PROJECT REPORT

PROJECT NAME: EFFICIENT WATER QUALITY ANALYSIS AND PREDICTION USING MACHINE LEARNING

TEAM ID:PNT2022TMID11573

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CHAPTER 1
INTRODUCTION
1.1 Project Overview:

Water quality analysis is a complex topic due to the different factors that influence it. This concept is inextricably linked to the various purposes for which water is used. Different needs necessitate different standards. There is a lot of study being done on water quality prediction. Water quality is normally determined by a set of physical and chemical parameters that are closely related to the water's intended usage. The acceptable and unacceptable values for each variable must then be established. Water that meets the predetermined parameters for a specific application is considered appropriate for that application. If the water does not fulfill these requirements, it must be treated before it may be used. Water quality can be assessed using a variety of physical and chemical properties. As a result, studying the behavior of each individual variable independently is not possible in practice to accurately describe water quality on a spatial or temporal basis.

The ecosystem and human health are directly impacted by the water quality. Water is used for many different things, including drinking, farming, and industrial uses. A crucial indicator of effective water management is the water quality index (WQI). The aim of this work was to classify a dataset of water quality in various locations across India using machine learning techniques including RF, NN, MLR, SVM, and BTM. Features including dissolved oxygen (DO), total coliform (TC), biological oxygen demand (BOD), nitrate, pH, and electric conductivity determine the quality of water (EC). These characteristics are handled in five steps: feature correlation, applied machine learning classification, model's feature significance, and data pre-processing utilizing min-max normalization and missing data management using RF.

1.2 Purpose:

The quality of water is a major concern for people living in urban areas. The quality of water serves as a powerful environmental determinant and a foundation for the prevention and control of waterborne diseases. However, predicting the urban water quality is a challenging task since the water quality varies in urban spaces non-linearly and depends on multiple factors, such as meteorology, water usage patterns, and land uses. The purpose of this project is to Predict Water Quality by considering all water quality standard indicators.

CHAPTER 2

LITERATURE SURVEY

2.1 EXISTING PROBLEM:

For testing the water quality we have to conduct lab tests on the water which is costly and time-consuming as well. So, in this paper, we propose an alternative approach using artificial intelligence to predict water quality. This method uses a significant and easily available water quality index which is set by the WHO(World Health Organisation). The data taken in this paper is taken from the PCPB India which includes 3277 examples of the distinct wellspring. In this paper, WQI(Water Quality Index) is calculated using AI techniques. So in future work, we can integrate this with an IoT based framework to study large datasets and to expand our study to a larger scale. By using that it can predict the water quality fast and more accurately than any other IoT framework. That IoT framework system uses some limits for the sensor to check the parameters like ph, Temperature, Turbidity, and so on. And further after reading this parameter pass these readings to the Arduino microcontroller and ZigBee handset for further prediction.

2.2 REFERENCES:

Machine learning algorithms for efficient water quality prediction: A Review of literature Jamal Mabrouki, Ghizlane Fattah, Azedine Guezzaz, Faissal Aziz, 2021

Water is an essential resource for human existence. In fact, more than 60% of the human body is made up of water. Our bodies consume water in every cell, in the different organisms and in the tissues. Therefore, to design a model that predicts water quality is nowadays very important to control water pollution, as well as to alert users in case of poor quality detection. The method we propose is based on four water parameters: temperature, pH, turbidity and coliforms. The use of the multiple regression algorithms has proven to be important and effective in predicting the water quality index. Water quality predicting is a key and primary task in the context of the environmental control strategy. Certainly, the accuracy of predictions will surely contribute significantly to more appropriate conservation of water resources. In this research paper, our goal is to suggest a model for predicting water quality based on machine learning algorithms and with minimal parameters. Machine learning is an analytical approach of data expected to make the analysis model more automatic.

Efficient water quality prediction models based on machine learning: A Review of literature Nainital Lake, Uttarakhand

Water quality deterioration increases day by day in hilly areas due to increasing tourism activity, unplanned construction, disposal of solid waste, improper sewage management. With this idea, the work investigates different machine learning algorithms to evaluate the water quality index (WQI) and the water quality class (WQC). This paper utilizes Nainital Lake as a study area. The models used for testing and training comprise algorithms of machine learning for both binary and multiclass classification. In this paper, eight machine learning algorithms were employed for regression analysis, and nine machine learning algorithms were used for classification analysis. The result demonstrates that in regression analysis, the Random Forest algorithm comes out to be the most efficient Machine Learning algorithm. However, in the case of classification analysis, no single algorithm is good enough for prediction, three algorithms Stochastic Gradient Descent, Random Forest, and Support Vector Machine with the same accuracy proved to be efficient to predict water quality.

Evaluation of E. coli in sediment for assessing irrigation water quality using machine learning

Fresh produce irrigated with contaminated water poses a substantial risk to human health. This study evaluated the impact of incorporating sediment information on improving the performance of machine learning models to quantify E. coli level in irrigation water. Field samples were collected from irrigation canals in the Southwest U.S., for which meteorological, chemical, and physical water quality variables as well as three additional flow and sediment properties: the concentration of E. coli in sediment, sediment median size, and bed shear stress. Water quality was classified based on E. coli concentration exceeding two standard levels: 1 E. coli and 126 E. coli colony forming units (CFU) per 100 ml of irrigation water. Two series of features, including (FIS) and excluding (FES) sediment features, were selected using multi-variant filter feature selection. The correlation analysis revealed the inclusion of sediment features improves the correlation with the target standards for E. coli compared to the models excluding these features. Support vector machines, logistic regression, and ridge classifiers were tested in this study. The support vector machine model performed the best for both targeted standards. Besides, incorporating sediment features improved all models' performance.

machine learning in water quality evaluation : A Review of literature MengyuanZhu,JiaweiWang,XiaoYang,2022.

With the rapid increase in the volume of data on the aquatic environment, machine learning has become an important tool for data analysis, classification, and prediction. Unlike traditional models used in water-related research, data-driven models based on machine learning can efficiently solve more complex nonlinear problems. In water environment research, models and conclusions derived from machine learning have been applied to the construction, monitoring, simulation, evaluation, and optimization of various water treatment and management systems. Additionally, machine learning can provide solutions for water pollution control, water quality improvement, and watershed ecosystem security management. In this review, we describe the cases in which machine learning algorithms have been applied to evaluate the water quality in different water environments, such as surface water, groundwater, drinking water, sewage, and seawater. Furthermore, we propose possible future applications of machine learning approaches to water environments.

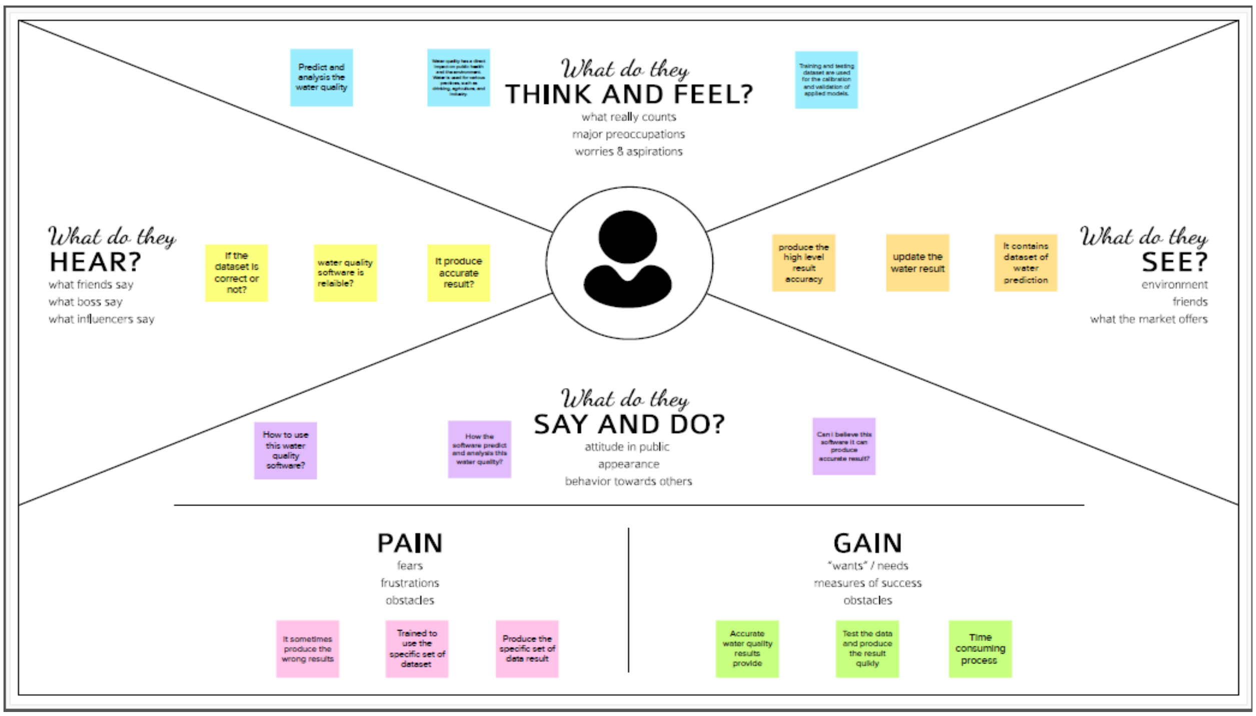
2.3 Problem statement definition:

Water is considered as a vital resource that affects various aspects of human health and lives. The quality of water is a major concern for people living in urban areas. The quality of water serves as a powerful environmental determinant and a foundation for the prevention and control of waterborne diseases. However predicting the urban water quality is a challenging task since the water quality varies in urban spaces non-linearly and depends on multiple factors, such as meteorology, water usage patterns, and land uses, so this project aims at building a Machine Learning (ML) model.

