Cape Town. This network takes into consideration the unique geographical features of Cape Town, such as mountains and elevations that might obstruct radio frequency propagation.
- Curate ample sized datasets on drinking and irrigation water that can be used to train (and test) machine learning models to automatically determine the `fitness for use'' of a sample of water for drinking and/or irrigation purposes.
- Build models that determine the most critical parameters that influence the accuracy of machine learning models in analyzing water for drinking or irrigation.

2.3.1 ADVANTAGES OF THE PROPOSED SYSTEM

- The purpose of WaterNet is to gather data on water parameters from dams across the city. These parameters are then used to assess the quality of water with regards ``fitness for use'' for drinking and irrigation purposes.
- In this work, rather than relying on instrumental and physico-chemical analysis carried out in laboratories to assess water parameters, we propose the use of machine learning (ML) models, which take the numerous water parameters into consideration and automatically determine if a sample of water is potable or fit for agricultural use.

2.4 FEASIBILITY STUDY

The feasibility of the project is analyzed in this phase and business proposals put forth with a very general plan for the project and some cost estimates. During system analysis the feasibility study of the proposed system is to be carried out. This is to ensure that the proposed system is not a burden to the company. For feasibility analysis, some understanding of the major requirements for the system is essential. Three key considerations involved in the feasibility analysis are

- ECONOMICAL FEASIBILITY
- TECHNICAL FEASIBILITY
- SOCIAL FEASIBILITY

2.4.1 ECONOMIC FEASIBILITY

This study is carried out to check the economic impact that the system will have on the organization. The amount of fund that the company can pour into the research and development of the system is limited. The expenditures must be justified. Thus the developed system as well within the budget and this was achieved because most of the technologies used are freely available. Only the customized products had to be purchased

2.4.2 TECHNICAL FEASIBILITY

This study is carried out to check the technical feasibility, that is, the technical requirements of the system. Any system developed must not have a high demand on the available technical resources. This will lead to high demands on the available technical resources. This will lead to high demands being placed on the client. The developed system must have a modest requirement, as only minimal or null changes are required for implementing this system.

2.4.3 SOCIAL FEASIBILITY

The aspect of study is to check the level of acceptance of the system by the user. This includes the process of training the user to use the system efficiently. The user must not feel threatened by the system, instead must accept it as a necessity. The level of acceptance by the users solely depends on the methods that are employed to educate the user about the system and to make him familiar with it. His level of confidence must be raised so that he is also able to make some constructive criticism, which is welcomed, as he is the final user of the system.

2.5 HARDWARE & SOFTWARE REQUIREMENTS

2.5.1 HARDWARE REQUIREMENTS:

Hardware interfaces specify the logical characteristics of each interface between the software product and the hardware components of the system. The following are some hardware requirements.

- Processor : intel i5
- RAM : 4 GB (min)
- Hard Disk : 20 GB
- Key Board : Standard Windows Keyboard
- Mouse : Two or Three Button Mouse
- Monitor : SVGA

2.5.2 SOFTWARE REQUIREMENTS:

Software Requirements specifies the logical characteristics of each interface and software components of the system. The following are some software requirements,

- Operating system : Windows 7 Ultimate.
- Coding Language : Python.
- Front-End : Python.
- Back-End : Django-ORM
- Designing : Html, css, javascript.
- Data Base : MySQL (WAMP Server).

3.ARCHITECTURE

3. ARCHITECTURE

3.1 PROJECT ARCHITECTURE

This project architecture shows the procedure followed for classification, starting from input to final prediction.

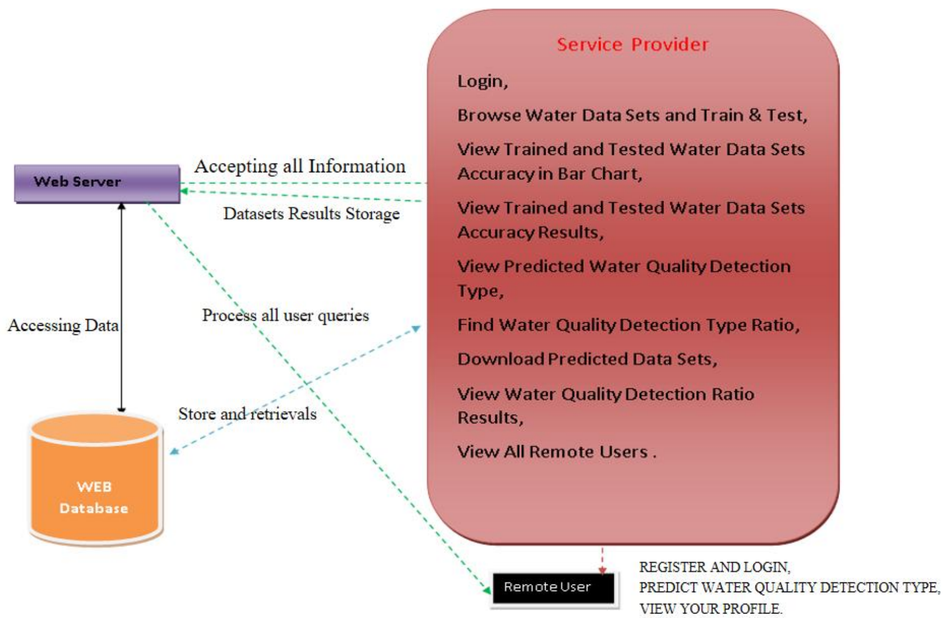

Figure 3.1 Water Quality Monitoring And Forecasting System

3.2 DESCRIPTION

The proposed architecture for this water quality monitoring system is a sophisticated framework that seamlessly integrates data collection, processing, and assessment. It encompasses a sensor network strategically placed to measure key water parameters, a central data hub utilizing machine learning models for automated assessment, and a robust communication infrastructure utilizing LPWAN technology like LoRa for efficient real-time data transmission. The network topology is optimized for land characteristics, while scalability and ethical considerations ensure a responsible and adaptable solution for safeguarding water resources and public health.

