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Air & Water Quality Index & Environment Monitoring

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Abstract : Ecosystem sustainability and public health are directly impacted by environmental quality. Indicators of the quality of the air and water are essential for evaluating and controlling environmental conditions. The main ideas are summarized in this abstract. significance, and techniques related to the creation of quality indicators, as well as the monitoring of air and water quality. To solve this issue, this study suggests a novel Internet of Things (IoT) solution for the real-time monitoring of the Water Quality Index (WQI) and Air Quality Index (AQI).
In order to continually detect important contaminants in the air and water, the system consists of sensor nodes placed strategically across the target region. Pollutant concentrations are detected using sensors for the purpose of monitoring air quality. Similarly, temperature and turbidity are measured using water quality sensors. The sensor nodes gather data, which is then wirelessly sent to a central server for processing and analysis. Using sophisticated algorithms, real-time AQI and WQI values are computed using the sensor data that has been gathered. These indices offer a thorough evaluation of the state of the environment, allowing interested parties to decide wisely and act quickly to reduce pollution. Additionally, a user-friendly mobile application and online interface are created to provide the AQI and WQI data in an understandable way.

Index Terms **- Prediction, Machine Learning, Random Forest, Air Quality, P.M 2.5 , Root mean squared error(RMSE), Mean Squared error(MSE),mean absolute error (MAE), Air quality Index (AQI)**

I. INTRODUCTION

The resources that naturally exist in the environment are known as natural resources. Natural resources come in various forms, such as light, soil, minerals, natural gas, forests, and lumber. The two primary abiotic elements of the environment, air and water, are necessary for practically every function of life support systems. The poisoning of air and water resources happens as a result of the society's fast growth and the acceleration of various human activities. Thus, in order to ensure its safety in real time, it is required to periodically detect any changes in these parameters. Sensor technologies are used in many different domains, such as surveillance, medical diagnostics, disaster management, emergency response, interior climate control, environmental monitoring, and sensing data collection in friendly environments. Sensor technology makes it possible to create inexpensive systems for monitoring the quality of the air and water, which lowers installation costs and facilitates rapid and simple configuration. In order to take appropriate action, the suggested system uses a number of sensors to monitor the air and water quality in real time. It is affordable, precise, and requires less labor. Millions of people worldwide are impacted by air pollution, which is a widespread issue that causes negative health effects, environmental damage, and financial losses. According to estimates from the World Health Organization (WHO), air pollution is one of the biggest threats to world health, resulting in around 7 million premature deaths each year (WHO, 2021). The Air Quality Index (AQI) is a metric for air pollution that gives details on the state of the air and any related health hazards. Particulate matter (PM), ozone (O3), nitrogen dioxide (NO2), sulfur dioxide (SO2), and other main air pollutants are the basis for calculating the Air Quality Index (AQI), which is a numerical number that ranges from 0 to 500.
A number of strategies, such as emission limits, forecasts, and regulatory laws, have been created to monitor and control the quality of the air. The goal of air quality forecasting is to estimate future AQI levels by utilizing machine learning and statistical models that are grounded on past data and meteorological variables. Air quality forecasting has made use of machine learning techniques including decision trees, support vector regression (SVR), and linear regression. In recent investigations, the potent machine learning algorithm Random Forest (RF) has been applied for AQI prediction.

II. PROBLEM STATEMENT

To create, evaluate, and distribute data on air and water quality in order to facilitate informed decision-making, public awareness campaigns, and environmental protection initiatives. To design and execute a comprehensive environmental monitoring system that includes the creation of an Air Quality Index and a Water Quality Index.

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III. OBJECTIVE

To design and implement comprehensive environmental monitoring system that incudes calculating AQI and WQI. This system aims to continuously collect and analyse the data and develop an air and water quality index monitoring system.

When air and water quality sensors are integrated into wearables, smart accessories, and mobile devices (such watches and glasses), people may track their own exposure to contaminants in real time.

With the help of this individualized information, users will be able to choose their hobbies and behaviors with the least amount of exposure.

Predictive models that anticipate air and water quality conditions across different time frames may be constructed by merging IoT data with geographical, historical, and meteorological data.

Planning ahead, making proactive decisions, and implementing public health initiatives can all be aided by these projections.