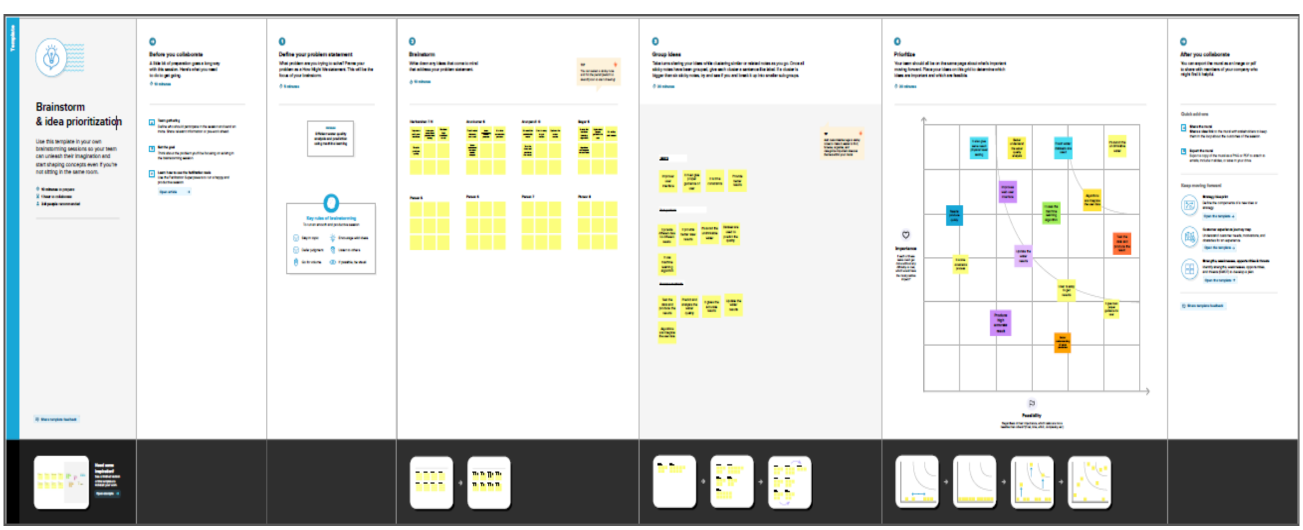
CHAPTER 3

IDEATION PHASE

3.1 EMPATHY MAP CANVAS:



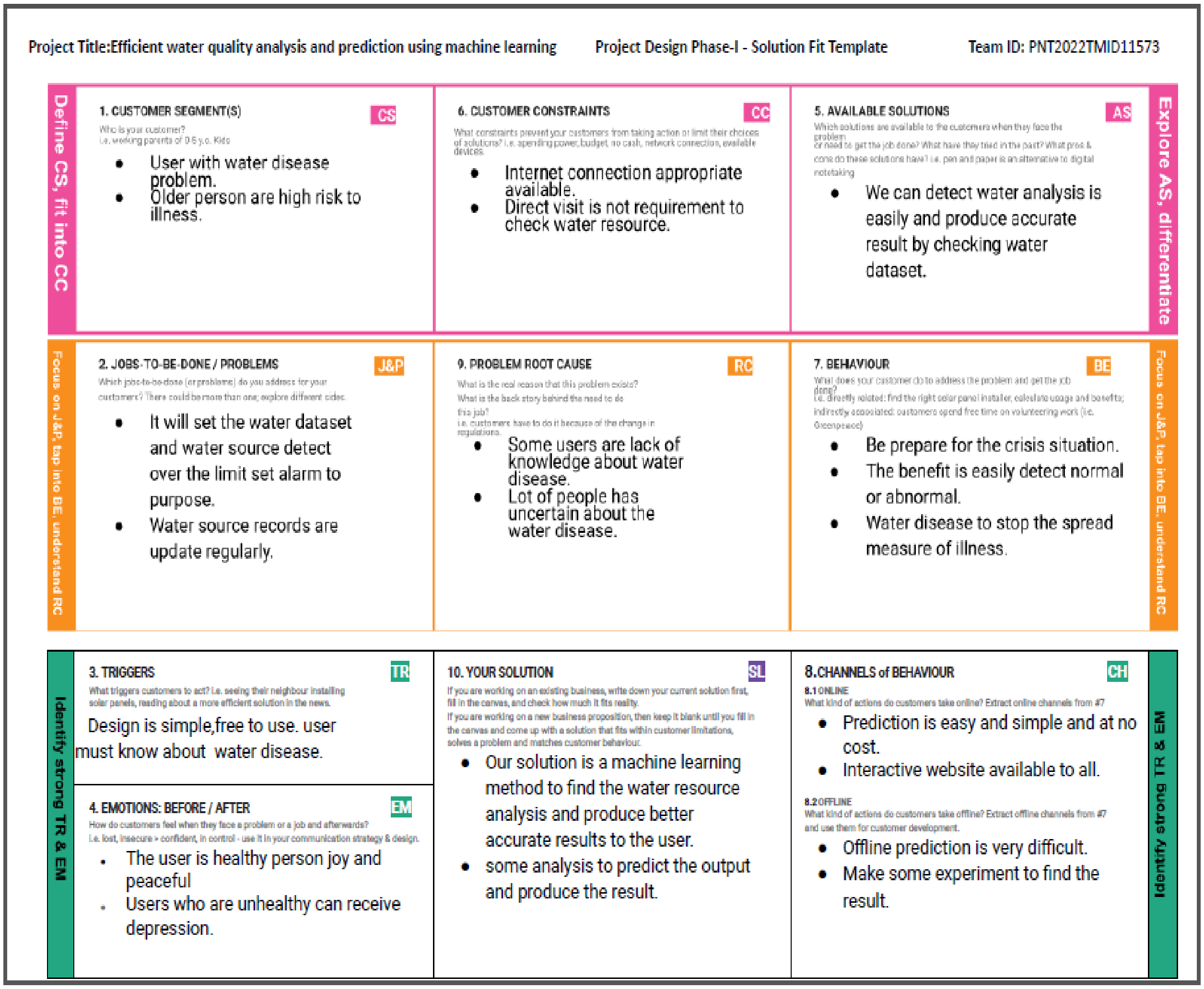
3.2 IDEATION & BRAINSTORMING:



3.3 PROPOSED SOLUTION:

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	The software has been developed to predict and analysis the water quality and produce better result.
2.	Idea / Solution description	Collect the water quality analysis dataset and create user interacts with the UI (User Interface) to enter Data. The entered data is analyzed by the model which is integrated. Once model analyses the input the prediction is showcased on the UI.
3.	Novelty / Uniqueness	The water has highly polluted then show the alertness to the user.
4.	Social Impact / Customer Satisfaction	To produce better water quality prediction Can drive to the vision of healthy nation. It can be identify the accurate level of water.
5.	Business Model (Revenue Model)	It been sell our service/product to water purifier companies. Can collaborate with governments in analysing and providing the water quality solutions.
6.	Scalability of the Solution	It provides the better accuracy of water quality. Easy to identify the ph level, temperature.

3.4 PROBLEM SOLUTION FIT:



Project Title:Efficient water quality analysis and prediction using machine learning | Project Design Phase-I - Solution Fit Template | Team ID: PNT2022TMID11573

Define CS, fit into CC

1. CUSTOMER SEGMENT(S) CS

Who is your customer?
i.e. working parents of 0-5 y.o. Kids

- User with water disease problem.
- Older person are high risk to illness.

6. CUSTOMER CONSTRAINTS CC

What constraints prevent your customers from taking action or limit their choices of solutions? i.e. spending power, budget, no cash, network connection, available devices.

- Internet connection appropriate available.
- Direct visit is not requirement to check water resource.

5. AVAILABLE SOLUTIONS AS

Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? i.e. pen and paper is an alternative to digital notetaking

- We can detect water analysis is easily and produce accurate result by checking water dataset.

Explore AS, differentiate

Focus on J&P, tap into BE, understand RC

2. JOBS-TO-BE-DONE / PROBLEMS J&P

Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one; explore different sides.

- It will set the water dataset and water source detect over the limit set alarm to purpose.
- Water source records are update regularly.

