Deliverables of Web application to track water quality in different locations

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Literature Review

1 Paper 1: A Low-Cost Multi-Parameter Water Quality Monitoring System

Journal/Conference Rank: Q1
Publication Year: 2021
Reference: [1]

1.1 Summary

The research describes a low-cost water quality monitoring system that uses electrochemical sensors and a smartphone app to evaluate free chlorine, temperature,pH, and BPA. The paper claims that the system can provide real-time and reliable data for environmental monitoring. The manufacturing, calibration, and testing of the sensors, as well as the design and execution of the readout circuit and the smartphone app, are all included in the article. The paper reports that the system can achieve high sensitivities for the water quality parameters.

1.2 Software Architecture

The software architecture consists of three components: a sensor readout circuit that is a potentiostat, a smartphone application that is an Android app, and a wireless connectivity that is a Bluetooth module. The sensor readout circuit can measure the current and voltage signals from the sensors and send them to the smartphone app via the Bluetooth module. The smartphone app may alert the user to any irregularities and show real-time water quality data.

1.3 Data Parameters

The paper uses four data parameters to measure water quality using electrochemical sensors. They are:
• **pH:** This parameter shows whether the water is acidic or alkaline. The pH scale runs from 0 to 14, with 7 being neutral, anything below that being acidic, and anything above that being alkaline.
• **Free chlorine:** This parameter indicates the amount of chlorine that is available to disinfect water. It is measured by the current generated by the oxidation of free chlorine at a gold electrode.
• **Temperature:** It is measured by the change in resistance of a platinum wire due to thermal expansion or contraction. The temperature unit is degree Celsius (°C) or Kelvin (K)4.
• **Bisphenol A (BPA):** This parameter indicates the presence of an endocrine-disrupting chemical that can leach from plastic products into water. The BPA concentration is expressed in nanomolar (nM) or parts per trillion (ppt).

1.4 Datasets Used

Laboratory datasets and field datasets are the two types of data sets used in the article to assess the effectiveness of the water quality monitoring system. The sensors are tested in controlled environments with known concentrations of pH, free chlorine, and BPA to acquire the laboratory datasets. The field datasets are obtained by deploying the sensors in real-world scenarios, such as a swimming pool, a river, and a tap water source.

1.4.1 Paper Link

Access the paper at https://www.mdpi.com/1424-8220/21/11/3775.

2 Paper 2: Water Quality Monitoring with Arduino Based Sensors

Journal/Conference Rank: Q2
Publication Year: 2021
Reference: [2]

2.1 Summary

The paper presents a prototype of an Arduino-based sensor system for water quality monitoring. The system gauges the pH, temperature, turbidity, and total dissolved solids of the water. The system is made to be affordable, dependable, and real-time. The system was tested at a lake in Brunei for four weeks and the results were compared with a commercial water quality meter. The paper discusses the challenges and limitations of the system, as well as the future work to improve it.

2.2 Software Architecture

The paper uses a modular software architecture that consists of three main components: the sensor node, the sink node, and the data analysis.Data from the associated sensors must be gathered and prepared by the sensor node before being transmitted through Zigbee wireless communication to the sink node. The sink node is in charge of obtaining, storing, and showing data from the sensor node on an LCD screen. The data analysis is done on a computer using MATLAB software.

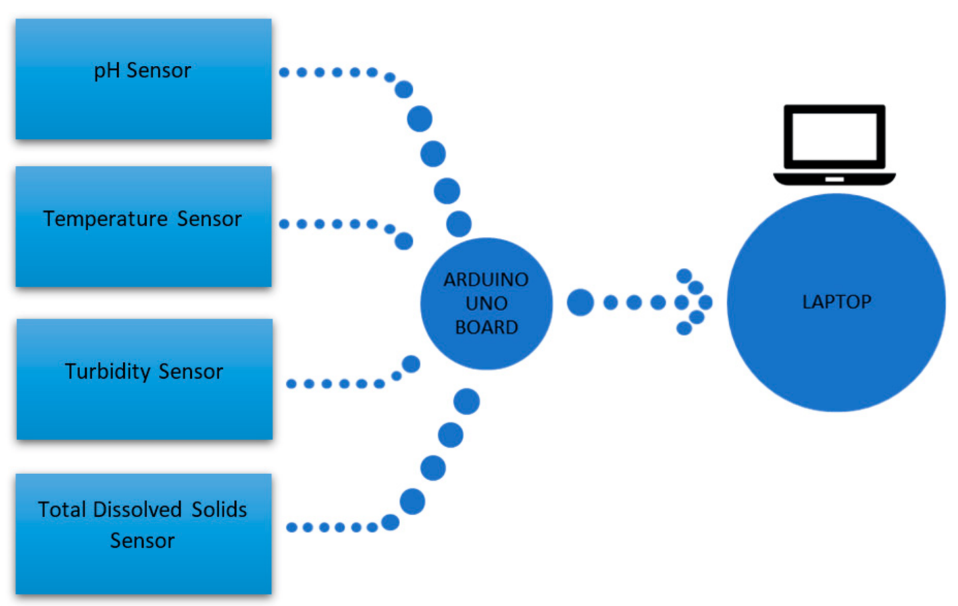

Figure 1: Block diagram of the connections of Paper 2.

2.3 Data Parameters

The paper uses four data parameters to measure water quality: pH, temperature, turbidity, and total dissolved solids (TDS). The solubility and availability of nutrients and contaminants are influenced by the acidity or alkalinity of the water, which is measured by pH. Temperature is a measure of the thermal state of water, which affects the biological activity and chemical reactions. Water clarity or cloudiness is measured by turbidity, which has an impact on light refraction and aquatic plant development. Dissolved solids, which are determined by TDS, have an effect on the conductivity and salinity of water.

2.4 Datasets Used

The system's performance is assessed using two datasets: one from Tasek Merimbun Lake in Brunei and the other from a commercial water quality meter (Hanna HI 9828). The onsite tests were conducted for four weeks at different times of the day (morning, afternoon, and evening). The commercial meter was used as a reference to compare the accuracy and reliability of the system. The paper provides tables and graphs to show the comparison of the datasets for each parameter.

2.4.1 Paper Link

Access the full paper at https://www.mdpi.com/2076-3298/8/1/6.

3 Paper 3: Monitoring of water quality in a shrimp farm using a FANET

Journal/Conference Rank: Q1
Publication Year: 2019
Reference: [3]

3.1 Summary

The study presents a design for monitoring water quality in shrimp farms using Flying Ad-Hoc Networks (FANETs). It highlights the essential water quality criteria for the growth and well-being of shrimp. It is suggested to use controlled mobility in a mobile sensing platform based on FANETs to improve spatial monitoring. After conducting laboratory testing, the authors intend to present this method to Mexican shrimp farmers, highlighting the significance of regular water quality monitoring for farm profitability.

3.2 Software Architecture

The paper employs a three-tier software architecture: Sensing Tier: Drones equipped with wireless sensors collect water quality data. Processing Tier: A laptop processes data, calculates Water Quality Index (WQI), detects anomalies, and localizes contamination events. Cloud Tier: A cloud server stores and analyzes data, offering backup, visualization, sharing, and data mining services. Various software tools and languages, including Python, MATLAB, TensorFlow, and scikit-learn, are used to implement this architecture, adhering to principles like modular programming and object-oriented programming.