A. Need of Project

To safeguard public health, it is essential to monitor the quality of the air and water. Cardiovascular disorders, respiratory difficulties, and other health concerns can be brought on by poor air quality. Drinking contaminated water can lead to waterborne infections. For plants and animals to survive, clean air and water are essential, and monitoring changes in these elements can help spot any environmental hazards. In order to guarantee adherence to environmental norms and laws, regulatory bodies frequently demand that the quality of the air and water be monitored. Monitoring air quality is crucial for keeping tabs on greenhouse gas emissions and how they affect global warming. It is essential to comprehend the concentration of pollutants such as carbon dioxide and methane in order to evaluate the success of emission control initiatives.

B. Motivation

Pollution of the air and water is the greatest issue facing every country, developed or developing. Gas emissions frequently have an impact on respiration, lung cancer, and eye discomfort in both humans and animals.

In addition to moderate allergy reactions around the eyes, nose, and throat, pollution can also cause more significant health issues like pneumonia, lung infections, bronchitis, and worsening asthma. Businesses that dispose of their waste materials in rivers contaminate the water and endanger public health. We are working on this project in order to solve this issue.

IV. LITERATURE REVIEW

A review of the literature comprises the state of the art, encompassing significant discoveries as well as theoretical and methodological advancements on a given subject. Reviews of the literature do not provide brand-new or innovative experimental work. Anyone may study and report on what the literature in the area has to say about any topic or subject by doing a literature survey, also known as a literature review. There could be several of related books, or perhaps only a little amount. In any case, the objective is to demonstrate that he has read and comprehended the perspectives of other scholars who have researched the problem issue that he is looking at. The reader can develop his methodological emphasis and theoretical framework with its help. He or she is making a proposal in light of previous work, even if it is a novel theory or approach.

In order to anticipate and predict the quality of the air and water as well as the use of energy resources, this study proposes a smart resource management system. Effective methods and machine intelligence algorithms have been in contrast to estimate the caliber of these resources. More than 85% of the country's energy comes from fossil fuels including coal, oil, and natural gas. Natural gas burns the cleanest among the fossil fuels and has a high British thermal unit (Btu) content (2). It is also a dependable and efficient energy source. In the near future, reliance on natural gas as a source of energy will not decrease. Recent increases in energy use, a decline in readily accessible oil and gas reserves, and the effectiveness of harvesting unconventional natural gas resources in It is projected that unconventional resource-derived natural gas will make up an ever-growing share of the US natural gas reserves. [1]

This paper designs an indoor air quality monitoring system based on sensor technology and Internet of things technology, the system function includes air quality detection, real-time data display, server transfer, remote display thought We-chat mini program and others, the system can detect six important environmental parameters and allows users to view the data on mobile phone.[2]

This article introduces development of a system that monitors indoor air quality by using Internet of Things (IoT) technology. The objective of this system is to monitor and improve indoor air quality automatically. [3]

This paper introduces various human activities that produce pollutants that endanger their lives. By utilizing current technology, it is possible to design a Water and Air Quality Monitoring System based on the Internet of Things to monitor air and water quality quickly and in real-time in the surrounding environment [4]

This article recognizes rapid industrialization and urbanization of our world have led to increasing concerns about air and water pollution, which pose significant threats to human health and the environment. [5]

This research aims to provide valuable insights for policymakers and urban planners in addressing environmental challenges and improving the overall quality of life for Madurai's residents. [6]

A method for assessing the air quality levels using the Naïve Bayes and J48 classification algorithms has been proposed by Ranjana Waman Gore et al. The dataset's accuracy when using the J48 decision tree algorithm was 91.99%, whereas it was 86.66% accurate when using the Naïve Bayes algorithm. The J48 method produces more accurate results than the Naïve Bayes algorithm, which the author further justifies.[7]

Sandhya P. has suggested an approach that uses the random forest, Naïve Bayes, and decision tree algorithms to forecast PM2.5. [8]

In their proposal, Bonny Paulose et al. primarily examined Delhi's air quality and utilized the K-means clustering technique to identify the sources of the pollutants that contribute to air pollution. Additionally, the author demonstrated that Punjabi Bagh, R K Puramand, and Anand Vihar are among the most polluted areas. [9]