9. PROBLEM ROOT CAUSE RC

What is the real reason that this problem exists? What is the back story behind the need to do this job?
i.e. customers have to do it because of the change in regulations.

- Some users are lack of knowledge about water disease.
- Lot of people has uncertain about the water disease.

7. BEHAVIOUR BE

What does your customer do to address the problem and get the job done?
i.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (i.e. Greenpeace)

- Be prepare for the crisis situation.
- The benefit is easily detect normal or abnormal.
- Water disease to stop the spread measure of illness.

Focus on J&P, tap into BE, understand RC

Identify strong TR & EM

3. TRIGGERS TR

What triggers customers to act? i.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news.

Design is simple,free to use. user must know about water disease.

4. EMOTIONS: BEFORE / AFTER EM

How do customers feel when they face a problem or a job and afterwards?
i.e. lost, insecure > confident, in control - use it in your communication strategy & design.

- The user is healthy person joy and peaceful
- Users who are unhealthy can receive depression.

10. YOUR SOLUTION SL

If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality.
If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behaviour.

- Our solution is a machine learning method to find the water resource analysis and produce better accurate results to the user.
- some analysis to predict the output and produce the result.

8.CHANNELS of BEHAVIOUR CH

8.1 ONLINE
What kind of actions do customers take online? Extract online channels from #7

- Prediction is easy and simple and at no cost.
- Interactive website available to all.

8.2 OFFLINE
What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.

- Offline prediction is very difficult.
- Make some experiment to find the result.

Identify strong TR & EM

CHAPTER 4

REQUIREMENT ANALYSIS

4.1 FUNCTIONAL REQUIREMENTS:

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail Registration through LinkedIN
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	User input	Users are required to give chemical components of their water which they need tested. The chemical components such as Temperature,pH,DissolvedOxygen,Fecal Coliform,Biochemical oxygen demand,conductivity and Nitratenan details are must.
FR-4	Output Display	Based on the range of water quality index available,given water samples are analyzed and predicted the final results.
FR-5	Model prediction	Confirming based on water quality index and shows the ML prediction with percent of various parameter.
FR-6	Data handling	File contains water quality metrics for different water bodies.
FR-7	Quality analysis	Analyze with acquired information of water across various water quality indication using different models.

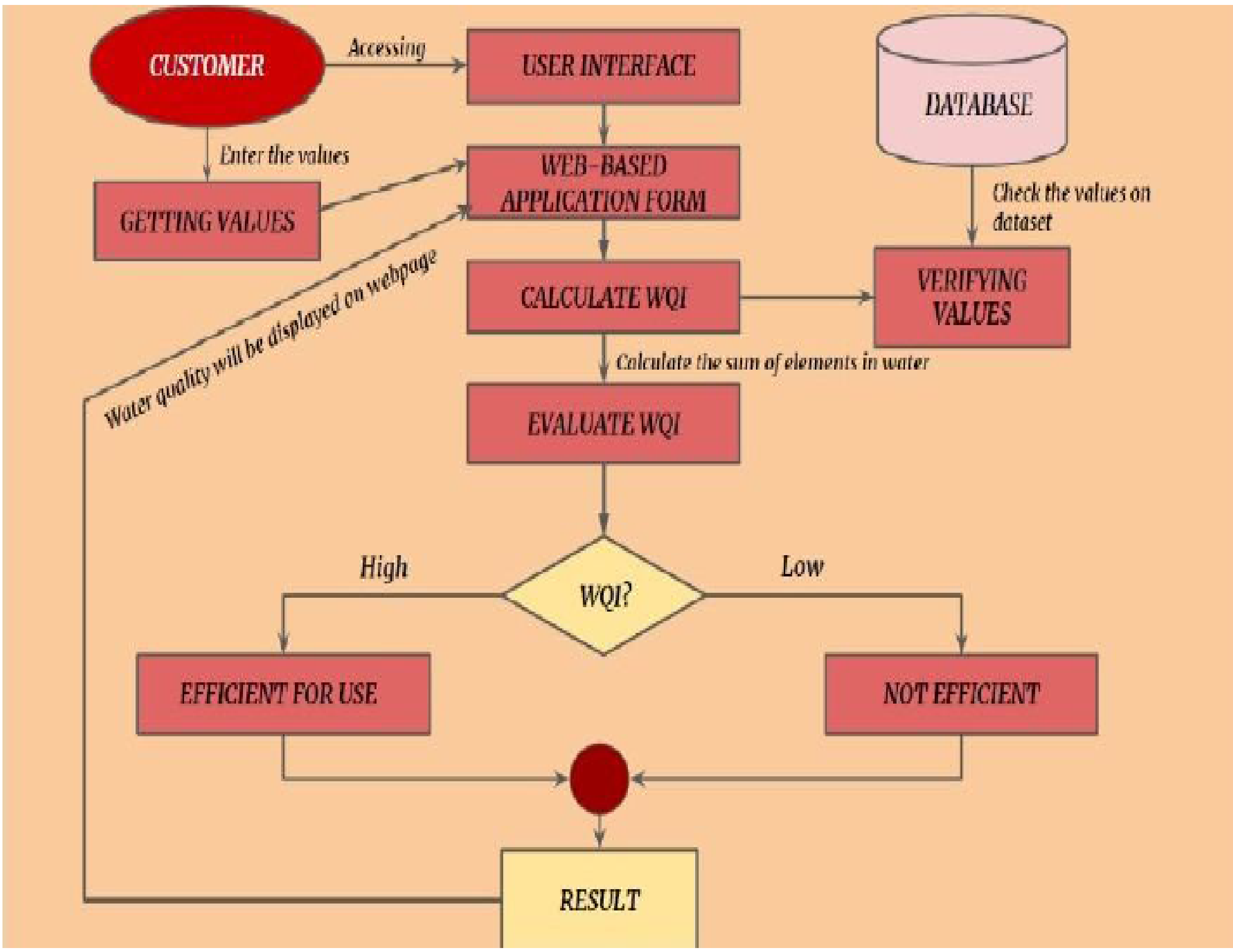
4.2 NON FUNCTIONAL REQUIREMENTS:

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	System is stand up to the customer's expectations. When an application is, users can easily navigate its interface. The user can determine what feature and what it can do.
NFR-2	**Security**	Various forms of question for calculating the water quality index(wqi) and securely stored in database.
NFR-3	**Reliability**	If the number of failures is low, it means that the system operates properly. reliability of Track the time between critical feature can help you understand
NFR-4	**Performance**	Our system should run on a 32 bit(x86) or 64 bit(x64) dual-core 2.66-GHZ or faster processor. It should not exceed 2 GB ram.
NFR-5	**Availability**	The system should be available for the duration of the user access to the system until the user terminates the access.
NFR-6	**Scalability**	It provides an efficient outcome and ability to increase or decrease the performance of a system based on datasets.