3.3 Data Parameters

The two data types that are highlighted in this research are: Water Quality Measurement Various information, including pH, dissolved oxygen (DO), temperature, turbidity, ammonia (NH3), nitrite (NO2), nitrate (NO3), and phosphate (PO4). Also Water Quality Index (WQI), anomaly detection, and contamination localization based on water quality data.

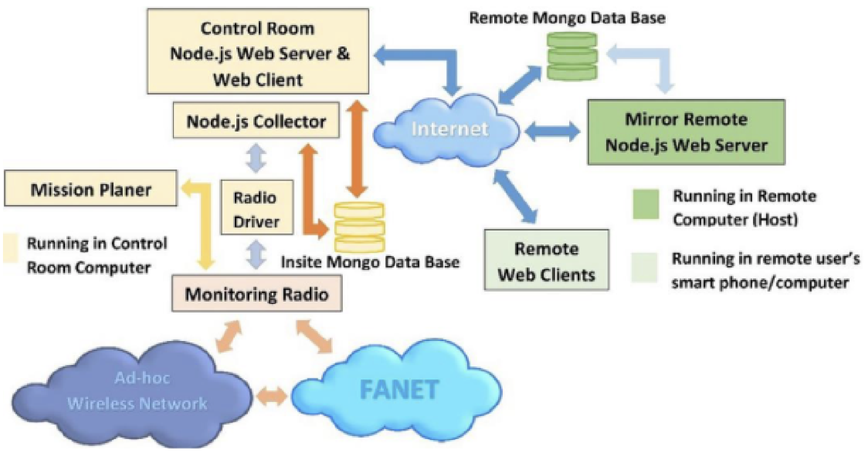

Figure 2: Software architecture diagram for Paper 3.

3.4 Datasets Used

Water Quality Measurement Data: Real-time data collected by drones equipped with wireless sensors. Water Quality Analysis Data: Data related to WQI, anomaly detection, and contamination localization for monitoring and ensuring the health of shrimp farms.

3.4.1 Paper Link

Access the full paper at https://sci-hub.se/https://doi.org/10.1016/j.iot.2020.100170.

4 Paper 4: State of the Art Techniques for Water Quality Monitoring Systems for Fish Ponds Using IoT and Underwater Sensors: A Review

Journal/Conference Rank: Q1
Publication Year: 2022
Reference: [4]

4.1 Summary

In-depth reviews of water quality monitoring systems (WQSN) that use IoT and underwater sensors that were created by researchers between 2011 and 2020 are done in this research. It highlights how vitally important clean water supplies are and how ongoing monitoring is required because of pollution, contamination, and climate change. The drawbacks of conventional water quality monitoring systems—manually collected samples and laboratory analysis—are emphasized. The authors suggest many WQSNs that employ wireless sensor networks (WSN) based on the Internet of Things (IoT) to continually monitor parameters including temperature, turbidity, pH, dissolved oxygen, and electrical conductivity. Furthermore, the gathered data is analyzed by machine learning algorithms, which also offer early alerts for problems with water quality. The discussion of significant accomplishments, success metrics, and recommendations for future WQSN research directions round up the report.

4.2 Software Architecture

The paper presents a three-layer architecture: Sensing Layer (underwater sensors), Processing Layer (IoT devices for data analysis), and Cloud Layer (data storage and services). Tools include Arduino, Python, MATLAB, Java, Firebase, and Google Maps API. Design principles ensure reliability.

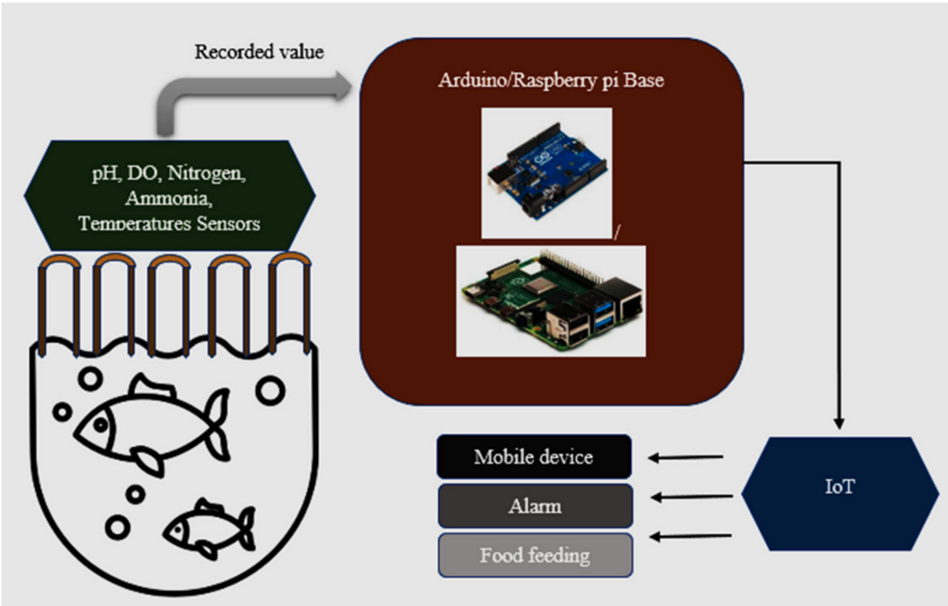

Figure 3: Proposed WQMS using IoT system for Paper 4.

4.3 Data Parameters

The paper focuses on two data categories: Water Quality Measurement Data: pH, DO, temperature, turbidity, ammonia, nitrite, nitrate, phosphate. Water Quality Analysis Data: Water Quality Index (WQI), water quality prediction, and control mechanisms for water quality management.

4.4 Datasets Used

Datasets Used The paper utilizes two primary datasets: Water Quality Measurement Data: Real-time data from underwater sensors. Water Quality Analysis Data: Data related to WQI, predictions, and control mechanisms.

4.4.1 Paper Link

Access the full paper at https://www.mdpi.com/1424-8220/22/6/2088.

5 Paper 5: Spatio-temporal analysis of water quality for pesticides and other agricultural pollutants in Deduru Oya river basin of Sri Lanka

Journal/Conference Rank: Q1
Publication Year: 2021
Reference: [5]

5.1 Summary

The paper's main objective is to evaluate the water quality in Sri Lanka's Deduru Oya river basin, especially in regions that get a substantial amount of agricultural input. Between the 2019 dry season (Yala) and the 2019–2020 wet season (Maha), the authors collected 183 water samples every two weeks. 39 factors, such as pesticides, heavy metals, minerals, and physico-chemical characteristics, were examined in these samples. Although heavy metal residues were not identified in the water samples, but some pesticides that exceeded national legal limits were found in them. The use of pesticides in agriculture and natural mineralization are two primary causes of water contamination in the region, according to the research.