For the analysis of air quality, Ranjana Gore et al. suggested a method that employed multiclass classifier and Random forest classification algorithms. Additionally, the author demonstrated the superiority of multiclass classifier over random forest. [10]

A model for examining Karnataka state's air pollution was presented by Mohamed Shakir et al. The ZeroR method was employed by the author to analyze air contaminants. Additionally, the author illustrates the connections and interdependencies among contaminants.[11]

Shweta Taneja and colleagues have put out a method for forecasting Delhi's air pollution. In order to forecast air contaminants, the author employed time series analytic techniques, namely multilayer perceptrons and linear regression. [12]

A model for the binary categorization of PM10 levels has been presented by Kiymet Kaya et al. To classify PM10 levels, the author employed the Random Forest, Gradient Boosting, and Extra Tree classifiers. Additionally, the author argues that findings from the Random Forest classifier are more accurate.[13]

Kostandina Veljanovska et al. have presented a machine learning-based method for air quality index prediction. The algorithms that an author uses include Decision Tree, SVM, K-Nearest Neighbor, and Neural Network. The author comes to the conclusion that a neural network has more accuracy than any other. [14]

A method for air pollution prediction was put out by Rubal et al. In order to get exact findings, the author employed a hybrid prediction strategy that blended the random forest algorithm with the differential evolution method. [15]

V. PROJECT METHODOLOGY

A standardized metric called the Air Quality Index is used to assess how safe and clean the air we breathe is.The Air Quality Index (AQI) gives a numerical value between 0 and 500, where larger values indicate more pollution and lower ones indicate cleaner air. The general public may easily comprehend the possible health concerns connected with the present air quality by looking at the several color-coded categories into which these values are grouped. A numerical method known as the Water Quality Index is used to evaluate the general safety and health of water bodies, including lakes, rivers, and reservoirs. It considers a number of variables, such as biological components, chemical factors, and physical attributes. Similar to the AQI, the WQI rates the quality of the water, with lower numbers denoting safer and cleaner water and larger scores denoting declining water quality. Predicting the Water Quality Index is the goal. In order to do this, we first extract the water data from the dataset and count the number of rows and columns of the provided data before moving on to the following stages. The steps in our approach are as follows: first, gather the necessary data; next, analyze the relationship between the various data columns and apply pre-processing techniques; finally, analyze the data and predict the water quality index of the water sample given specific values such as pH, dissolved oxygen, biochemical oxygen demand, total coliform, electric conductivity, and nitrates. The usual work-flow for training is displayed below.

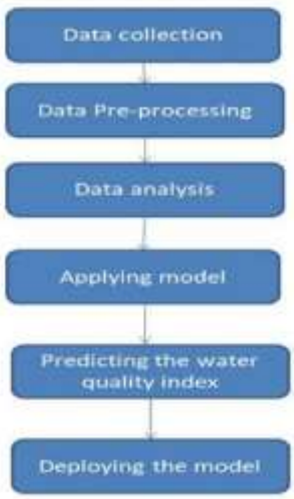

Fig 1. General Work-flow.

Water_dataX.csv, the data collection utilized in this instance, has 12 columns and around 1992 rows. The Kaggle dataset was used. The station code, location, state, and several input characteristics such as temperature, ph, dissolved oxygen, conductivity, biochemical oxygen demand, fecal coliform, total coliform, nitrates, and year are among the various columns that are included. Float64 has been selected since the parameter values are kept as fractions. The water's quality is determined by a variable called WQI, which is constructed using information from npH, NBDO, NEC, NNA, WPH, WDO, WBDO, WEC, WNA, and WCO.

VI. MODELING AND ANALYSIS

Linear Regression:

To emphasize the relationship between continuous variables in predictive analysis, linear regression is a calm and uncomplicated statistical regression approach. A statistical technique known as "linear regression" shows a linear connection between the dependent variable (Y-axis) and the independent variable (X-axis). If there is just one input variable (x), this type of linear regression is referred to as simple linear regression. If there are several input variables, this kind of linear regression is sometimes referred to as multiple linear regression. In a linear regression model, a sloping straight line represents the relationship between the variables.