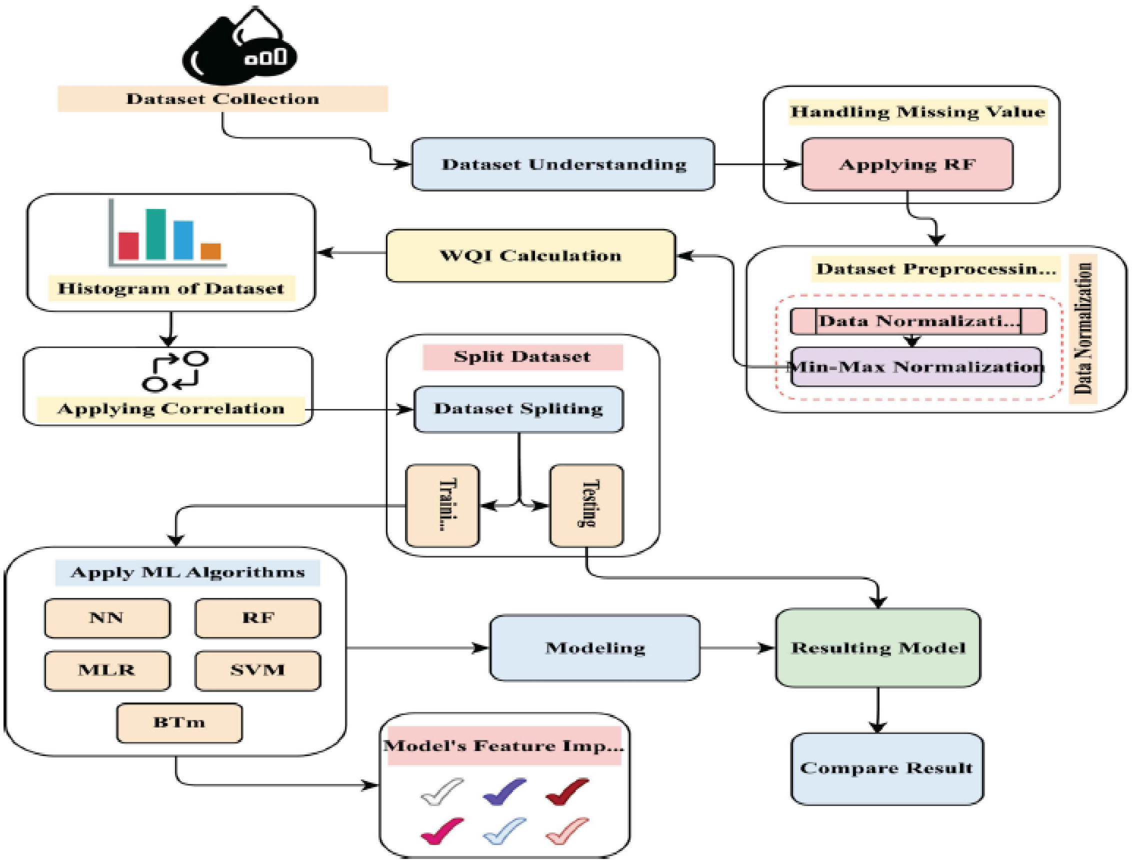
CHAPTER 5

PROJECT DESIGN

5.1 DATA FLOW DIAGRAM:



5.2 SOLUTION & TECHNICAL ARCHITECTURE:



5.3 USER STORIES:

User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Release
Customer (Web user)	Access web page	USN-1	As a user, anyone can access the web page to check the water quality.	I can access my webpage online at any time.	High	Sprint-1
Customer	Usage of water	USN-2	As per the usage of the user the quality of water should be predicted in an easy way.	Prediction can be done in an easy way.	High	Sprint-2
Customer	Accuracy of water	USN-3	Using a prediction model the user will know the quality of water on a daily basis.	The quality analysis of water will be accurate.	High	Sprint-3
Administrator	Manage the web page	USN-4	As admin, I can manage user details and update parameters essential for prediction.	Make changes on user interface(UI).	High	Sprint-3
Administrator	Calculation of WQI	USN-5	An admin can update the calculations for water quality index calculation.	Improves the accuracy of the calculation.	High	Sprint-3

CHAPTER 6

PROJECT PLANNING AND SCHEDULING

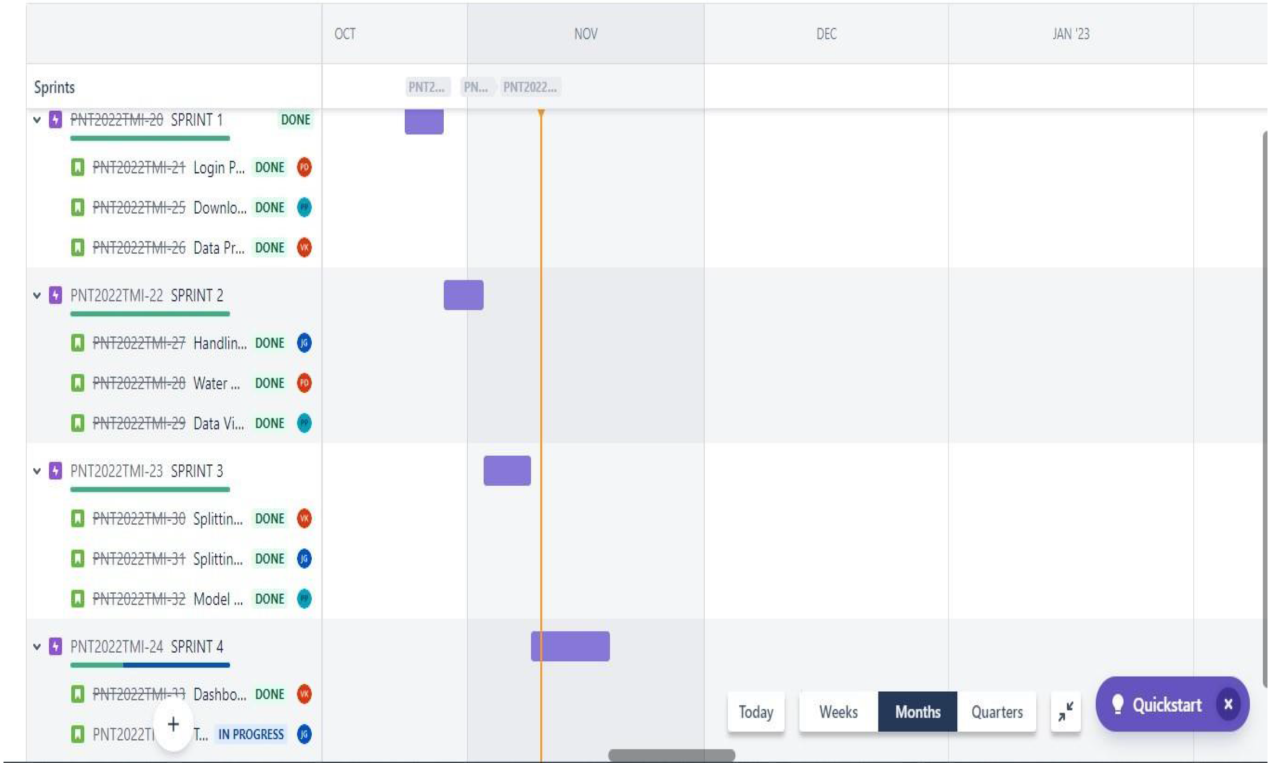
6.1 SPRINT PLANNING AND ESTIMATION:

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	Data Preparation	USN-1	Collecting water dataset and pre-processing it	10	High	S.Arunkumar G.Arunpandi
Sprint-1	Model Building and Model Evaluation	USN-2	Create an ML model to predict water quality.Calculate the performance, error rate, and complexity of the ML model and evaluate the dataset based on the parameter that the dataset consists.	10	High	S.Arunkumar G.Arunpandi
Sprint-2	Model Deployment	USN-3	As a user, I need to deploy the model and need to find the results.	20	High	T.N.Harivarshan S.Arunkumar
Sprint-3	Web page (Form)	USN-4	As a user, I can use the application by entering the water dataset to analyze or predict the results.	20	High	T.N.Harivarshan S.Arunkumar G.Arunpandi S.Bogar
Sprint-4	Dashboard	USN-5	As a user, I can predict the water quality by clicking the submit button and the application will show whether the water is efficient for use or not.	20	High	T.N.Harivarshan S.Arunkumar G.Arunpandi S.Bogar

6.2 SPRINT DELIVERY SCHEDULE:

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint-1	20	6 Days	24 Oct 2022	29 Oct 2022	20	29 Oct 2022
Sprint-2	20	6 Days	31 Oct 2022	05 Nov 2022	20	5 Nov 2022
Sprint-3	20	6 Days	07 Nov 2022	12 Nov 2022	20	12 Nov 2022
Sprint-4	20	6 Days	14 Nov 2022	19 Nov 2022	20	19 Nov 2022

6.3 REPORTS FROM JIRA:



CHAPTER 7
CODING & SOLUTIONING

7.1 FEATURE 1:

The proposed system is the machine learning model where we could predict the quality of the water from giving the necessary details regarding the water body. This part deals with creating a model from the random forest algorithm. With the dataset we will be finding out the water quality index and using that we split the data into the training and testing set. Then the model will be created using the splitted data. After the model is created the accuracy of the

model will be determined and the model is deployed in the pickle. There is also another method to deploy a model using the IBM cloud.
The flask app is created to act as an interface to predict the quality from the details the user is giving,

```
import numpy as np
from flask import Flask,render_template,request
import pickle
app= Flask(__name__)
model = pickle.load(open('wqi.pkl','rb'))
@app.route('/')
def home() :
  return render_template("web.html")
@app.route('/web')
def Home():
  return render_template("web.html")
@app.route('/quality_test')
def QualityTest():
  return render_template("quality_test.html")
@app.route('/about')
def About():
  return render_template("about.html")

@app.route('/login',methods = ['POST'])
def login() :
  year = request.form["year"]
  do = request.form["do"]
  ph = request.form["ph"]
  co = request.form["co"]
```

```
  bod = request.form["bod"]
  tc = request.form["tc"]
  na = request.form["na"]
  total = [[float(do),float(ph),float(co),float(bod),float(na),float(tc)]]
  y_pred = model.predict(total)
  y_pred = y_pred[[0]]
  if(y_pred >= 95 and y_pred<=100):
        return render_template("quality_test.html",showcase = 'Excellent, The Predicted Value Is'+ str(y_pred))
  elif(y_pred >= 89 and y_pred<=94):
       return render_template("quality_test.html",showcase = 'Very Good, The Predicted Value Is'+ str(y_pred))
  elif(y_pred >= 80 and y_pred<=88):
     return render_template("quality_test.html",showcase = 'Good, The Predicted Value Is'+ str(y_pred))
  elif(y_pred >= 65 and y_pred<=79):
      return render_template("quality_test.html",showcase = 'Fair, The Predicted Value Is'+ str(y_pred))
  elif(y_pred >= 45 and y_pred<=64):
        return render_template("quality_test.html",showcase = 'Marginal, The Predicted Value Is'+ str(y_pred))
  else:
     return render_template("quality_test.html",showcase = 'Poor, The Predicted Value Is'+ str(y_pred))



if __name__ == '__main__':
    app.run(debug = True,port=5000)
```