5.2 Software Architecture

The paper doesn't provide explicit details about the software architecture used for its analysis. However, the study likely has three key components: data collection, data analysis involving statistical methods and water quality index calculations, and data visualization to present the findings. Software tools and languages are employed for these tasks.

5.3 Data Parameters

The study incorporates four main categories of data parameters: Pesticides: Testing 20 pesticides used in Sri Lankan rice cultivation, with ten of them detected in the water samples, exceeding regulatory limits. Heavy Metals: Testing ten heavy metals, none of which were found in the water samples. Minerals: Testing nine minerals, some of which exceeded drinking water standards. Physico-chemical properties: Testing nine properties affecting water quality, including pH, DO, temperature, turbidity, NH3, NO2, NO3, and PO4, with the data used to calculate a Water Quality Index (WQI).

5.4 Datasets Used

1.Dataset for Monitoring Water Quality: This dataset contains information gathered from 183 water samples taken at 12 different sites in the Deduru Oya river basin. 39 parameters were looked at in 2019 after samples were taken during both the dry and wet seasons. The data was gathered using approved techniques and procedures. 2.Statistical Analysis Data: Samples were taken in 2019 during both the dry and wet seasons, and 39 parameters were looked at. It offers information on the geographical distribution across the river basin as well as variation and linkages among water quality metrics.

5.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/pii/S0959652621040671.

6 Paper 6: Low-Cost Internet-of-Things Water-Quality Monitoring System for Rural Areas

Journal/Conference Rank: Q1
Publication Year: 2023
Reference: [6]

6.1 Summary

The article describes a low-cost internet-of-things (IoT) system designed to track and record the quality of various water sources. It monitors the turbidity, pH, temperature, and other characteristics of the water in a rural community using a number of sensors. The study emphasizes how crucial water quality monitoring is to protecting human life, fostering economic growth, and upholding the natural order. In order to provide early alerts and avoid contamination, the authors offer a low-cost prototype method for monitoring and assessing water sources in rural regions as their final point.

6.2 Software Architecture

The paper employs a web-based software architecture with three components: an IoT device for data collection, a mobile application for processing and user feedback, and a web server for data storage and sharing. It uses various software tools and principles like modular programming and object-oriented programming.

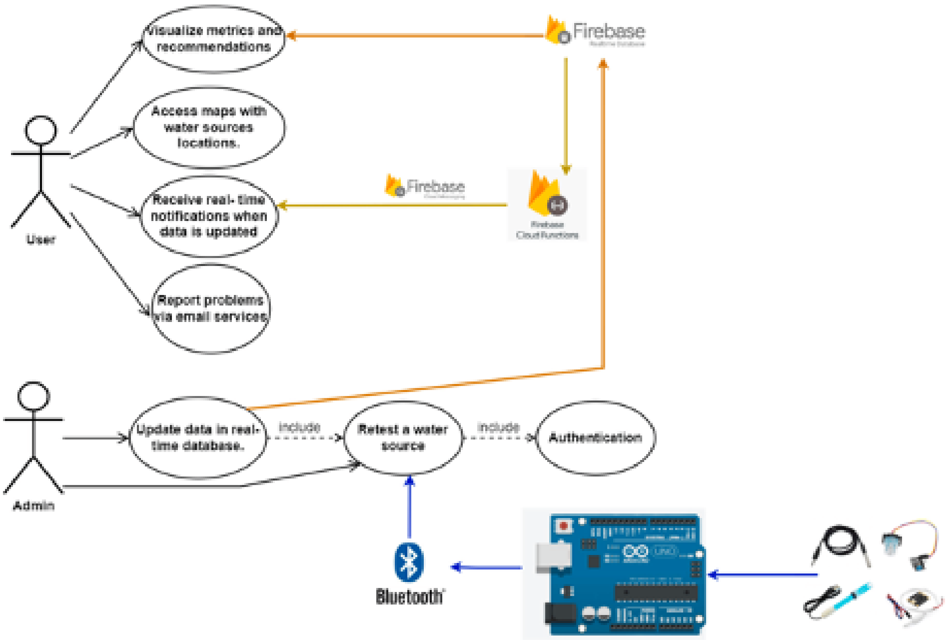

Figure 4: Software Architecture for Paper 6.

6.3 Data Parameters

The paper focuses on two main types of data parameters: Water Quality Measurement Data: Parameters include pH, dissolved oxygen (DO), temperature, turbidity, ammonia (NH3), nitrite (NO2), nitrate (NO3), and phosphate (PO4). Water Quality Analysis Data: This involves the Water Quality Index (WQI), anomaly detection, and contamination localization based on water quality data.

6.4 Datasets Used

The paper uses datasets for real-time water quality measurements in rural areas and offers insights into water quality, pollution sources, and remedial measures.

6.4.1 Paper Link

Access the full paper at https://www.mdpi.com/1424-8220/23/8/3919.

7 Paper 7: Applications of Online UV-Vis Spectrophotometer for Drinking Water Quality Monitoring and Process Control: A Review

Journal/Conference Rank: Q1
Publication Year: 2022
Reference: [7]

7.1 Summary

The use of online UV-Vis spectrophotometers for process control and drinking water quality monitoring is discussed in the study. It talks about how these sensors are superior to more conventional approaches and emphasizes how they can quickly detect changes in water quality and record the events. The use of chemometrics for improved usability and the usage of UV-Vis spectrophotometers to measure various water quality parameters are also covered in the paper. Anomaly detection and early warning systems are also explored in this. The paper concludes by discussing the need for further research, including industrial-scale evaluation and integration with real-time water treatment control systems.

7.2 Software Architecture

The paper employs a web-based software architecture. It has three components in it. They are the online UV-Vis instrument, web server, and web client. These components are responsible for data collection, processing, and user interaction using languages like Python, HTML, CSS, JavaScript, and MySQL.

7.3 Data Parameters

The study makes use of measurements of water quality, including spectral, dissolved organic carbon (DOC), total organic carbon (TOC), turbidity, and UV 254 absorbance indices. For chemometrics data, various methods like PCA, PLSR, ANNs, SVMs, and RFs are employed for analysis, utilizing software tools such as MATLAB, and Python.

7.4 Datasets Used

The paper utilizes two types of datasets: water quality measurement data obtained from online UV-Vis instruments and chemometrics data for enhancing usability. These datasets are necessary for monitoring and improving drinking water quality.

7.4.1 Paper Link

Access the full paper at https://www.mdpi.com/1424-8220/22/8/2987.

8 Paper 8: Water quality monitoring in smart city: A pilot project

Journal/Conference Rank: Q1
Publication Year: 2018
Reference: [8]

8.1 Summary

The system described in this work collects and displays high-frequency, real-time data on water quality from Bristol Floating Harbour, which is a component of Bristol, UK's smart city infrastructure. TThe system employs cloud computing, Internet of Things, and wireless sensor networks to track many aspects of water quality, including conductivity, pH, temperature, and dissolved oxygen. The feasibility and advantages of adopting such a system for urban water management and environmental protection are presented in the study.