3.3 USE CASE DIAGRAM

In the use case diagram, we have basically one actor who is the user in the trained model.A use case diagram is a graphical depiction of a user's possible interactions with a system.

A use case diagram shows various use cases and different types of usersthe system has. The use cases are represented by either circles or ellipses. The actors are often shown as stick figures.

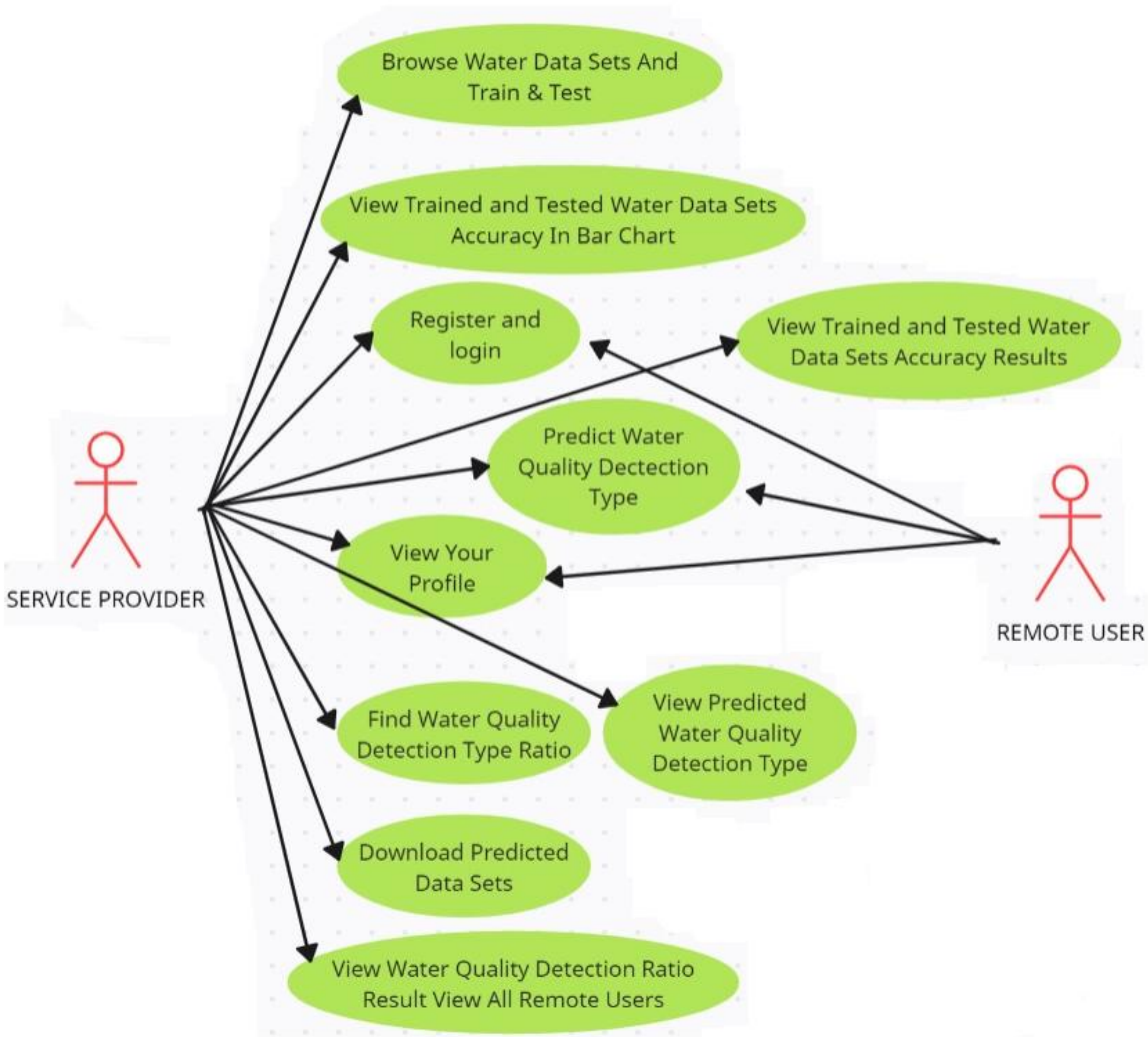

Figure 3.2: Use Case Diagram for Water Quality Monitoring And Forecasting System.

3.4 CLASS DIAGRAM

Class diagram is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among objects