7.2 FEATURE 2:

The model is deployed in the IBM cloud with the following code:

```
import requests

import json

# NOTE: you must manually set API_KEY below using information retrieved from your IBM Cloud account.

API_KEY = "tkJeJFVitloTIn9x13pYMVA7AtDG4btmwjuOjVblFO_z"
token_response = requests.post('https://iam.cloud.ibm.com/identity/token', data={"apikey":
 API_KEY, "grant_type": 'urn:ibm:params:oauth:grant-type:apikey'})
mltoken = token_response.json()["access_token"]
print("mltoken",mltoken)
header = {'Content-Type': 'application/json', 'Authorization': 'Bearer ' + mltoken}


# NOTE: manually define and pass the array(s) of values to be scored in the next line
payload_scoring = {"input_data": [{"field": [["year","do","ph","co","bod","tc","na"]], "values": [[2014,6.7, 7.5, 203, 2, 0.1, 27.0]]}]}
```

```
response_scoring =
requests.post('https://us-south.ml.cloud.ibm.com/ml/v4/deployments/033cf98b-2359-4eb1-b4bf-1c1a494432bd/predictions?version=2022-11-18',
json=payload_scoring,
 headers={'Authorization': 'Bearer ' + mltoken})

print("Scoring response")

predict = response_scoring.json()

pred = (predict['predictions'][0]['values'][0][0])
print(pred)
```

CHAPTER 8
TESTING

8.1 TEST CASES:

- Verify that the user was able to use that web page.
- Verify that the user was able to enter the value.
- Verify that the values entered by the user are computed.
- Verify that the user was able to see the predicted value.

8.2.USER ACCEPTANCE TESTING:

8.2.1 DEFECT ANALYSIS:

This report shows the number of resolved or closed bugs at each severity level, and how they were resolved

Resolution	Severity 1	Severity 2	Severity 3	Severity 4	Subtotal
By Design	9	3	2	1	15
Duplicate	1	0	0	0	1
External	2	1	0	1	4
Fixed	6	5	4	25	40
Not Reproduced	0	0	1	0	1
Skipped	0	0	1	1	2
Won't Fix	0	3	2	1	6
Totals	18	12	10	29	69

8.2.2 TEST CASE ANALYSIS:

This report shows the number of test cases that have passed, failed, and untested

Section	Total Cases	Not Tested	Fail	Pass
Print Engine	7	0	0	7
Client Application	48	0	0	48
Security	2	0	0	2
Outsource Shipping	3	0	0	3
Exception Reporting	5	0	0	5
Final Report Output	4	0	0	4
Version Control	2	0	0	2

CHAPTER 9
RESULTS

9.1. PERFORMANCE METRICS:

The performance metrics are the accuracy of the model and the errors that the model is predicting.The MAE(Mean Absolute Error), MSE(Mean Squared Error) and RMSE(Root Mean Squared Error) are 0.9469473684210586 ,5.005409984962409 and 2.2372773598645317 respectively. The accuracy of the model is 0.9727155181897961. These are the factors that determine the performance of the model.

CHAPTER 10
ADVANTAGES & DISADVANTAGES

ADVANTAGES:

- water quality prediction helps in controlling Water Pollution
- To predict whether the water is safe or not.
- Predicting potable water quality for water management and water pollution prevention.
- Water quality prediction conveys the health of ecosystems, safety of human contact, extent of water pollution and condition of drinking water.

DISADVANTAGES:

- Training necessary Somewhat difficult to manage over time and with large data sets.
- Requires manual operation to submit data, some configuration required.
- Costly, usually only feasible under Exchange Network grants Technical expertise and network server required.
- Requires manual operation to submit data Cannot respond to data queries from other nodes, and therefore cannot interact with the Exchange Network Technical expertise and network server required.

CHAPTER 11

CONCLUSION:

The water quality is monitored and managed effectively because of the importance of drinking water. Water has a direct effect on our health. This adds more reason to test the quality of drinking water. Several boards of committees and protocols are established to check the quality of water. The assessment of water quality differs from origin to origin. Using machine learning techniques the water quality is tested without any regular laboratory tests. By using Random Forest algorithm, we can evaluate the quality of water based on the attributes such as pH, BOD, DO, minerals and coliform in the water.This model can be used for predicting the quality of water and can monitor the potability of the water. This model acts as a prototype for the IoT sensors and can make the model even more efficient to predict the quality of water and potability of water. Data cleaning and processing, missing value analysis, exploratory analysis, and model creation and evaluation were all part of the analytical process. The best accuracy on a public test set will be discovered, as will the highest accuracy score. This application can assist in determining the current state of water quality.

CHAPTER 12

FUTURE SCOPE:

In future works, we propose integrating the findings of this research in a large-scale IoT-based online monitoring system using only the sensors of the required parameters. The tested algorithms would predict the water quality immediately based on the real-time data fed from the IoT system.The proposed IoT system would employ the parameter sensors of pH, turbidity, temperature and TDS for parameter readings and communicate those readings using an Arduino microcontroller. It would identify poor quality water before it is released for consumption and alert concerned authorities. It will hopefully result in curtailment of people consuming poor quality water and consequently de-escalate harrowing diseases like typhoid and diarrhea. In this regard, the application of a prescriptive analysis from the expected values would lead to future facilities to support decision and policy makers.

CHAPTER 13

APPENDIX:

SOURCE CODE:

Importing the libraries

In [1]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import warnings
```

Reading Dataset

In [2]:
```
data = pd.read_csv('water_dataX.csv',encoding='ISO-8859-1',low_memory=False)
```

Analyse the data

In [3]:
```
data.head()
```

Out[3]:

	STATION CODE	LOCATIONS	STATE	Temp	D.O. (mg/l)	PH	CONDUCTIVITY (µmhos/cm)	B.O.D. (mg/l)	NITRATENAN N+ NITRITENANN (mg/l)	FECAL COLIFORM (MPN/100ml)	TOTAL COLIFORM (MPN/100ml)Mean	year
0	1393	DAMANGANGA AT D/S OF MADHUBAN, DAMAN	DAMAN & DIU	30.6	6.7	7.5	203	NAN	0.1	11	27	2014

In [4]:
```
data.describe()
```

Out[4]:

	year
count	1991.000000
mean	2010.038172
std	3.057333
min	2003.000000
25%	2008.000000
50%	2011.000000
75%	2013.000000
max	2014.000000

In [5]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1991 entries, 0 to 1990
Data columns (total 12 columns):
 #   Column                              Non-Null Count  Dtype
---  ------                              --------------  -----
 0   STATION CODE                        1991 non-null   object
 1   LOCATIONS                           1991 non-null   object
 2   STATE                               1991 non-null   object
 3   Temp                                1991 non-null   object
 4   D.O. (mg/l)                         1991 non-null   object
 5   PH                                  1991 non-null   object
 6   CONDUCTIVITY (µmhos/cm)             1991 non-null   object
 7   B.O.D. (mg/l)                       1991 non-null   object
 8   NITRATENAN N+ NITRITENANN (mg/l)    1991 non-null   object
 9   FECAL COLIFORM (MPN/100ml)          1991 non-null   object
 10  TOTAL COLIFORM (MPN/100ml)Mean      1991 non-null   object
 11  year                                1991 non-null   int64
dtypes: int64(1), object(11)
```

In [6]:
```
data.shape
```

Out[6]:
```
(1991, 12)
```

Handling Missing Values 1

In [7]:
```
data.isnull().any()
```

Out[7]:
```
STATION CODE                        False
LOCATIONS                           False
STATE                               False
Temp                                False
D.O. (mg/l)                         False
PH                                  False
CONDUCTIVITY (µmhos/cm)             False
B.O.D. (mg/l)                       False
NITRATENAN N+ NITRITENANN (mg/l)    False
FECAL COLIFORM (MPN/100ml)          False
TOTAL COLIFORM (MPN/100ml)Mean      False
year                                False
dtype: bool
```

In [8]:
```
data.isnull().sum()
```

Out[8]:
```
STATION CODE                        0
LOCATIONS                           0
STATE                               0
Temp                                0
D.O. (mg/l)                         0
PH                                  0
CONDUCTIVITY (µmhos/cm)             0
B.O.D. (mg/l)                       0
NITRATENAN N+ NITRITENANN (mg/l)    0
FECAL COLIFORM (MPN/100ml)          0
TOTAL COLIFORM (MPN/100ml)Mean      0
year                                0
```

```
In [9]: data.dtypes
```

```
Out[9]: STATION CODE                          object
        LOCATIONS                             object
        STATE                                 object
        Temp                                  object
        D.O. (mg/l)                           object
        PH                                    object
        CONDUCTIVITY (µmhos/cm)               object
        B.O.D. (mg/l)                         object
        NITRATENAN N+ NITRITENANN (mg/l)      object
        FECAL COLIFORM (MPN/100ml)            object
        TOTAL COLIFORM (MPN/100ml)Mean        object
        year                                   int64
        dtype: object
```