8.2 Software Architecture

The sensor layer, the network layer, the cloud layer, and the application layer make up the four levels of the software architecture employed in the article. Wireless sensor nodes that detect water quality parameters and communicate the information to a gateway make up the sensor layer. The gateway and the Bristol Is Open network make up the network layer, which connects wirelessly to the cloud layer and transmits data there. The cloud layer is made up of a server that uses software programs like MySQL, PHP, Python, and R to store and analyze data. The application layer consists of a web portal that displays the real-time data and graphs online.

8.3 Data Parameters

The data parameters used in the paper are:
• **Dissolved oxygen (DO):** The degree of organic contamination and the amount of dissolved oxygen in the water, which both reflect the health of aquatic life.
• **pH:** The acidity or alkalinity of water, which has an impact on how easily metals and nutrients dissolve in water and how quickly organisms develop.

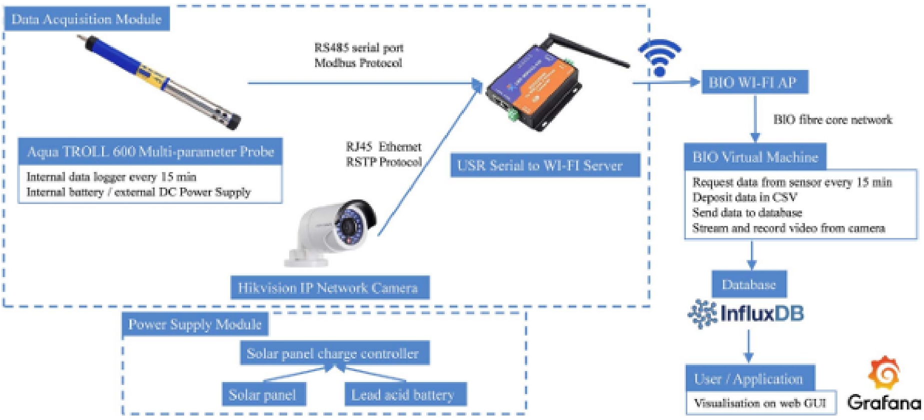

Figure 5: General Design of the System for Paper 8.

• **Temperature:** The degree of heat or cold of water, which affects the metabolism, reproduction, and distribution of aquatic life and the solubility of gases and chemicals.
• **Turbidity:** The cloudiness or clarity of water, which indicates the presence of suspended solids, such as soil, algae, or organic matter.
• **Conductivity:** Electric current conductivity, a measure of the quantity of dissolved salts or minerals in water.

8.4 Datasets Used

The datasets used in the paper are:
• **Water quality data:** The data collected by the wireless sensor nodes from Bristol Floating Harbour from June 2016 to March 2017. The data includes measurements of DO, pH, temperature, turbidity, and conductivity at 15-minute intervals.
• **Weather data:** The data obtained from the Met Office website for Bristol from June 2016 to March 2017. The information contains hourly readings of the air temperature, rainfall, wind speed, and wind direction.
• **Tidal data:** The data obtained from the UK Hydrographic Office website for Avonmouth from June 2016 to March 2017. The data includes measurements of tidal height at 15-minute intervals.

8.4.1 Paper Link

Access the full paper at https://sci-hub.se/https://doi.org/10.1016/j.autcon.2018.02.008.

9 Paper 9: Internet-based applications for interrogating 50 years of data from the South African national water quality monitoring network

Journal/Conference Rank: Q1
Publication Year: 2019
Reference: [9]

9.1 Summary

In order to study and visualize the data from South Africa's national water quality monitoring network, which has been in operation since the 1970s, the author created and used two web-based tools, which are described in the article. The paper shows how the applications can help researchers and managers to locate relevant historical data, identify spatial and temporal patterns and trends, and compare different water quality parameters and sites. The paper also discusses the challenges and limitations of the applications and suggests future improvements.

9.2 Software Architecture

The software architecture of the paper consists of three components: the data source, the web server, and the web applications. The data source is the national water quality database, which contains more than 50 million records from over 2,000 monitoring sites across South Africa. The web server is a Linux-based system that hosts the web applications and communicates with the database using PHP scripts. The web applications are interactive web pages that use HTML, CSS, JavaScript, jQuery, and Google Maps API to display maps, graphs, tables, and statistics of the water quality data.

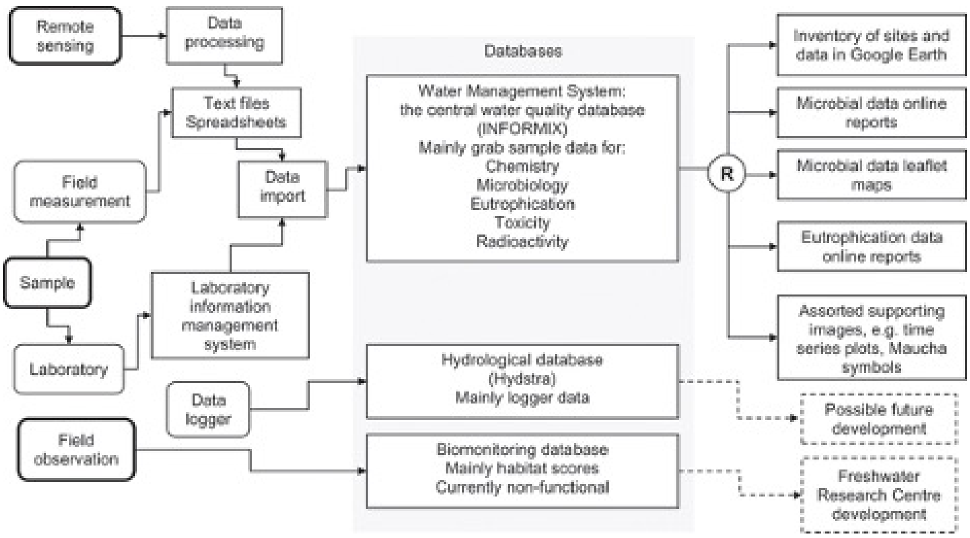

Figure 6: Workflow diagram that demonstrates the procedures for gathering, organizing, and displaying data on water quality monitoring for Paper 9.

9.3 Data Parameters

The physical, chemical, biological, and microbiological properties of water that are measured or observed by the national water quality monitoring network are the data parameters in the study. The paper focuses on 12 common parameters that are available for most sites and time periods: dissolved oxygen (DO), pH, temperature, turbidity, conductivity, total dissolved solids (TDS), chloride, sulphate, nitrate, phosphate, ammonia, and orthophosphate.

9.4 Datasets Used

The datasets used in the paper are:
• **Water Quality Data:** The groundwater, inland surface water, and coastal water in South Africa from 1972 to 2016 are included in the harmonized water quality data from the national water quality database. The paper uses a subset of water quality data that contains records of 12 common parameters from 1,500 sites.
• **Spatial Data:** The spatial data that provides information about the location, name, type, and catchment of each monitoring site. The article makes use of geographical data from several sources, including Google Maps, the Department of Water Affairs, and the Water Research Commission.
• **Metadata:** The metadata that provides information about the methods, units, standards, and quality control of each water quality parameter. The paper uses metadata from various sources, such as the Department of Water Affairs, the South African National Standards (SANS), and the World Health Organization (WHO).