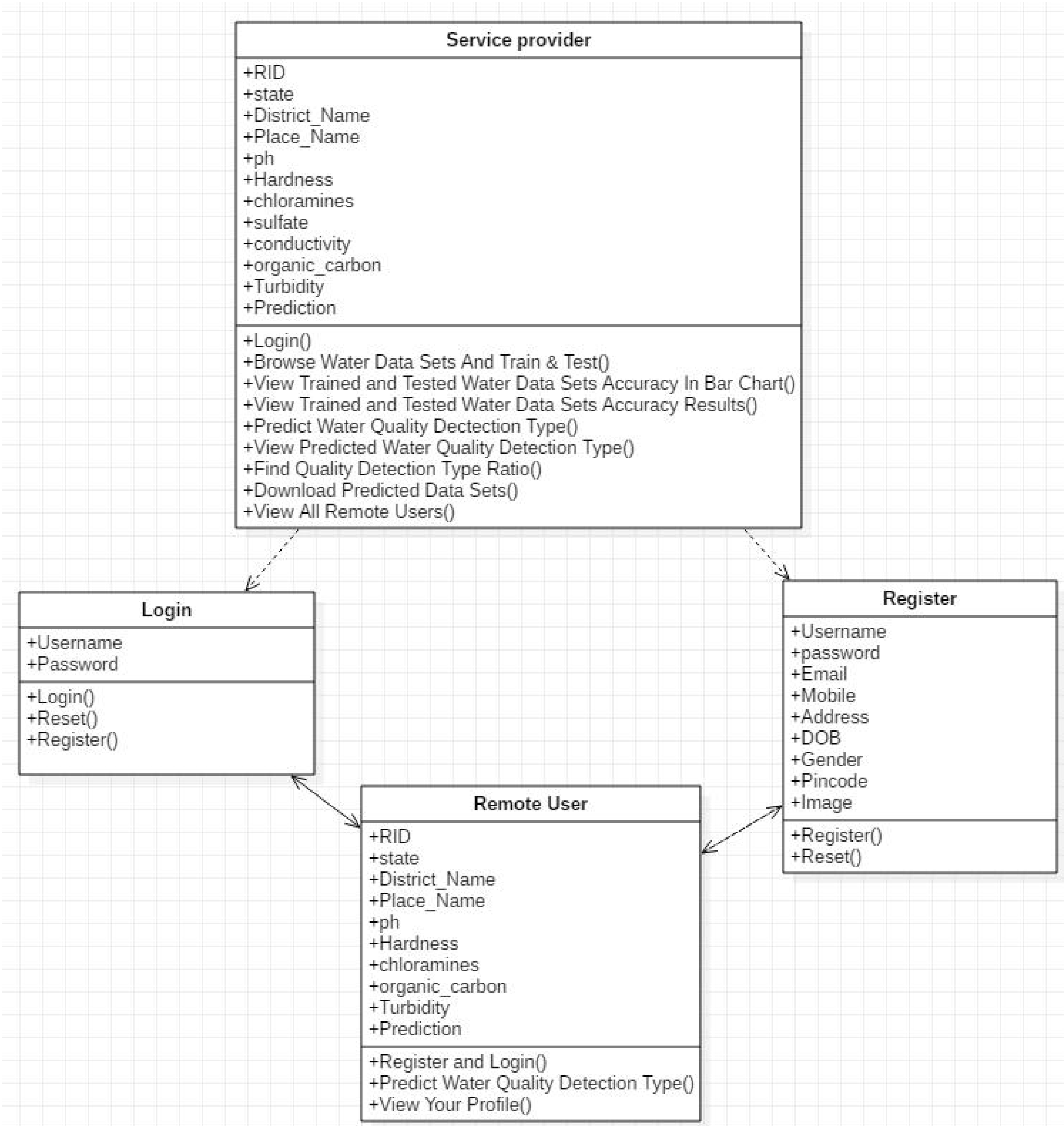

Figure 3.3: Class Diagram for Water Quality Monitoring And Forecasting System.

3.5 SEQUENCE DIAGRAM

A sequence diagram shows object interactions arranged in time sequence. It depicts the objects involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the logical view of the system under development.