Random Forest:

It was thought that the Random Forest Regressor's accuracy was crucial. Several decision trees serve as the basic classifiers of the supervised machine learning method known as the Random Forest classifier/regressor, which was developed by Brieman. Random Forest Classifier has strong accuracy with large datasets and provides great estimate of missing values in a dataset when a substantial percentage of values are missing. Randomness and replacement are introduced by choosing node sets and subsampling the training data. The following stages make up the algorithm that has to be used. Using feature and row sampling, choose N samples from the dataset. It was thought that the Random Forest Regressor's accuracy was crucial. Several decision trees serve as the basic classifiers of the supervised machine learning method known as the Random Forest classifier/regressor, which was developed by Brieman. Random Forest Classifier has strong accuracy with large datasets and provides great estimate of missing values in a dataset when a substantial percentage of values are missing. Randomness and replacement are introduced by choosing node sets and subsampling the training data. The following stages make up the algorithm that has to be used. Using feature and row sampling, choose N samples from the dataset. These samples serve as training datasets from which N decision trees with the ability to make predictions are extracted. Combine the outcomes that every decision tree generates. Ascertain the ultimate forecast by taking into account the bulk of the outcomes generated by N TREES. You may import the Random Forest Regressor from the Python SCI-KIT learn module. The number of decision trees, or n-estimators, that WE have selected is 10. The model predicts the Water Quality Class after being given the training data.

Software Requirement

Operating system: Microsoft Windows 7 and above.
Programming Language: Python
IDE: Visual Studio Code, Arduino IDE

Hardware Requirement

Processor: Intel Core i3 or higher - RAM: 4GB or higher - Hard disk: 100GB (min) - Arduino - Turbidity Sensor - Temperature Sensor - MQ-135 Sensor - Node MCU esp8266 - Capacitor 1000 - 104 pf ceramic capacitor – Transformer

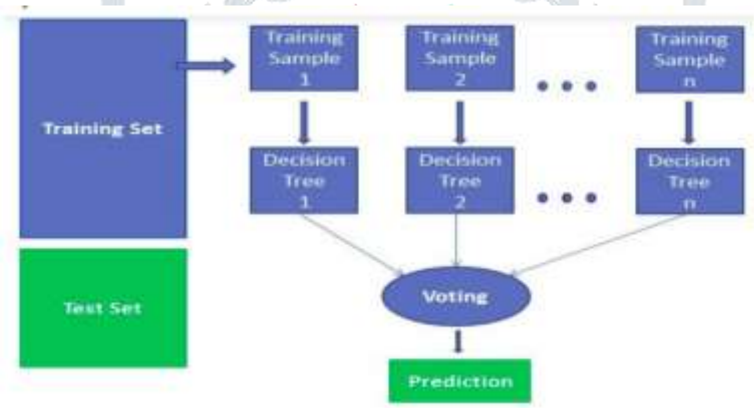

Fig 2: Working of Random Forest

Analyzing air and water quality monitoring using regression and random forest algorithms involves understanding the relationship between various environmental factors and the quality of air and water. Here's a structured approach:

1. Real time Data Collection:

●The system will gather data in real-time via Internet of Things (IoT) sensors that track several aspects of water and air quality, including temperature, turbidity, and pollutant concentrations. It guarantees that sensors can measure important pollutants for AQI and WQI computations.
It gathers data in real time from sensors on the concentrations of pollutants.

● It transmits data via wireless communication protocols like Wi-Fi. To compute AQI and WQI values from raw sensor data, train algorithms.

● Developed a mobile application and web-based dashboard user interface for AQI and WQI real-time monitoring. Predictive models based on historical data and environmental parameters were developed to estimate future changes in the AQI and WQI.
Makes use of machine learning methods to find connections, trends, and pollution event forecasts.

● Offers decision assistance tools and predictive analytics dashboards to users.

2. Data Preprocessing:

By forecasting the AQI and WQI values to be used in the environment, the algorithms aid in the analysis of the data that has been gathered. SVM (Support Vector Machine) and Random Forest are two machine learning techniques utilized in this research to categorize and forecast the quality of real-time data concerning the AQI and WQI monitoring systems.