9.4.1 Paper Link

Access the full paper at https://www.tandfonline.com/doi/full/10.1080/02626667.2019.1645334.

10 Paper 10: Water quality data for national-scale aquatic research: The Water Quality Portal

Journal/Conference Rank: Q1
Publication Year: 2017
Reference: [10]

10.1 Summary

The Water Quality Portal (WQP), an online service that offers access to more than 290 million water quality records from diverse sources in the United States and abroad, is introduced in the article. The document provides an overview of the WQP's data, standardized data model, data access, and services. The analysis of the seasonal variance in lake water clarity throughout the various areas of the continental U.S. in this research serves to further highlight the importance of the WQP data.

10.2 Software Architecture

The software architecture of the WQP consists of four components: the data providers, the data harmonizer, the data server, and the data consumers. The data providers are the agencies and organizations that collect and submit water quality data to the WQP. Data from various formats and vocabularies are transformed by the data harmonizer, a piece of software, into a single data model based on the Water Quality Exchange (WQX) standard. The data server is a web application that uses RESTful APIs, SOAP, and OGC standards to store and serve the harmonized data. The data consumers are the users and applications that access and use the WQP data for various purposes, such as research, education, management, and policy.

10.3 Data Parameters

The physical, chemical, biological, and microbiological properties of water that are measured or seen by the data providers are the data parameters in the WQP. The WQP supports more than 12,000 different parameters, which are organized into five groups: inorganics, metals, nutrients, organics, and other. Some examples of data parameters are dissolved oxygen, pH, temperature, turbidity, conductivity, nitrate, phosphate, chlorophyll a, fecal coliform, and E. coli.

10.4 Datasets Used

The datasets used in the paper are:
• **WQP Data:** The harmonized water quality data from the WQP that covers groundwater, inland surface water, and coastal water in the United States and beyond. The paper uses a subset of WQP data that contains records of Secchi depth (a measure of water clarity) from lakes in the continental U.S. from 2007 to 2016.
• **NHDPlus Data:** A geographic database called the National Hydrography Dataset Plus (NHDPlus) has data on surface water features such streams, lakes, watersheds, and flow directions. The paper uses NHDPlus data to link WQP sites to their corresponding hydrologic units and regions.
• **NLCD Data:** Information on different forms of land use and land cover in the U.S. is available thanks to the National Land Cover Database (NLCD), a land cover categorization system. The paper uses NLCD data to calculate the percentage of urban land cover within each hydrologic unit.

10.4.1 Paper Link

Access the full paper at https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2016WR019993.

11 Paper 11: Data Conditioning Modes for the Study of Groundwater Resource Quality Using a Large Physico-Chemical and Bacteriological Database, Occitanie Region, France

Journal/Conference Rank: Q1
Publication Year: 2023
Reference: [11]

11.1 Summary

In the study of a large and diverse database containing various types of parameters (microbiological, chemical, physicochemical) related to water quality in the Occitanie region of France, extreme values (Z-scores ¿ 2.5) are frequently observed. These extreme values contain a significant amount of information, making it challenging to analyze the overall dataset effectively. To address this issue, the researchers tested three different data conditioning methods, comparing them to the use of raw data. The results showed that using a logarithmic transformation was the most effective approach. This transformation helped reveal relationships between E. coli content and the other parameters while reducing the impact of extreme values without completely removing them. This concentration of information improved the data's spatial structure and representation. Using the square root function for data conditioning also showed some improvement but not as much as the logarithmic transformation. Ultimately, these findings could lead to more efficient and cost-effective monitoring of water quality by Regional Health Agencies, enhancing the understanding of the associated processes and spatial distribution of water quality parameters.

11.2 Software Architecture

This paper does not have a software architecture due to it being a Study.

11.3 Data Parameters

A large and diverse database containing various types of parameters (microbiological, chemical, physicochemical) related to water quality in the Occitanie region of France.

11.4 Datasets Used

National SISE-EAUX database.

11.4.1 Paper Link

Access the full paper at https://drive.google.com/.

12 Paper 12: The Surface Water and Ocean Topography (SWOT) Mission River Database.

Journal/Conference Rank: Q1
Publication Year: 2021
Reference: [12]

12.1 Summary

The SWOT satellite mission, launched in 2022, is the first to focus on monitoring Earth's surface water. It did provide data on global rivers over 100m wide, including water elevation, width, and slope. To effectively use this data, a static river database is needed. The SWOT River Database (SWORD) is introduced, consisting of river reaches (about 10 km long) and nodes (spaced about 200m apart within reaches). SWORD includes various hydrological and morphological attributes and can expand in the future. Before SWOT's launch, SWORD can be used for global river flow modeling and large-scale hydrological analyses using ground measurements and other satellite data.

12.2 Software Architecture

Their primary choice is pandas, a swift, robust, adaptable, and user-friendly open-source tool for data analysis and manipulation, which is constructed on the foundation of the Python programming language.

For handling geospatial data, they opt for GeoPandas. This open-source initiative aims to simplify working with geospatial data in Python. GeoPandas expands the data structures utilized in pandas to enable spatial operations on geometric shapes. Shapely handles geometric operations, while GeoPandas relies on fiona for file access and utilizes matplotlib for plotting.

12.3 Data Parameters

Darms, Low Permeable Dams, Locks, Channel Darms.

12.4 Datasets Used

Global River Widths from Landsat (GRWL) (Allen Pavelsky, 2018). MERIT Hydro (Yamazaki et al., 2019). HydroBASINS (Lehner Grill, 2013). Global River Obstruction Database (GROD) (Whittemore et al., 2020). Please see the dataset table 1 in the paper for more info and reference on dataset used.

12.4.1 Paper Link

Access the full paper at https://drive.google.com/file/d/1M-GXdMc29aNHjA33034FfLorMugUGzt6/vi

13 Paper 13: Underwater Internet of Things in Smart Ocean: System Architecture and Open Issues.

Journal/Conference Rank: Q1
Publication Year: 2019
Reference: [13]

13.1 Summary

This paper explores the establishment of a "smart ocean" by introducing the concept of the Underwater Internet of Things (IoT). It underscores the significance of comprehending the ocean's characteristics and characterizes the Underwater IoT as a potent technology for achieving this goal. The document delves into current advancements, forthcoming system designs, applications, difficulties, and unresolved matters linked to the Underwater IoT. It acknowledges that recent progress in autonomous underwater vehicles, intelligent sensors, communication technologies, and routing protocols are enabling the Underwater IoT. In the coming years, it is anticipated to form a network of interconnected underwater entities with self-learning and intelligent computational capabilities. The paper outlines a five-tier system structure and proposes that cloud computing, fog computing, and artificial intelligence will be instrumental in addressing current challenges and shaping the direction of future research endeavors within the realm of the Underwater IoT.

13.2 Software Architecture

This paper proposes a system design thus it does not have specific software architecture.