Handling missing values 2

```
In [10]: data['Temp']=pd.to_numeric(data['Temp'],errors='coerce')
         data['D.O. (mg/l)']=pd.to_numeric(data['D.O. (mg/l)'],errors='coerce')
         data['PH']=pd.to_numeric(data['PH'],errors='coerce')
         data['B.O.D. (mg/l)']=pd.to_numeric(data['B.O.D. (mg/l)'],errors='coerce')
         data['CONDUCTIVITY (µmhos/cm)']=pd.to_numeric(data['CONDUCTIVITY (µmhos/cm)'],errors='coerce')
         data['NITRATENAN N+ NITRITENANN (mg/l)']=pd.to_numeric(data['NITRATENAN N+ NITRITENANN (mg/l)'],errors='coerce')
         data['TOTAL COLIFORM (MPN/100ml)Mean']=pd.to_numeric(data['TOTAL COLIFORM (MPN/100ml)Mean'],errors='coerce')
         data.dtypes
```

```
Out[10]: STATION CODE                           object
         LOCATIONS                              object
         STATE                                  object
         Temp                                  float64
         D.O. (mg/l)                           float64
         PH                                    float64
         CONDUCTIVITY (µmhos/cm)               float64
```

```
In [11]: data.isnull().sum()
```

```
Out[11]: STATION CODE                          0
         LOCATIONS                             0
         STATE                                 0
         Temp                                 92
         D.O. (mg/l)                          31
         PH                                    8
         CONDUCTIVITY (µmhos/cm)              25
         B.O.D. (mg/l)                        43
         NITRATENAN N+ NITRITENANN (mg/l)    225
         FECAL COLIFORM (MPN/100ml)            0
         TOTAL COLIFORM (MPN/100ml)Mean      132
         year                                  0
         dtype: int64
```

Handling missing values 3

```
In [12]: data['Temp'].fillna(data['Temp'].mean(),inplace=True)
         data['D.O. (mg/l)'].fillna(data['D.O. (mg/l)'].mean(),inplace=True)
         data['PH'].fillna(data['PH'].mean(),inplace=True)
         data['CONDUCTIVITY (µmhos/cm)'].fillna(data['CONDUCTIVITY (µmhos/cm)'].mean(),inplace=True)
         data['B.O.D. (mg/l)'].fillna(data['B.O.D. (mg/l)'].mean(),inplace=True)
         data['NITRATENAN N+ NITRITENANN (mg/l)'].fillna(data['NITRATENAN N+ NITRITENANN (mg/l)'].mean(),inplace=True)
         data['TOTAL COLIFORM (MPN/100ml)Mean'].fillna(data['TOTAL COLIFORM (MPN/100ml)Mean'].mean(),inplace=True)
```

```
In [13]: data.drop(["FECAL COLIFORM (MPN/100ml)"],axis=1,inplace=True)
```

```
In [14]: data=data.rename(columns = {'D.O. (mg/l)': 'do'})
data=data.rename(columns = {'CONDUCTIVITY (µmhos/cm)': 'co'})
data=data.rename(columns = {'B.O.D. (mg/l)': 'bod'})
data=data.rename(columns = {'NITRATENAN N+ NITRITENANN (mg/l)': 'na'})
data=data.rename(columns = {'TOTAL COLIFORM (MPN/100ml)Mean': 'tc'})
data=data.rename(columns = {'STATION CODE': 'station'})
data=data.rename(columns = {'LOCATIONS': 'location'})
data=data.rename(columns = {'STATE': 'state'})
data=data.rename(columns = {'PH': 'ph'})
```

Water Quality Index (WQI) Calculation-1

```
In [15]: #calculation of pH
data['npH']=data.ph.apply(lambda x: (100 if(8.5>=x>=7)
                                else(80 if(8.6>=x>=8.5) or (6.9>=x>=6.8)
                                  else (60 if(8.8>=x>=8.6) or (6.8>=x>=6.7)
                                      else(40 if(9>=x>=8.8) or (6.7>=x>=6.5)
                                          else 0)))))
```

```
In [16]: #calculation of dissolved oxygen
data['ndo']=data.do.apply(lambda x: (100 if(x>=6)
                                else(80 if(6>=x>=5.1)
                                  else (60 if(5>=x>=4.1)
                                      else(40 if(4>=x>=3)
                                          else 0)))))
```

Water Quality Index (WQI) Calculation-2

```
In [17]: #calculation of total coliform
data['nco']=data.tc.apply(lambda x: (100 if(5>=x>=0)
                                else(80 if(50>=x>=5)
                                  else (60 if(500>=x>=50)
                                      else(40 if(10000>=x>=500)
                                          else 0)))))
```

```
In [18]: #calculation of B.D.O
data['nbdo']=data.bod.apply(lambda x:(100 if(3>=x>=0)
                                else(80 if(6>=x>=3)
                                  else (60 if(80>=x>=6)
                                      else(40 if(125>=x>=80)
                                          else 0)))))
```

Water Quality Index (WQI) Calculation-3

```
In [19]: #calculation of electric conductivity
data['nec']=data.co.apply(lambda x:(100 if(75>=x>=0)
                                else(80 if(150>=x>=75)
                                  else (60 if(225>=x>=150)
                                      else(40 if(300>=x>=225)
                                          else 0)))))
```

```
In [20]: #calculation of nitrate
data['nna']=data.na.apply(lambda x:(100 if(20>=x>=0)
                                else(80 if(50>=x>=20)
                                  else (60 if(100>=x>=50)
                                      else(40 if(200>=x>=100)
                                          else 0)))))
```

In [21]:

```
#Calculation of Water Quality Index WQI
data['wph']=data.npH*0.165
data['wdo']=data.ndo*0.281
data['wbdo']=data.nbdo*0.234
data['wec']=data.nec*0.009
data['wna']=data.nna*0.028
data['wco']=data.nco*0.281
data['wqi']=data.wph+data.wdo+data.wbdo+data.wec+data.wna+data.wco
data
```

Out[21]:

	station	location	state	Temp	do	ph	co	bod	na	tc	...	nbdo	nec	nna	wph	wdo	wbdo	wec	wna	wco
0	1393	DAMANGANGA AT D/S OF MADHUBAN, DAMAN	DAMAN & DIU	30.600000	6.7	7.5	203.0	6.940049	0.100000	27.0	...	60	60	100	16.5	28.10	14.04	0.54	2.8	22.48
1	1399	ZUARI AT D/S OF PT. WHERE KUMBARJRIA CANAL JOI...	GOA	29.800000	5.7	7.2	189.0	2.000000	0.200000	8391.0	...	100	60	100	16.5	22.48	23.40	0.54	2.8	11.24
2	1475	ZUARI AT PANCHAWADI	GOA	29.500000	6.3	6.9	179.0	1.700000	0.100000	5330.0	...	100	60	100	13.2	28.10	23.40	0.54	2.8	11.24
3	3181	RIVER ZUARI AT BORIM BRIDGE	GOA	29.700000	5.8	6.9	64.0	3.800000	0.500000	8443.0	...	80	100	100	13.2	22.48	18.72	0.90	2.8	11.24
4	3182	RIVER ZUARI AT MARCAIM JETTY	GOA	29.500000	5.8	7.3	83.0	1.900000	0.400000	5500.0	...	100	80	100	16.5	22.48	23.40	0.72	2.8	11.24
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1986	1330	TAMBIRAPARANI AT ARUMUGANERI, TAMILNADU	NAN	26.209814	7.9	738.0	7.2	2.700000	0.518000	202.0	...	100	100	100	0.0	28.10	23.40	0.90	2.8	16.86
1987	1450	PALAR AT VANIYAMBADI WATER SUPPLY HEAD WORK, T...	NAN	29.000000	7.5	585.0	6.3	2.600000	0.155000	315.0	...	100	100	100	0.0	28.10	23.40	0.90	2.8	16.86

In [22]:

```
#Calculation of overall WQI for each year
average = data.groupby('year')['wqi'].mean()
average.head()
```

Out[22]:

```
year
2003    66.239545
2004    61.290000
2005    73.762689
2006    72.909714
2007    74.233000
Name: wqi, dtype: float64
```

Splitting Dependent and Independent Columns

In [23]:

```
data.head()
data.drop(['location','station','state'],axis =1,inplace=True)
```

In [24]:

```
data.head()
```

Out[24]:

	Temp	do	ph	co	bod	na	tc	year	npH	ndo	...	nbdo	nec	nna	wph	wdo	wbdo	wec	wna	wco	wqi
0	30.6	6.7	7.5	203.0	6.940049	0.1	27.0	2014	100	100	...	60	60	100	16.5	28.10	14.04	0.54	2.8	22.48	84.46
1	29.8	5.7	7.2	189.0	2.000000	0.2	8391.0	2014	100	80	...	100	60	100	16.5	22.48	23.40	0.54	2.8	11.24	76.96
2	29.5	6.3	6.9	179.0	1.700000	0.1	5330.0	2014	80	100	...	100	60	100	13.2	28.10	23.40	0.54	2.8	11.24	79.28
3	29.7	5.8	6.9	64.0	3.800000	0.5	8443.0	2014	80	80	...	80	100	100	13.2	22.48	18.72	0.90	2.8	11.24	69.34
4	29.5	5.8	7.3	83.0	1.900000	0.4	5500.0	2014	100	80	...	100	80	100	16.5	22.48	23.40	0.72	2.8	11.24	77.14

5 rows × 21 columns

In [41]:

```
x=data.iloc[:,1:7].values
```

In [42]:
```
x.shape
```
Out[42]:
```
(1991, 6)
```

In [64]:
```
y=data.iloc[:,20:].values
y.shape
```
Out[64]:
```
(1991, 1)
```

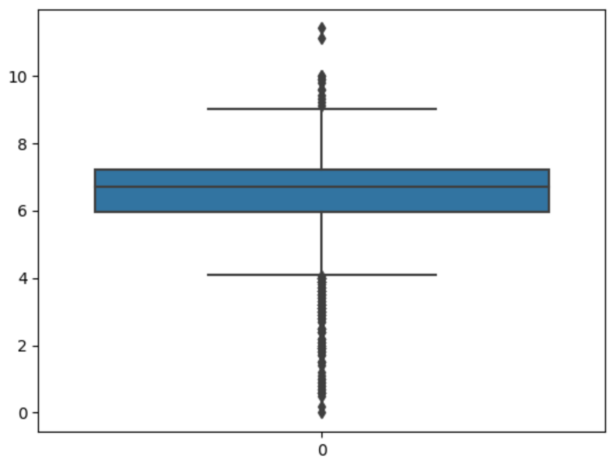
In [65]:
```
print(x)
```
```
[[16.5   28.1  14.04  0.54  2.8   22.48]
 [16.5   22.48 23.4   0.54  2.8   11.24]
 [13.2   28.1  23.4   0.54  2.8   11.24]
 ...
 [ 0.    28.1  23.4   0.9   2.8   11.24]
 [ 0.    28.1  23.4   0.9   2.8   11.24]
 [ 0.    28.1  23.4   0.9   2.8   11.24]]
```

In [66]:
```
print(y)
```
```
[[84.46]
 [76.96]
 [79.28]
 ...
 [66.44]
 [66.44]
 [66.44]]
```

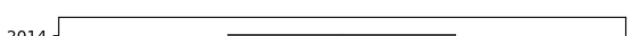
Data Visualization

In [30]:
```
import seaborn as sns
```

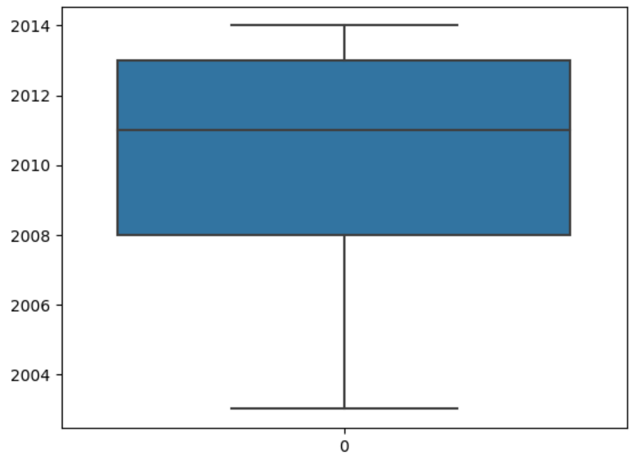
In [32]:
```
sns.boxplot(data["do"])
```
Out[32]: <AxesSubplot:>



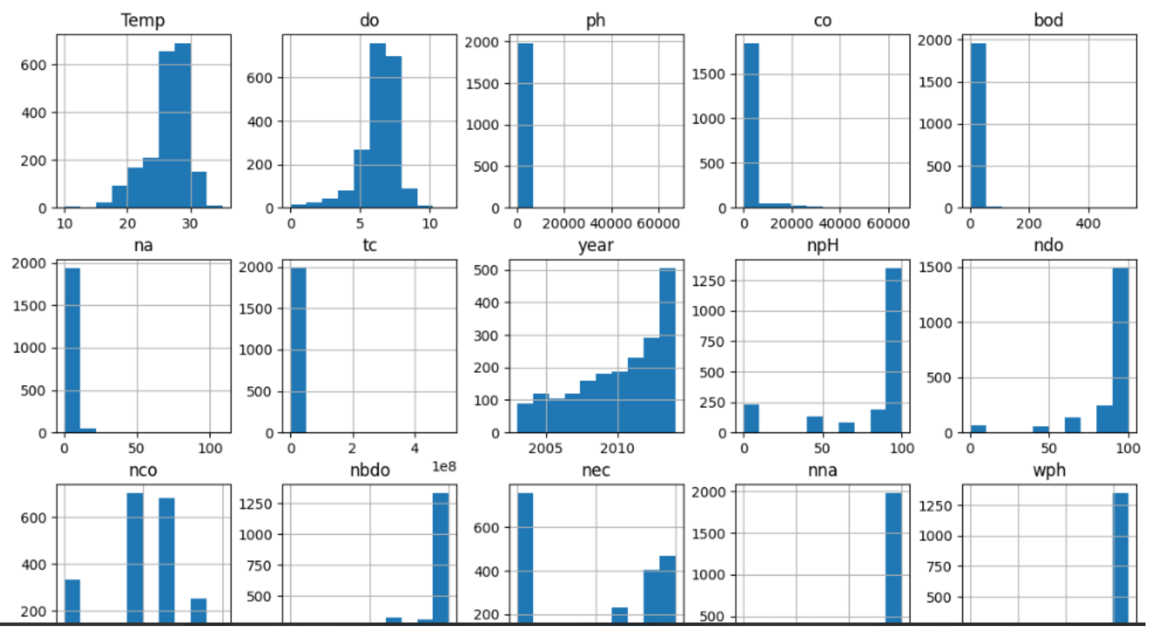
In [33]:
```
sns.boxplot(data["year"])
```
Out[33]: <AxesSubplot:>



In [33]:
```
sns.boxplot(data["year"])
```
Out[33]: <AxesSubplot:>



In [34]:
```
data.hist(figsize=(14,14))
plt.show()
```



Splitting the Data Into Train and Test

In [36]:
```
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size = 0.2,random_state=10)
```

Random_Forest_Regression

In [37]:
```
from sklearn.ensemble import RandomForestRegressor
regressor = RandomForestRegressor(n_estimators = 10, random_state = 0)
regressor.fit(x_train, y_train)
y_pred = regressor.predict(x_test)
```

Model Evaluation

In [38]:
```
from sklearn import metrics
print('MAE:',metrics.mean_absolute_error(y_test,y_pred))
print('MSE:',metrics.mean_squared_error(y_test,y_pred))
print('RMSE:',np.sqrt(metrics.mean_squared_error(y_test,y_pred)))
```

```
MAE: 0.9469473684210586
MSE: 5.005409984962409
RMSE: 2.2372773598645317
```

In [39]:
```
#accuracy of the model
metrics.r2_score(y_test, y_pred)
```

Out[39]:
```
0.9727155181897961
```

Save the model

In [40]:
```
import pickle
pickle.dump(regressor,open('wqi.pkl','wb'))
model=pickle.load(open('wqi.pkl','rb'))
```

APP.PY:

```python

import numpy as np
from flask import Flask,render_template,request
import pickle
app= Flask(__name__)
model = pickle.load(open('wqi.pkl','rb'))
@app.route('/')
def home() :
  return render_template("web.html")
@app.route('/web')
def Home():
  return render_template("web.html")
@app.route('/quality_test')
def QualityTest():
  return render_template("quality_test.html")
@app.route('/about')
def About():
  return render_template("about.html")

@app.route('/login',methods = ['POST'])
def login() :
  year = request.form["year"]
  do = request.form["do"]
  ph = request.form["ph"]
  co = request.form["co"]
  bod = request.form["bod"]
  tc = request.form["tc"]
  na = request.form["na"]
  total = [[float(do),float(ph),float(co),float(bod),float(na),float(tc)]]
  y_pred = model.predict(total)
  y_pred = y_pred[[0]]
  if(y_pred >= 95 and y_pred<=100):
    return render_template("quality_test.html",showcase = 'Excellent, The Predicted Value Is'+ str(y_pred))
  elif(y_pred >= 89 and y_pred<=94):
    return render_template("quality_test.html",showcase = 'Very Good, The Predicted Value Is'+ str(y_pred))
  elif(y_pred >= 80 and y_pred<=88):
    return render_template("quality_test.html",showcase = 'Good, The Predicted Value Is'+ str(y_pred))
  elif(y_pred >= 65 and y_pred<=79):
    return render_template("quality_test.html",showcase = 'Fair, The Predicted Value Is'+ str(y_pred))
  elif(y_pred >= 45 and y_pred<=64):
    return render_template("quality_test.html",showcase = 'Marginal, The Predicted Value Is'+ str(y_pred))
  else:
    return render_template("quality_test.html",showcase = 'Poor, The Predicted Value Is'+ str(y_pred))


if __name__ == '__main__':
     app.run(debug = True,port=5000)
```