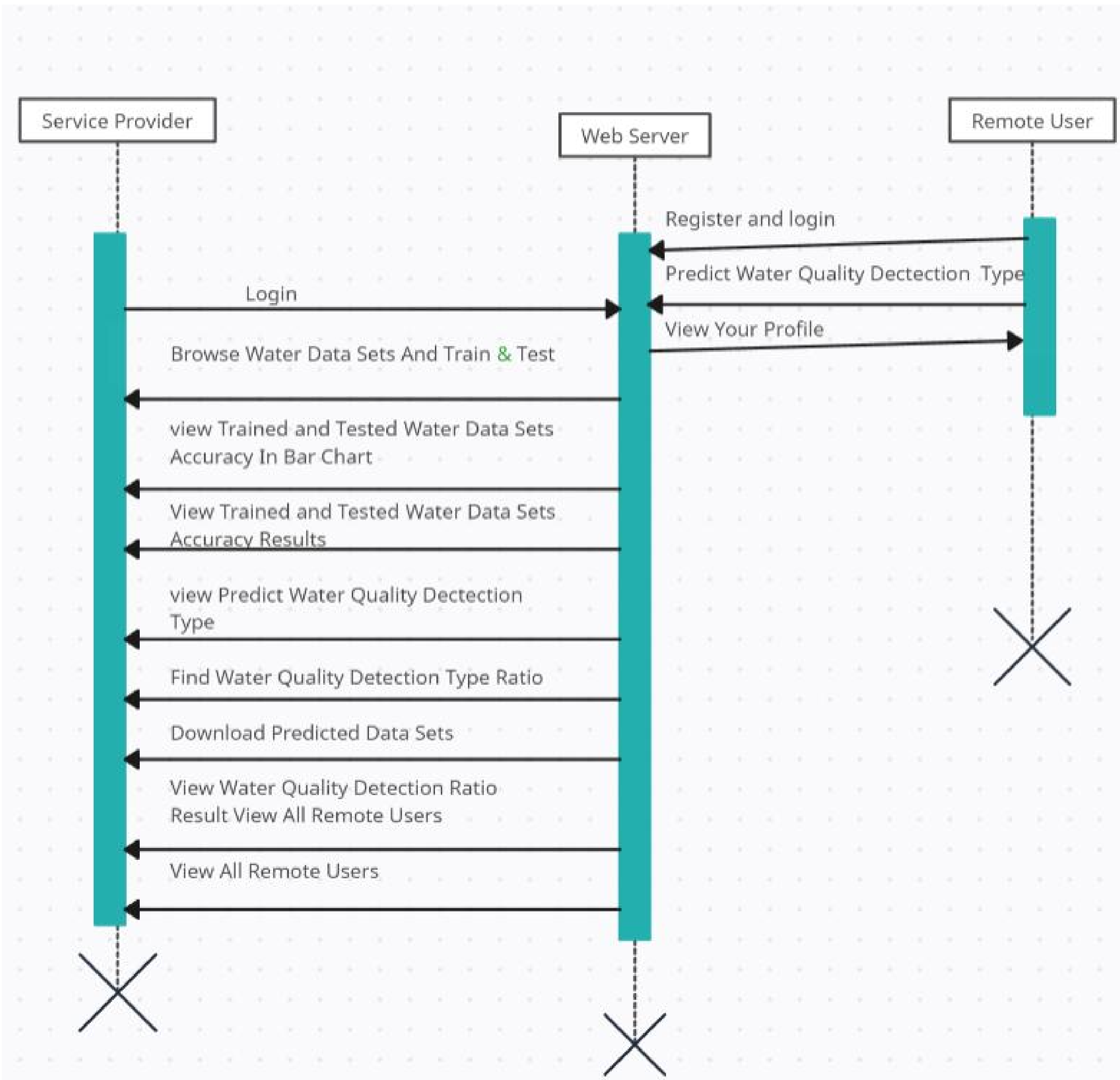

Figure 3.4: Sequence Diagram for Water Quality Monitoring And Forecasting System.

3.6 ACTIVITY DIAGRAM

Activity diagrams are graphical representations of workflows of stepwise activities and actions with support for choice, iteration and concurrency. They can alsoinclude elements showing the flow of data between activities through one or more datastores.

Remote User :

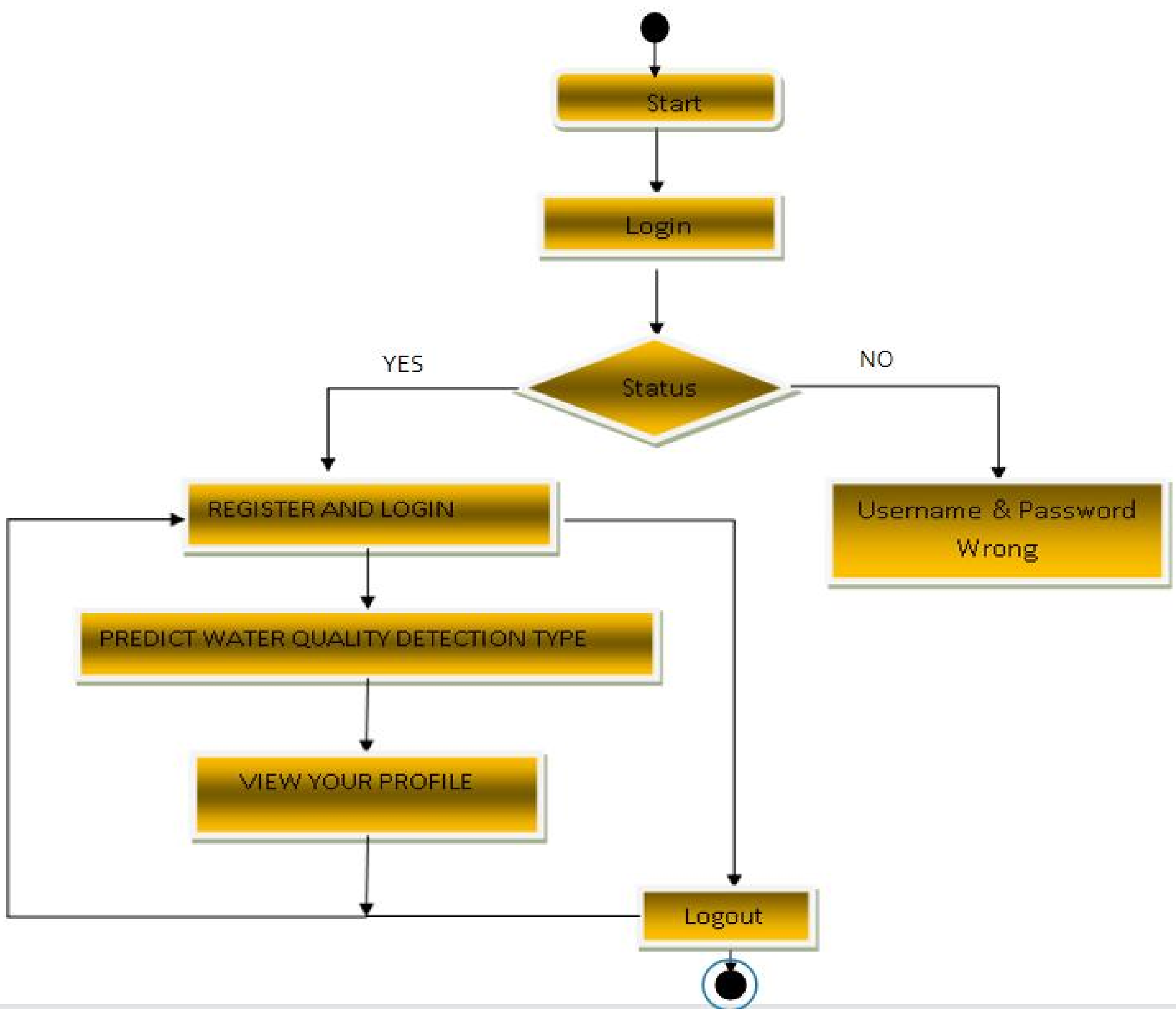

Figure 3.5: Activity Diagram for Water Quality Monitoring and Forecasting System

Service Provider :