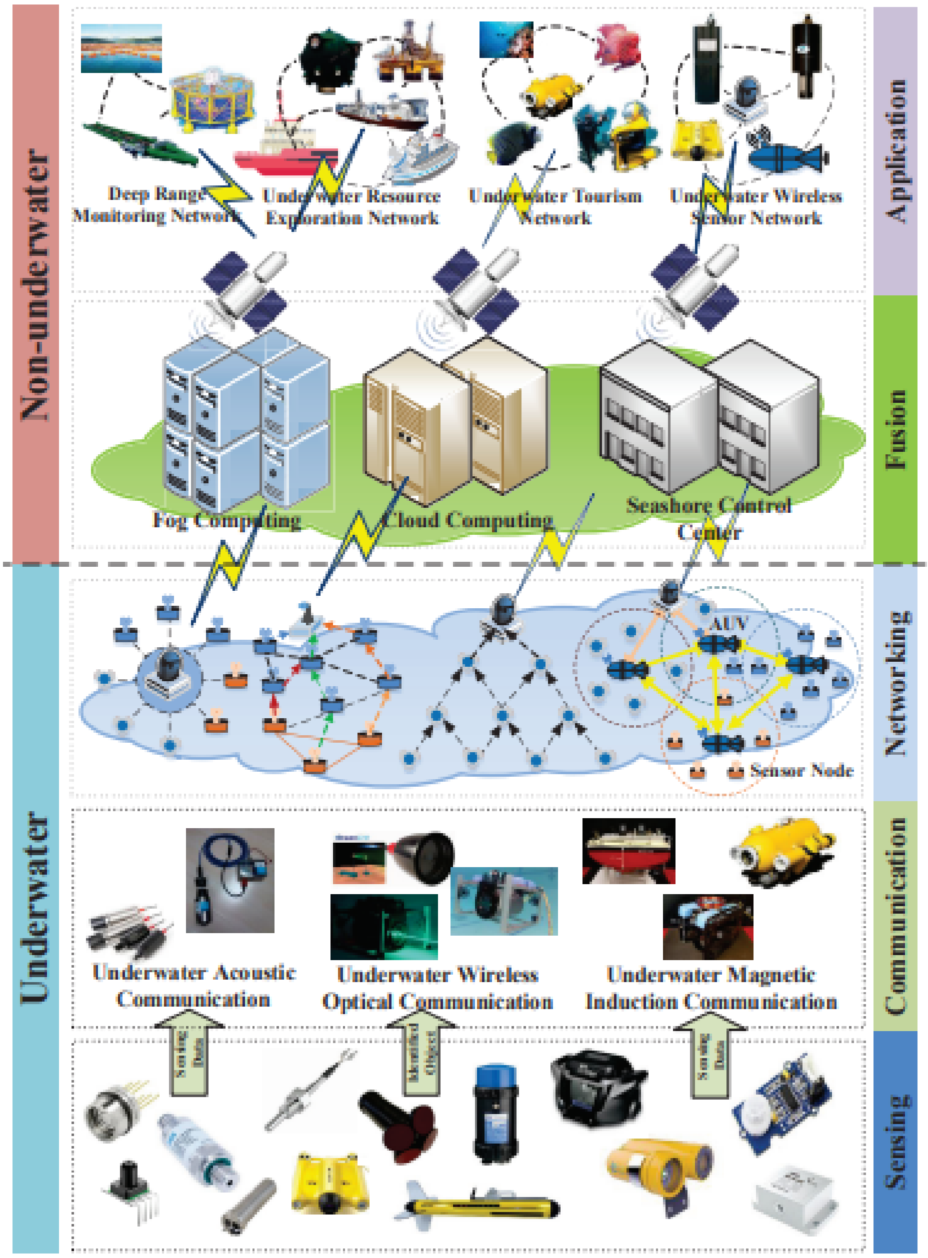

Figure 7: The system architecture of Underwater Internet of Things for Paper 13.

13.3 Data Parameters

Environmental - Water quality, marine organisms. Resource - Food resources, medicine resources, oil and gas resources, submarine pipeline. Disaster - Tsunami, volcano, earthquake, oil spill, hurricane.

13.4 Datasets Used

This paper does not use any dataset because it's a System Architecture proposal.

13.4.1 Paper Link

Access the full paper at https://drive.google.com/file/d/10yvioQ4IJIdpaHXCAVtrkdGig1VmkkXa/view

14 Paper 14: A comprehensive review of water quality monitoring and assessment in Nigeria.

Journal/Conference Rank: Q1
Publication Year: 2020
Reference: [14]

14.1 Summary

Nigeria, the world's most populated black nation with about 199 million people, faces a significant challenge as approximately 66.3 million Nigerians lack access to safe drinking water. This study systematically reviewed research findings on water quality monitoring and assessment in Nigeria over the past two decades. The country continues to struggle with enforcing water quality guidelines due to corruption within its socio-political environment.

The study examined the quality of surface water, groundwater, rainwater, and commercially available water, along with their pollution sources. Surface water quality is generally poor. Groundwater pollution results from landfill leachate, oil and gas exploration, sewage, and interactions with the base rock, leading to issues like the presence of lead and barium in groundwater. Rainwater's primary concern is its low pH, but it is relatively clean. Commercially available water, such as bottled or sachet water, is the best source of drinking water in Nigeria, with bottled water having higher quality than sachet water, which is often affected by microbe contamination.

The study suggests future perspectives in water quality monitoring and assessment, focusing on emerging contaminants and micro-pollutants, as well as utilizing internet-enabled technologies to improve the monitoring process.

14.2 Software Architecture

This is a study on water quality over the years in Nigeria, so it doesn't have a software architecture.

14.3 Data Parameters

Heavy metals (Fe, Pb, Zn, Cu, Cr, Mn, Co, As, Cd, Hg, Ni, Na) Physical parameters (pH, DO, BOD, COD, TDS, TH, TA, Temperature, Tubidity, EC) Other cations and anions (Nitrate, Ca, Cl, F, PO, Sulphate , Ammonia)

14.4 Datasets Used

This paper cites a lot of dataset in Table 2. There is too much to list here. Please see Table 2 from the paper to see more details.

14.4.1 Paper Link

Access the full paper at https://drive.google.com/file/d/1nd6T0vorX-m8l6RPix1GROoYARr1QY2-/view?usp=sharing.

15 Paper 15: Smart water quality monitoring system with cost-effective using IoT.

Journal/Conference Rank: Q1
Publication Year: 2020
Reference: [15]

15.1 Summary

Due to the population increase, urbanization, and pollution, the water quality has been declining over the course of time. Freshwater is becoming scarce for human life and agriculture. The decline in water quality leads to waterborne diseases from industrial pollution, fertilizers, and factory chemicals. The usual water quality monitoring methods are not strong enough to control water quality. Without real-time data, these methods are weak.