Our research distinguishes itself in the field of environmental monitoring systems by combining IOT devices with SVM (Support Vector Machines) and Random Forest machine learning methods. In contrast to traditional methods, we only use machine learning to evaluate air and water quality in real time, guaranteeing a more accurate assessment. Our system proficiently evaluates the real-time evaluations of environmental conditions with unparalleled precision by employing the Random Forest and SVM algorithms.

Handle missing data: Impute missing values or remove incomplete records.

Outlier detection: Identify and handle outliers which may skew the analysis.
Feature selection: Choose relevant features that impact air and water quality.

3. Exploratory Data Analysis (EDA):

Understand the distribution and relationships between variables.
Visualize correlations between different factors and air/water quality.

4. Regression Analysis:

Linear Regression:

Establish linear relationships between predictors (environmental factors) and the target (air or water quality).
Evaluate the model's performance using metrics like R-squared, Mean Squared Error (MSE), etc.

5. Random Forest Regression:

Train a Random Forest model:

Ensemble learning technique that builds multiple decision trees and averages their predictions.
Handle non-linear relationships and interactions between variables effectively.

Tune hyperparameters:

Use techniques like cross-validation to optimize model performance.

6. Model Evaluation:

Compare the performance of regression and random forest models using appropriate evaluation metrics (e.g., R-squared, MSE, MAE).
Assess the models' ability to predict air and water quality accurately.

7. Interpretation:

Understand the importance of different features in predicting air and water quality.
Identify which environmental factors have the most significant impact.
Explain the model's findings in the context of environmental science.

8. Deployment and Monitoring:

Deploy the chosen model for real-time or periodic predictions.
Continuously monitor model performance and update it as new data becomes available.
Integrate the model into decision-making processes for environmental management and policy.

Additional Considerations:

Feature Engineering: Create new features that may better capture complex relationships.
Model Explainability: Ensure the models' predictions are interpretable, especially in sensitive domains like environmental science.
Data Quality: Ensure the quality and reliability of the data used for training and validation.
Scale: Consider scalability when deploying the model to monitor air and water quality over large geographical areas.
Regulatory Compliance: Ensure the model meets any regulatory standards for air and water quality monitoring.
By following this structured approach, you can effectively analyze air and water quality monitoring using regression and random forest algorithms, providing valuable insights for environmental management and decision-making.