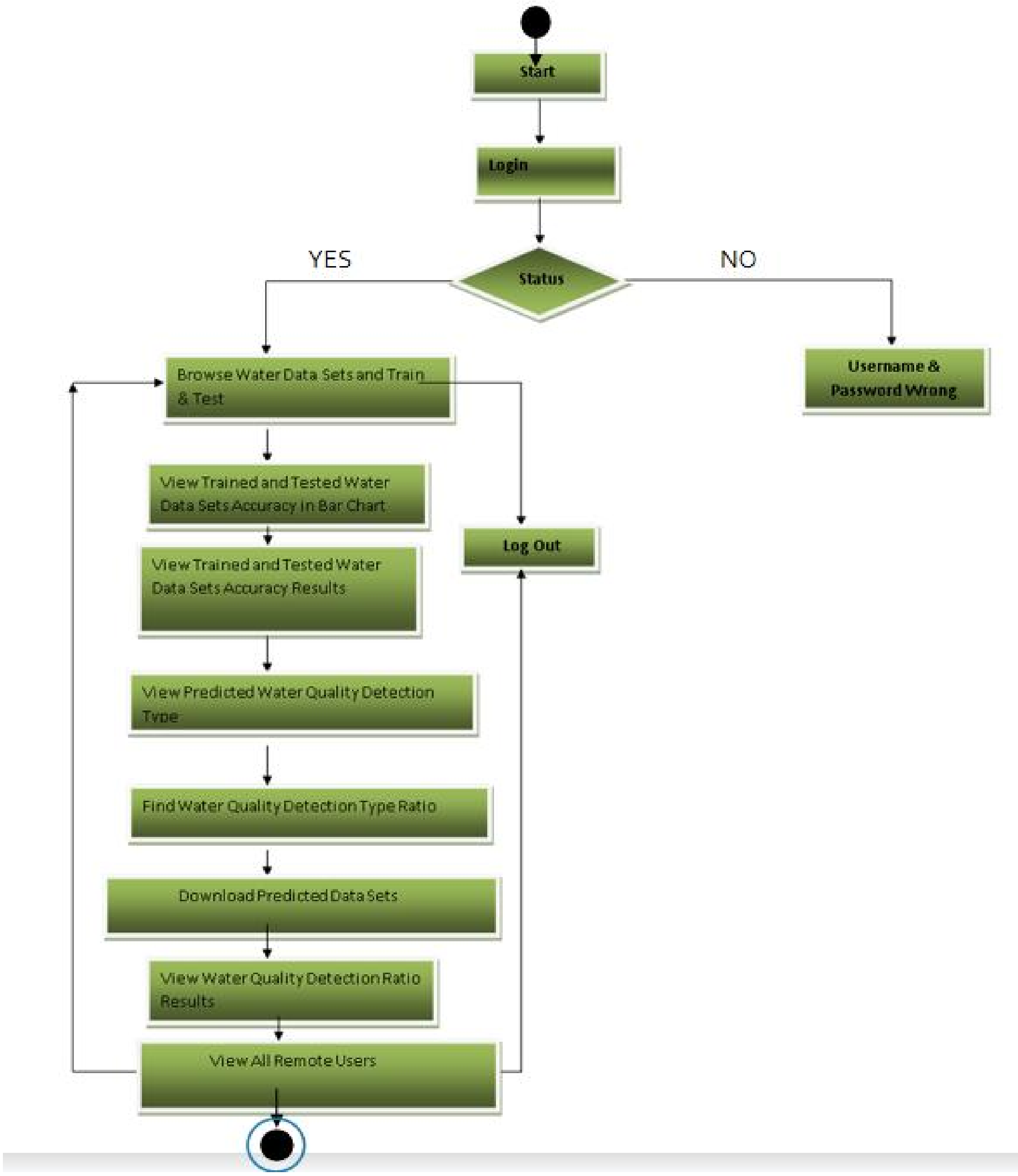

Figure 3.6: Activity Diagram for Water Quality Monitoring and Forecasting System

4.IMPLEMENTATION

4. IMPLEMENTATION

4.1 SAMPLE CODE

```
#!/usr/bin/env python
"""Django's command-line utility for administrative tasks."""
import os
import sys


def main():
    """Run administrative tasks."""
    os.environ.setdefault('DJANGO_SETTINGS_MODULE', 'waternet.settings')
    try:
        from django.core.management import execute_from_command_line
    except ImportError as exc:
        raise ImportError(
            "Couldn't import Django. Are you sure it's installed and "
            "available on your PYTHONPATH environment variable? Did you "
            "forget to activate a virtual environment?"
        ) from exc
    execute_from_command_line(sys.argv)


if __name__ == '__main__':
    main()
```

```
import os

# Build paths inside the project like this: os.path.join(BASE_DIR, ...)
BASE_DIR = os.path.dirname(os.path.dirname(os.path.abspath(__file__)))


# Quick-start development settings - unsuitable for production
# See https://docs.djangoproject.com/en/3.0/howto/deployment/checklist/

# SECURITY WARNING: keep the secret key used in production secret!
SECRET_KEY = 'm+1edl5m-5@u9u!b8-=4-4mq&o1%agco2xpl8c!7sn7!eowjk#'

# SECURITY WARNING: don't run with debug turned on in production!
DEBUG = True

ALLOWED_HOSTS = []


# Application definition

INSTALLED_APPS = [
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.staticfiles',
    'Remote_User',
    'Service_Provider',
]


MIDDLEWARE = [
    'django.middleware.security.SecurityMiddleware',
    'django.contrib.sessions.middleware.SessionMiddleware',
    'django.middleware.common.CommonMiddleware',
    'django.middleware.csrf.CsrfViewMiddleware',
    'django.contrib.auth.middleware.AuthenticationMiddleware',
    'django.contrib.messages.middleware.MessageMiddleware',
    'django.middleware.clickjacking.XFrameOptionsMiddleware',
]

ROOT_URLCONF = 'waternet.urls'
```

```
TEMPLATES = [
    {
        'BACKEND': 'django.template.backends.django.DjangoTemplates',
        'DIRS': [(os.path.join(BASE_DIR,'Template/htmls'))],
        'APP_DIRS': True,
        'OPTIONS': {
            'context_processors': [
                'django.template.context_processors.debug',
                'django.template.context_processors.request',
                'django.contrib.auth.context_processors.auth',
                'django.contrib.messages.context_processors.messages',
            ],
        },
    },
]

WSGI_APPLICATION = 'waternet.wsgi.application'

# Database
# https://docs.djangoproject.com/en/3.0/ref/settings/#databases

DATABASES = {
    'default': {
        'ENGINE': 'django.db.backends.mysql',
        'NAME': 'waternet',
        'USER':'root',
        'PASSWORD': '',
        'HOST' :'127.0.0.1',
        'PORT' :'3306',
    }
}

# Password validation
# https://docs.djangoproject.com/en/3.0/ref/settings/#auth-password-validators

AUTH_PASSWORD_VALIDATORS = [
    {
        'NAME':
'django.contrib.auth.password_validation.UserAttributeSimilarityValidator',
    },
    {
        'NAME': 'django.contrib.auth.password_validation.MinimumLengthValidator',
    },
    {
        'NAME': 'django.contrib.auth.password_validation.CommonPasswordValidator',
    },
```

```
    {
        'NAME': 'django.contrib.auth.password_validation.NumericPasswordValidator',
    },
]


# Internationalization
# https://docs.djangoproject.com/en/3.0/topics/i18n/

LANGUAGE_CODE = 'en-us'

TIME_ZONE = 'UTC'

USE_I18N = True

USE_L10N = True

USE_TZ = True


# Static files (CSS, JavaScript, Images)
# https://docs.djangoproject.com/en/3.0/howto/static-files/

STATIC_URL = '/static/'
STATICFILES_DIRS = [os.path.join(BASE_DIR,'Template/images')]
MEDIA_URL = '/media/'
MEDIA_ROOT = os.path.join(BASE_DIR, 'Template/media')

STATIC_ROOT = '/static/'

STATIC_URL = '/static/'
```