15.2 Software Architecture

The DHT-11, microcontroller unit, which serves as the processing module, and the ESP8266, which serves as the messenger and a Wi-Fi module, are the four sensors that are employed including turbidity, ultrasonic, pH. The Arduino Mega, which is the microcontroller unit works efficiently and is compact in size. The complete system is constructed in Embedded-C-C, and the Arduino IDE replicates the written code. ThingSpeak is an Internet of Things (IoT) data collection tool used to examine a range of sensor data, including pH, turbidity, voltage, temperature, moisture, and distance. It receives data from NodeMCU/ESP8266 and offers the ability to modify and analyze past data in a software environment. To use ThingSpeak, users must log in using their server credentials. Using MATLAB code, data may be evaluated and interpreted after being added to a ThingSpeak channel, and the platform can then be used to initiate tasks like tweeting and other notifications based on the collected data. The ThingSpeak smartphone app is a helpful tool for tracking water quality, especially for the Water Quality Commission authority. By utilizing the app to check in while using their user-identifying ID and password, authorized users may access important information. This makes it feasible for users to access and assess data on water quality inside of their accounts, making it a simple and practical way to manage and keep an eye on the quality of the water.

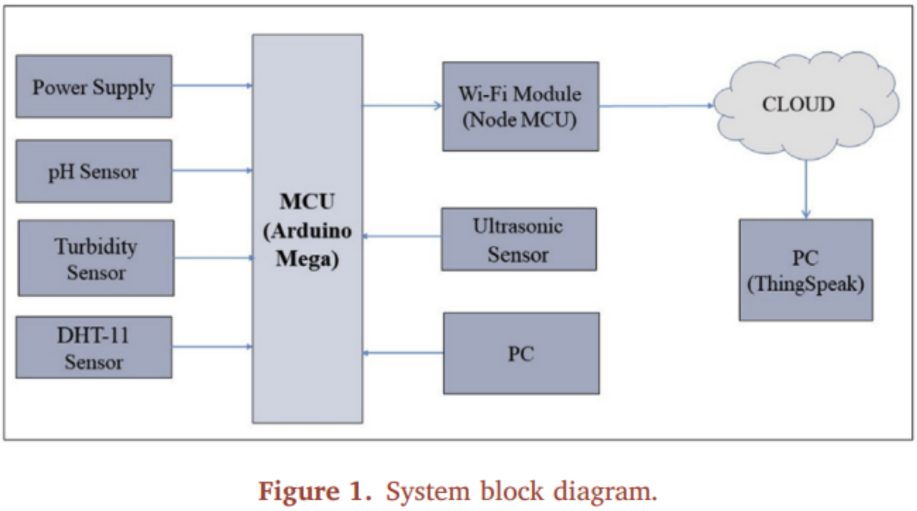

Figure 8: System Block Diagram for Paper 15.

15.3 Data Parameters

The recommended Water Quality Monitoring (WQM) system primarily analyzes significant water quality indicators, including pH level of the water, water's turbidity, the amount of water in the tank, and the temperature and humidity of the surrounding environment. Since these criteria are required for determining and ensuring water quality, the WQM system is a valuable tool for monitoring and maintaining safe and clean water resources.

15.4 Datasets Used

Not explicitly mentioned. But the concept is to collect sample water from different locations and extract WO.

15.4.1 Paper Link

Access the full paper at https://drive.google.com/file/d/1BMAq5nC6W-KAdQo2yIqvwjlRA8Ut8e2z/vi

16 Paper 16: A Low-Cost AI Buoy System for Monitoring Water Quality at Offshore Aquaculture Cages

Journal/Conference Rank: Q1
Publication Year: 2022
Reference: [16]

16.1 Summary

The research, "A Low-Cost AI Buoy System for Monitoring Water Quality at Offshore Aquaculture Cages" by Hoang-Yang Lu et al. discusses the significance of water quality in aquaculture. The maintenance of appropriate water conditions is essential for the growth and health of aquatic animals.Traditional manual monitoring techniques require a lot of work and are prone to mistakes. The research offers a unique AI buoy system capable of collecting and analyzing water quality data on its own. This system makes use of AI and machine learning to identify anomalies, predict trends, and offer immediate steps to maintain ideal circumstances. Notable features include its emphasis on affordability and accessibility, which may generalize advanced water quality monitoring technologies for a wider spectrum of aquaculture consumers. This research offers a practical solution for offshore settings in the growing field of AI-based water quality monitoring systems in aquaculture.

16.2 Software Architecture

The research paper describes a client-server software architecture for an efficient AI buoy system that monitors the water quality in offshore aquaculture cages. In order to measure variables like dissolved oxygen, salinity, water temperature, and velocity, the client-side, a hardware device, combines an Arduino UNO board and a variety of sensors. It then transmits this data to the server-side through Bluetooth. The server-side, a piece of software operating on a laptop, receives and processes the data before using machine learning techniques to produce short-term predictions for water temperature and velocity. A user-friendly graphical interface is used to convey both measured and estimated data. In order to guarantee the system's quality and dependability, the implementation makes use of a variety of software tools and languages, including the Arduino IDE, Python, TensorFlow, and Keras.

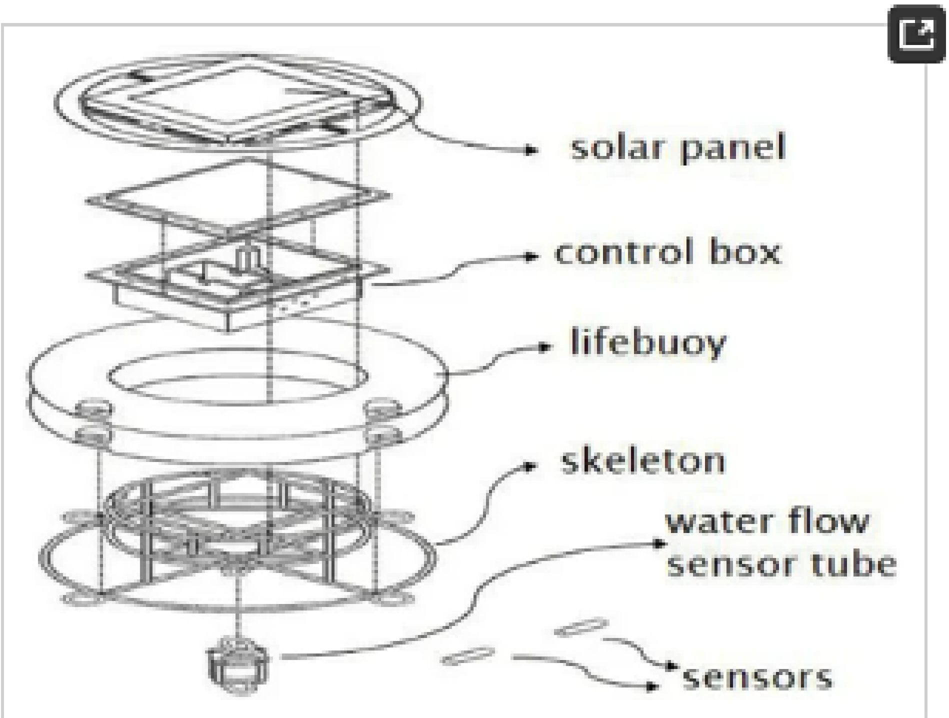

Figure 9: Architecture of the proposed offshore buoy for Paper 16.