Fig.3. Joining Page

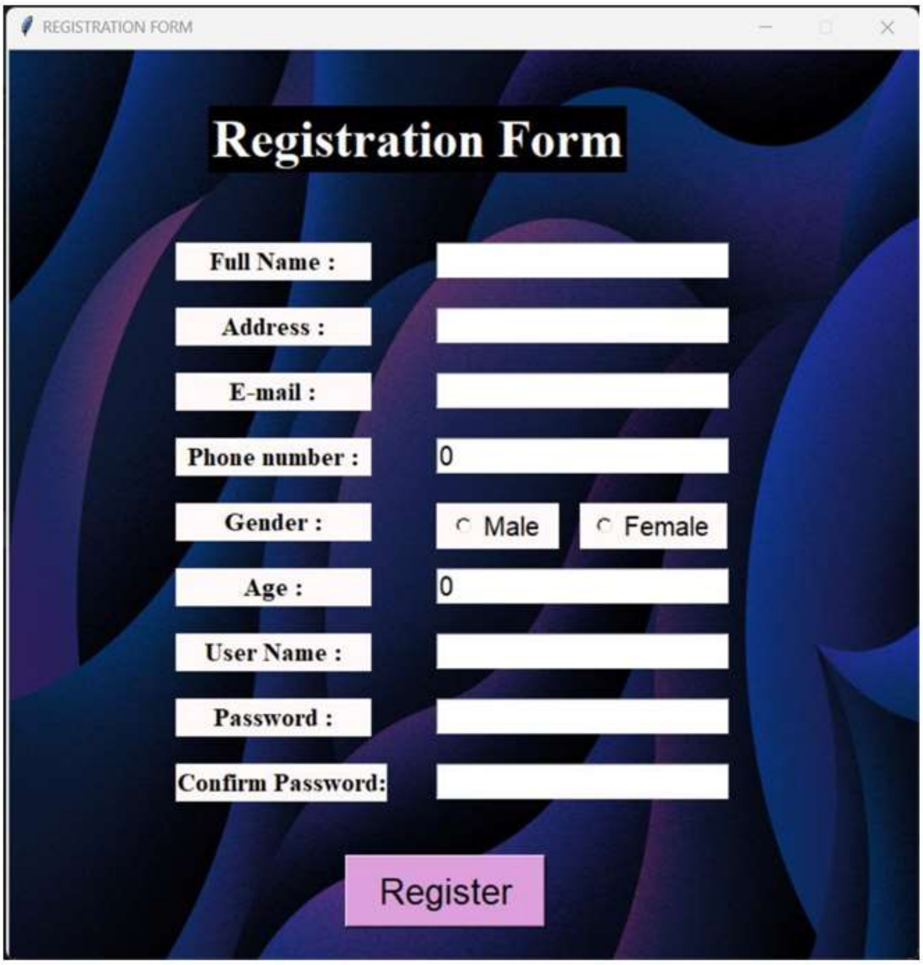

Fig 4. Registration form

Fig.5. Sign up page

The system's architecture is mostly built on machine learning and IOT algorithms. The components are divided into two main categories: software and hardware. The GSM/GPRS module provides the link between the hardware and software, while the sensors on the hardware portion aid in measuring values in real time.We used an Arduino to create a program in software. The PCB is designed in the first stage of production, with components and sensors installed.To view the output, the Android version of the BLYNK app must be installed. The kit and Arduino receive dc electricity when the system boots up, and the GSM/GPRS turns on.

The mobile application receives the results of the testing done on the water's parameters.Because of this, we are able to view the kit's real-time value on our cloud server from anywhere at any time when it is situated on a certain body of water and GSM/GPRS is available.

In addition to this IOT-based project, we have created software that makes use of SVM and other machine learning algorithms. There are n numbers of users present in this module. Registering is required before doing any operations. The user's information is stored in the database when they register. Following a successful registration, the user must log in using their approved username and password. Once successful login, user actions include managing accounts.

The user can access the new data once the administrator updates it. A user can provide the parameters shown on the BLYNK app as input to obtain a forecast on the quality of the air and water.

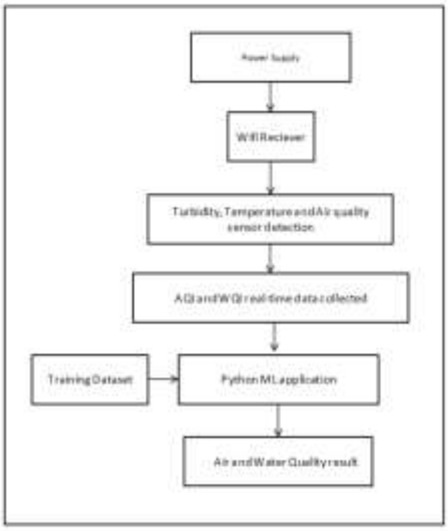

Fig .6. System Architecture

Module and their Functionality

Turbidity Sensor: Turbidity sensors calculate how much light is dispersed by the particles suspended in water. The turbidity level (as well as cloudiness or haziness) of water rises with the amount of total suspended solids (TSS) in the water. Turbidity sensors find use in laboratory measurements, sediment transport studies, wastewater and effluent measurements, control instruments for settling ponds, and river and stream gaging. In a lab or outdoors, turbidity is measured with sophisticated optical equipment. A water sample is exposed to light, and the amount of light dispersed is measured. The measurement is known as a Nephelometric Turbidity Unit (NTU), and it has several variants.

Temperature Measurement:

A temperature sensor is a device that uses an electrical signal to measure temperature and present the reading in a readable format. These devices are usually thermocouples or resistance temperature detectors.The simplest type of temperature meter for determining how hot or cold something is is a thermometer. In the geotechnical sector, temperature meters are used to track changes in structural integrity caused by seasonal fluctuations in various materials, including concrete, soil, water, bridges, and other structures. Two different metals are used to create a thermocouple (T/C), which produces an electrical voltage directly proportional to temperature changes.

MQ-135 (sensor for evaluating air quality)

The MQ-135 Gas sensor is capable of detecting smoke, other hazardous gases, ammonia (NH_3), sulfur (S), benzoene (C_6H_6), and CO_2.Among the prominent gas sensors in the MQ series, which are frequently used in air quality control equipment, is the MQ135. It runs between 2.5 and 5.0 volts.