5.SCREENSHOTS

SCREENSHOTS

5.1 LOGIN :

User must login with username and password if user doesn't exist user need to register in this application by necessary details.

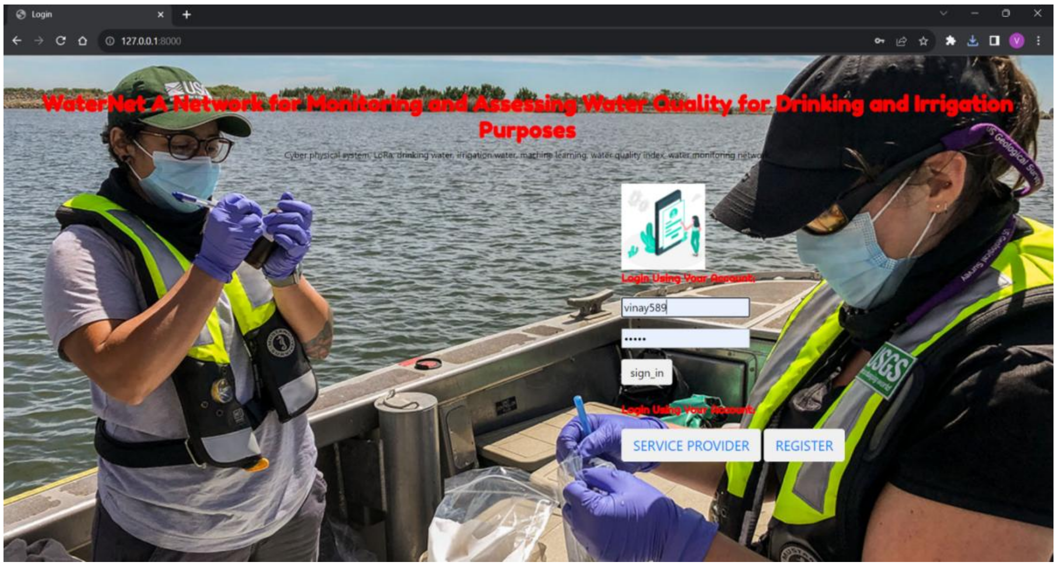

FIGURE 5.1: Login

5.2 ACCOUNT STATUS :

The users can view their profile details like Username,Mobile,Address,State,Email id,Country,City.

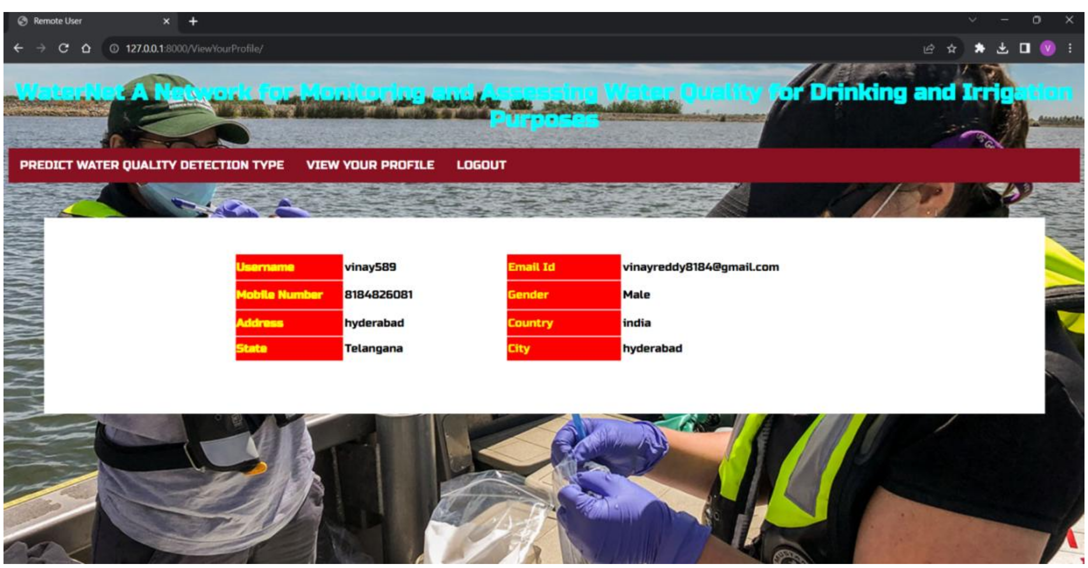

FIGURE 5.2: Account Status

5.3 PREDICTION

User has to give the water quality parameters values to predict the water quality.