ABOUT.HTML:

```html
<!DOCTYPE html>
<html lang="en">

<head>
<meta charset="UTF-8">
<meta http-equiv="X-UA-Compatible" content="IE=edge">
<meta name="viewport" content="width=device-width,initial-scale=1">
<link rel="stylesheet" href="static\css\about.css">
</head>

<body>

<ul>
  <li><a href="web">Home</a></li>
  <li><a href="quality_test">Quality Test</a></li>
  <li><a href="#contact">Contact</a></li>
  <li style="float:right"><a class="active" href="#about">About</a></li>
  <center><h1 style="color:Black;font-size:20px">Efficient Of Water Quality Analysis & Prediction</h1></center>
</ul><br><br>
<div class="container">

<p>Dissolved oxygen (DO) :</p>
<p>      Dissolved oxygen (DO) is a measure of how much oxygen is dissolved in the water - the amount of oxygen available to living aquatic organisms. The amount o
<p>potential hydrogen (ph):</p>
<p>      pH is a measure of how acidic/basic water is. The range goes from 0 to 14, with 7 being neutral. pHs of less than 7 indicate acidity, whereas a pH of grea
<p>Conductivity:</p>
<p>      Conductivity is a measure of the ability of water to pass an electrical current. Because dissolved salts and other inorganic chemicals conduct electrical
<p>Biochemical Oxygen Demand:</p>
<p>      BOD is a measure of the amount of oxygen required to remove waste organic matter from water in the process of decomposition by aerobic bacteria (those bac
<p>Nitrate-N :</p>
<p>      Nitrate-N is found naturally in soil and water, but usually at relatively low concentrations (less than 4 mg/L in water). However, nitrate is highly solub
<p>Total coliform :</p>
<p>      Total coliform counts give a general indication of the sanitary condition of a water supply. Total coliforms include bacteria that are found in the soil,
</div>
</body>

</html>
```

QUALITY_TEST.HTML:

```html
<!DOCTYPE html>
<html lang="en">
<head>
<meta charset="UTF-8">
<meta http-equiv="X-UA-Compatible" content="IE=edge">
<meta name="viewport" content="width=device-width,initial-scale=1">
<link rel="stylesheet" href="static\css\quality_test.css">
</head>
<body>
<ul>
  <li><a href="web">Home</a></li>
  <li><a href="#quality">Quality Test</a></li>
  <li><a href="#contact">Contact</a></li>
  <li style="float:right"><a class="active" href="about">About</a></li>
  <center><h1 style="color:Black;font-size:20px">Efficient Of Water Quality Analysis & Prediction</h1></center>
</ul><br>
 <form action="/login" method="POST">
   <div class="container">
    <div class="col-25">
      <label for="enter the year">Enter The Year:</label>
    </div>
    <select id="Year" name="year">
    <option value="2003">2003</option>
    <option value="2004">2004</option>
    <option value="2005">2005</option>
    <option value="2006">2006</option>
    <option value="2007">2007</option>
    <option value="2008">2008</option>
    <option value="2009">2009</option>
    <option value="2010">2010</option>
    <option value="2011">2011</option>
    <option value="2012">2012</option>
    <option value="2013">2013</option>
```

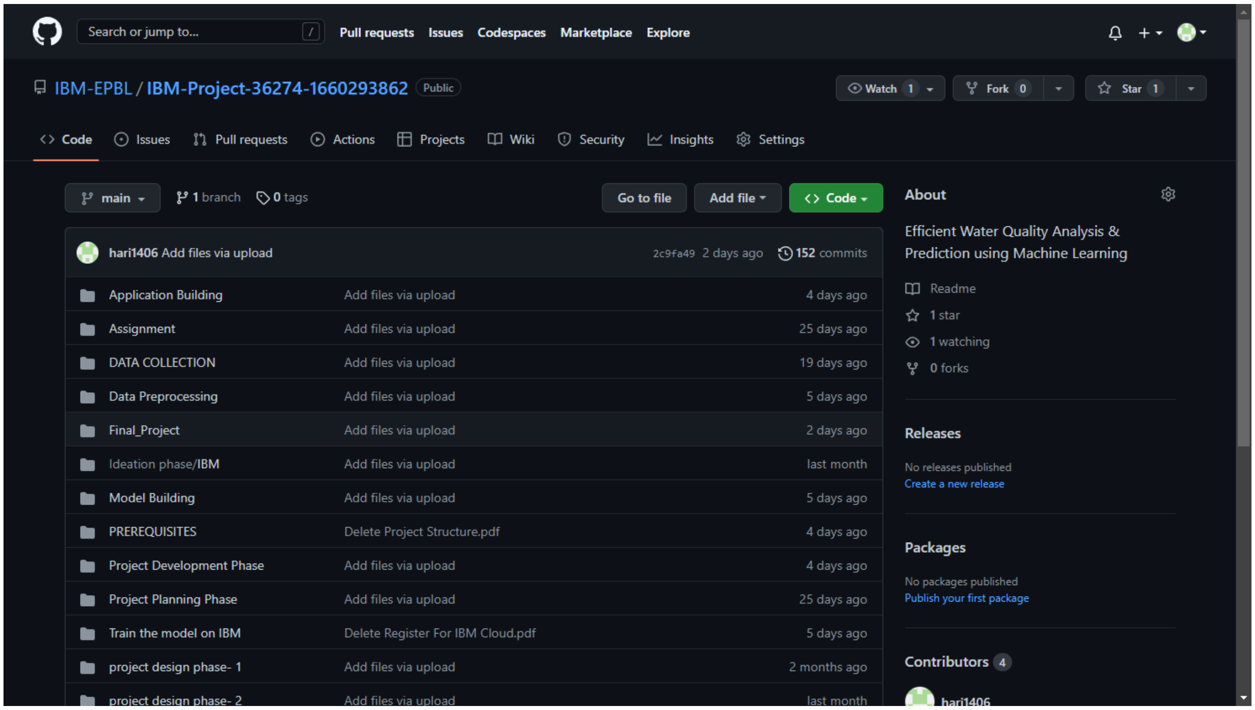
```html
  </select><br>
  <input type="text" id="Dissolved Oxygen" name="do" placeholder="Enter D.O" pattern="[0-9]+([\.,][0-9]+)?" required><br>
  <input type="text" id="Potential of Hydrogen" name="ph" placeholder="Enter PH" pattern="[0-9]+([\.,][0-9]+)?" required><br>
  <input type="text" id="Conductivity" name="co" placeholder="Enter Conductivity" pattern="[0-9]+([\.,][0-9]+)?" required><br>
  <input type="text" id="Biochemical  Oxygen Demand" name="bod" placeholder="Enter B.O.D" pattern="[0-9]+([\.,][0-9]+)?" required><br>
  <input type="text" id="Nitratenan" name="na" placeholder="Enter Nitratenan" pattern="[0-9]+([\.,][0-9]+)?" required><br>
  <input type="text" id="Total Coliform" name="tc" placeholder="Enter Total Coliform" pattern="[0-9]+([\.,][0-9]+)?" required><br>
  <input type="submit"  value="Submit"><br><br>
  <div class="result" id="result">
       {{showcase}}
  </div>
 </div>
</form>
</body>
```

WEB.HTML:

```html
<!DOCTYPE html>
<html lang="en">

<head>
<meta charset="UTF-8">
<meta http-equiv="X-UA-Compatible" content="IE=edge">
<meta name="viewport" content="width=device-width,initial-scale=1">
<link rel="stylesheet" href="static\css\web.css">
</head>

<body>



<ul>
  <li><a href="#home">Home</a></li>
  <li><a href="quality_test">Quality Test</a></li>
  <li><a href="#contact">Contact</a></li>
  <li style="float:right"><a class="active" href="about">About</a></li>
  <center><h1 style="color:Black;font-size:20px">Efficient Of Water Quality Analysis & Prediction</h1></center>
</ul><br>
<div class="container">

<p1>"The amount of water on the planet does not change,only its quality."</p1><br>
<p2> Making testing of water sample simple,faster and easier.</p2>


<button class="btn" id="myButton">Let's predict water quality</button>
<script type="text/javascript">
    document.getElementById("myButton").onclick = function () {
        location.href = "quality_test";
 };
</script>
</div>
</body>
</html>
```

OUTPUT:

GITHUB:



PROJECT DEMO LINK:

https://github.com/IBM-EPBL/IBM-Project-36274-1660293862/blob/main/Final_Project/project%20video%20record.mp4