MCU 8266 Node

An open-source LUA-based firmware called Node MCU was created for the ESP8266 WiFi chip. Node MCU software, which is included with the ESP8266 Development board/kit, or Node MCU Development board, allows users to explore the capabilities of the ESP8266 chip.

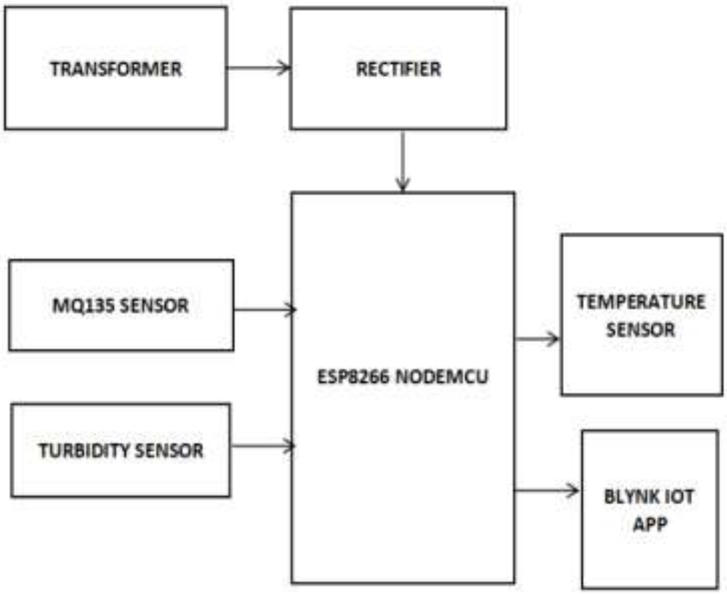

Fig.9.Block Diagram

VII. Result and Discussion

In conclusion, the goal of our Internet of Things project was to use cutting-edge technology to address the important problems of monitoring the quality of the air and water. We have successfully designed a robust system that can monitor and analyze air and water quality metrics in real-time by utilizing Internet of Things (IoT) sensors. Our AQI and WQI assessments were proven to be accurate and reliable through rigorous testing and validation. This initiative has important ramifications for public health and environmental sustainability in addition to its contribution to environmental monitoring.Further improvements like adding predictive analytics and growing sensor networks can boost our solution's efficacy and scalability in the future. All things considered, this endeavor is a big step in the right direction toward using technology to improve society and the environment.

In this module, there are n numbers of users are present. User should register before doing any operations. Once user registers, their details will saved in the database. After registration successful,he has to login by using authorized user name and password. Once Login is successful user will do some operations like Manage Account.

- The admin will update the data & user can view updated data.
- After the data set has been created the user has to an option to search the city and see the Air quality & water quality.
- The user will receive an SMS notification of Air and water quality index to which the user has registered.
- The user will also receive an alarm notification when the air and water quality has shown changes done by admin in data set.

VIII. Conclusion

The air and water quality index, along with comprehensive environmental monitoring, plays a vital role in assessing the state of our environment and guiding policies and actions to protect it. In summary, air and water quality indices and broader environmental monitoring efforts are essential tools for safeguarding the health of our planet and ensuring a sustainable future. When it comes to protecting the environment and human well-being, data collection and analysis are crucial for making informed decisions and acting promptly. Provide wearable sensors that can track a person's exposure to water and air contaminants over time. This can give people up-to-date information about their local surroundings and support them in making health-conscious decisions.Work together on smart city projects to include WQI and AQI sensors into the city's infrastructure. In order to enhance the quality of the air and water in highly populated places, city planners may be able to use this to monitor environmental quality in real-time and carry out targeted interventions. To increase the AQI and WQI sensors' sensitivity, durability, and accuracy, research and development should be prioritized. Improvements in sensor technologies, such as optical and nanomaterial-based sensors, may result in more dependable and reasonably priced monitoring options. Establish and put into effect recommendations for WQI and AQI monitoring procedures in close collaboration with standardization organizations and regulatory authorities. Data on environmental quality may be consistently and comparably collected, analyzed, and reported across many locations and authorities by establishing standard processes.

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