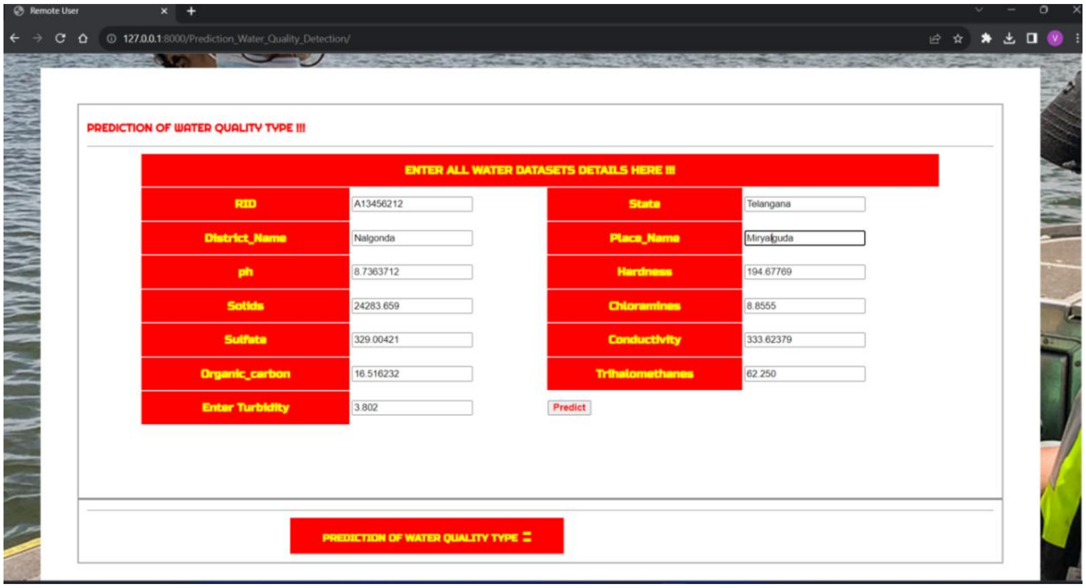

FIGURE 5.3: Prediction

5.4 PREDICTION WATER QUALITY

After user entering all the water quality parameters values user need to click the predict and it will predict whether it is useful for irrigation water or Drinking Water.

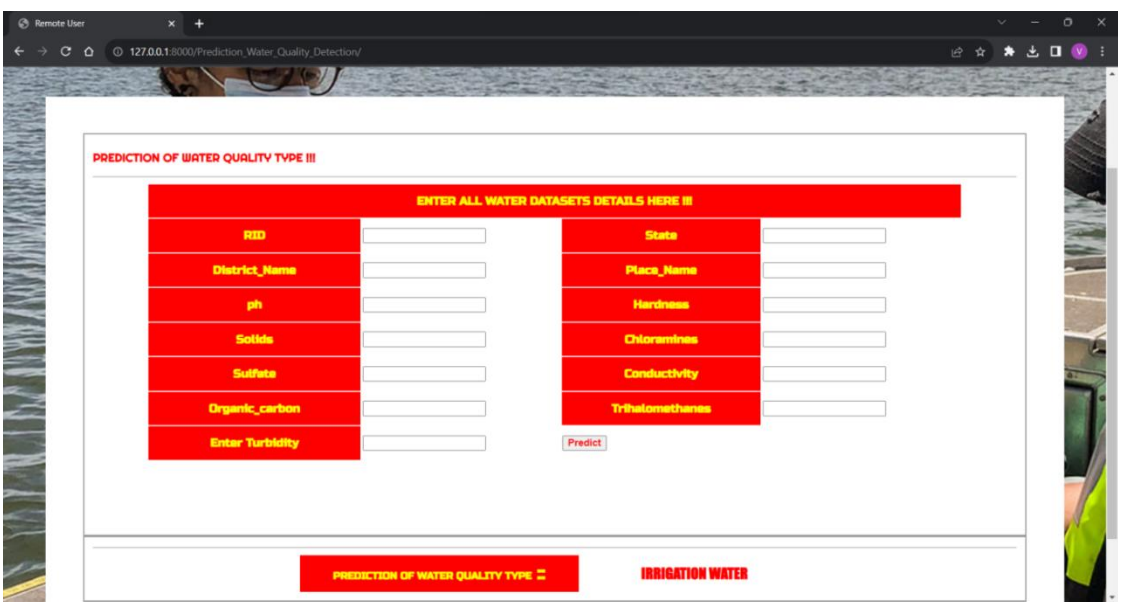

FIGURE 5.4: Prediction Water Quality

5.5 REGISTERED USERS :

Service Provider can view all the registered remote users and their details like Username,Email,Gender,Address,Mobile No,Country,State,City and also can view predicted water quality data.

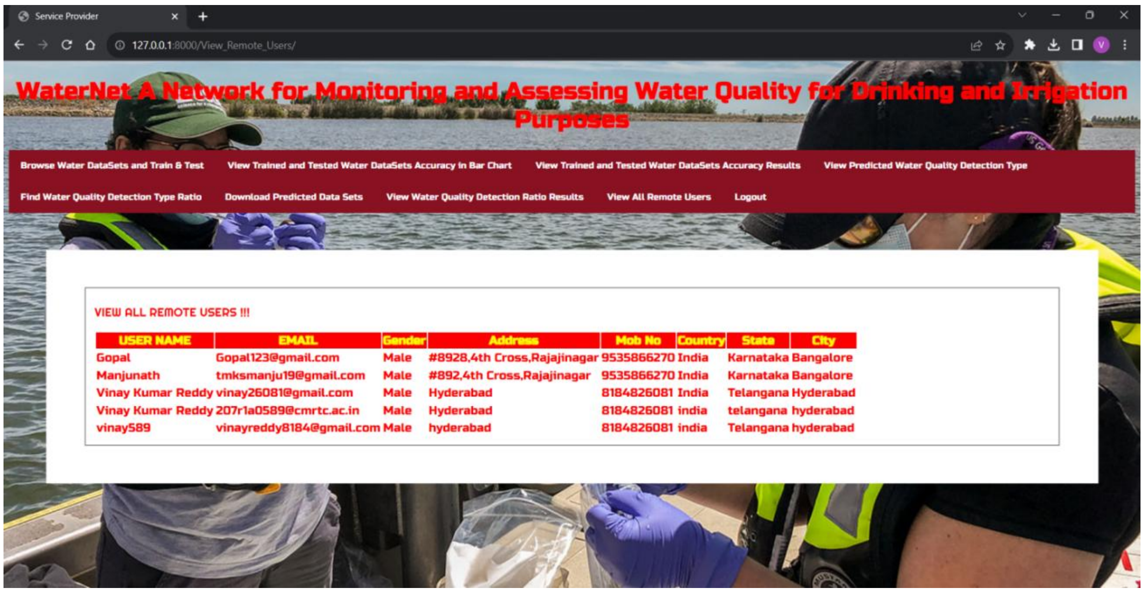

FIGURE 5.5: Registered Users

6.TESTING

6.TESTING

6.1 INTRODUCTION TO TESTING

The purpose of testing is to discover errors. Testing is the process of trying to discover every conceivable fault or weakness in a work product. It provides a way to check the functionality of components, subassemblies, assemblies and/or a finished product. It is the process of exercising software with the intent of ensuring that the Software system meets its requirements and user expectations and does not fail in an unacceptable manner. There are various types of tests. Each test type addresses a specific testing requirement

6.2 TYPES OF TESTING

6.2.1 UNIT TESTING

Unit testing involves the design of test cases that validate that the internal program logic is functioning properly, and that program inputs produce valid outputs. All decision branches and internal code flow should be validated. It is the testing of individual software units of the application. It is done after the completion of an individual unit before integration. This is a structural testing that relies on knowledge of its construction and is invasive. Unit tests perform basic tests at component level and test a specific business process, application and/or system configuration. Unit tests ensure that each unique path of a business process performs accurately to the documented specifications and contains clearly defined inputs and expected results.

6.2.2 INTEGRATION TESTING

Integration tests are designed to test integrated software components to determine if they actually run as one program. Integration tests demonstrate that although the components were individually satisfactory, as shown by successfully unit testing, the combination of components is correct and consistent. Integration testing is specifically aimed at exposing the problems that arise from the combination of components.

6.2.3 FUNCTIONAL TESTING

Functional tests provide systematic demonstrations that functions tested are available as specified by the business and technical requirements, system documentation, and user manuals.

Functional testing is centered on the following items:

Valid Input : identified classes of valid input must be accepted.

Invalid Input : identified classes of invalid input mustbe rejected.

Functions : identified functions must be exercised.

Output : identified classes of application outputsmust be exercised.

Systems/Procedures : interfacing systems or procedures must be invoked.

6.3 TEST CASES

6.3.1 CLASSIFICATION

Test Case ID	Test Case Description	Expected Outcome	Status
01	Data Validation Test	Validate that incoming data falls within acceptable ranges.	Passed
02	Predictive Model Accuracy Test	Validate the accuracy of water quality predictions against actual data.	Passed
03	User Access Control Test	Check that different user roles have appropriate data access.	Passed

7.CONCLUSION

7.CONCLUSION & FUTURE SCOPE

7.1 PROJECT CONCLUSION

This work focused on two major concept, firstly, the proposal of a real-time water monitoring network for gathering data on water parameters from water bodies. Secondly, the application of machine learning (ML) models as means of assessing water quality. The developed water monitoring network is based on Lo Ra, a low power long range protocol for data transmission, and was developed using the City of Cape Town as case study. Results of the simulation done in Radio Mobile, revealed a partial mesh network topology as the most adequate network to cover the city. Data gathered from this monitoring network would ideally be aggregated on a Cloud server, where ML models can then be applied to assess the water's fitness of use for drinking or irrigation purposes. Due to the absence of relevant datasets, two suitable datasets were built in this work and used to training and testing three ML models considered, which are Random Forest (RF), Logistic Regression (LR) and Support Vector Machine (SVM). Results of the test showed that LR performed best for drinking water, as it gave the highest classification accuracy and lowest false positive and negative values, while SVM was better suited for irrigation water. Finally, a model for identifying the most influential water parameter(s) w.r.t classification accuracies of the ML models was then explored using recursive feature elimination (RFE). Obtained results showed that pH, and total hardness were the least influential parameters in drinking water, while SSP was the least for irrigation water.

7.2 FUTURE SCOPE

These future goals should be aligned with the overarching mission of the project, which is likely to involve safeguarding water resources, protecting public health, and preserving ecosystems. The project should remain adaptable and responsive to the changing needs of the environment and society

8.REFERENCES

8.1 REFERENCES

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8.2 GITHUB LINK

https://github.com/vinayreddy2/Water-Quality-Monitoring-MINI-PROJECT