16.3 Data Parameters

Dissolved Oxygen (DO): DO levels, which are important to aquatic life and also indications of organic pollution that affects aquatic life.
Salinity: Affects water density, conductivity, and osmotic pressure, which makes it essential for species in offshore aquaculture that require precise salinity levels.
Water Temperature: Has a direct impact on aquatic creatures metabolism, development, and reproduction, making it an essential aspect for managing aquaculture.
Water Velocity: For the transportation of pollutants, nutrients, and oxygen as well as to maintain a healthy habitat for aquatic life, flow speed and direction measurements are important.

16.4 Datasets Used

There are two types of datasets used in this paper. The first dataset is the water quality measurement data which has the values of DO, salinity, temperature and the velocity of water. The second type of dataset is the water quality evaluation data which measures the accuracy, precision, stability and the cost-effectiveness of the system.

16.4.1 Paper Link

Access the full paper at https://www.mdpi.com/1424-8220/22/11/4078.

17 Paper 17: Generative adversarial networks for detecting contamination events in water distribution systems using multi-parameter, multi-site water quality monitoring.

Journal/Conference Rank: Q1
Publication Year: 2023
Reference: [17]

17.1 Summary

The study "Generative adversarial networks for detecting contamination events in water distribution systems using multi-parameter, multi-site water quality monitoring" by Zilin Li et al. addresses the crucial problem of contamination detection in water distribution systems. The detection of contamination events by conventional approaches often falls short of being thorough and quick. Anomalies suggestive of contamination are more easily and accurately detected because of recent developments in water quality monitoring that involve the integration of data from multiple sites and multiple parameters. In the study, generative adversarial networks (GANs) are used to simulate typical water quality patterns and spot unusual differences that could be signs of pollution. This innovative approach shows promise, but further research and practical application are needed to fully realize its potential for maintaining public health and ensuring the security of drinking water.

17.2 Software Architecture

The software architecture described in this paper uses generative adversarial networks (GANs) to detect water distribution system contamination events. "Data acquisition" handles data gathering and preparation using a wireless sensor network and a synthetic contamination injection system (SCIS), as well as Python libraries like pandas, numpy, and scipy. Using programs like Matplotlib, Seaborn, and GIS for spatial visualization, "data analysis" entails exploratory data analysis and descriptive statistics. TensorFlow, Keras, and scikit-learn are used in the "Model training" phase to build and train GAN models. Finally, "Model evaluation" evaluates the performance of the GAN model using sklearn.metrics and visualization. A diversity of software tools, languages, and design principles guarantee a solid and high-quality software foundation.

17.3 Data Parameters

The study's data parameters covered all the critical components of monitoring water quality. Dataset 1 contained parameters such dissolved oxygen, salinity, water temperature, and water velocity that were collected from 12 selected sensor sites at a sample frequency of every 15 minutes. The spatial-temporal GAN (ST-GAN) model and generative adversarial networks (GANs) were both used in Dataset 2's machine learning-focused components. Accuracy, precision, recall, and F1-score were among the measures used in performance evaluation to determine the model's effectiveness in detecting contamination events.

17.4 Datasets Used

Dataset 1: Utilized a wireless sensor network and a simulated contamination injection device to collect data (such as DO and salinity) from 12 sensor locations with a 15-minute sample frequency.

Dataset 2: Generative adversarial networks (GANs) were used, including a spatial-temporal GAN (ST-GAN), and their performance was evaluated in terms of accuracy, precision, recall, and F1-score for the purpose of detecting contamination events.

17.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/pii/S2666498422000874

18 Paper 18: Assessment of urban river water quality using modified NSF water quality index model at Siliguri city, West Bengal, India.

Journal/Conference Rank: Q1
Publication Year: 2022
Reference: [18]

18.1 Summary

The research, "Assessment of urban river water quality using a modified NSF water quality index model at Siliguri city, West Bengal, India," addresses the important issue of urban river water quality in the context of rapid urbanization. Due to industrialization and population expansion, water contamination in urban areas tends to get worse. The research offers a modified version of the NSF Water Quality Index (WQI) model, highlighting the importance of identifying such models. The case study of Siliguri, India, provides information on river health and influences plans for pollution management and urban growth. In areas that are quickly urbanizing, it is essential to understand the water quality of urban rivers. In order to manage water resources effectively.

18.2 Software Architecture

Three vital components form the software architecture for the Ganga River system water quality evaluation in Siliguri, India: data collecting, data analysis, and data visualization. 19 water quality parameters are carefully measured at 20 sampling sites as part of the data collection process. To calculate water quality indices, data analysis uses statistical techniques, principal component analysis (PCA), and a modified NSFWQI model. Cluster analysis and PCA are conducted using SPSS software. Data visualization uses a variety of graphical representations and GIS-based spatial analysis to map parameter distributions. Despite the fact that specific software tools and design ideas aren't specifically addressed in the paper, this architecture ensures thorough water quality evaluation.

18.3 Data Parameters

The study evaluated the quality of urban river water through a number of parameters, including pH (acidity/alkalinity), dissolved oxygen (essential for aquatic life), total suspended solids (affecting clarity), total dissolved solids (minerals affecting taste), nitrate (which can cause eutrophication), phosphate (also contributes to eutrophication), and coliform bacteria (indicating fecal contamination).

18.4 Datasets Used

Dataset 1 includes a variety of important water parameters, such as pH, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total suspended solids, total dissolved solids, nitrate, phosphate, and coliform bacteria. Dataset 2 includes calculations for Weighting Factors, Quality Rating Scales, Sub-Indices for each parameter, and the comprehensive Water Quality Index, which together supply a comprehensive assessment of the suitability of the water quality. Dataset 2 is centered on the Water Quality Index (WQI) utilizing the modified NSF model.

18.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/pii/S2665972722000344.

19 Paper 19: Application of digital PCR for public health-related water quality monitoring

Journal/Conference Rank: Q1
Publication Year: 2022
Reference: [19]

19.1 Summary

The work by Ananda Tiwari and colleagues addresses a significant public health concern and highlights the importance of using digital PCR (DPCR) technology in water quality monitoring to discover waterborne pathogens. While reliable, conventional monitoring techniques might not be able to catch newly developing pollutants. The detection of pathogens in water samples could be improved by the use of DPCR, an advanced molecular biology approach that offers increased sensitivity and precision. This work represents a significant step in the search for more precise and sensitive techniques for monitoring water quality in relation to public health. DPCR method optimization, sample processing methods, and cost-effectiveness and scalability assessments across various environmental settings might all be the subject of future research.

19.2 Software Architecture

Three essential components make up the inferred software architecture for digital PCR (DPCR) in water quality monitoring for public health. The hardware that analyzes genetic material using various DPCR platforms is known as a DPCR device. Through a user-friendly interface, the DPCR software controls instrument operation, data acquisition, processing, and display. Through a structured framework, the DPCR database controls data storage, retrieval, and sharing. A variety of software tools and languages are used in the implementation, and design principles like object-oriented programming, modular programming, and thorough documentation provide a dependable and strong software system for successful DPCR-based water quality testing.

19.3 Data Parameters

The study evaluates limit of detection (LOD), limit of quantification (LOQ), sensitivity, specificity, precision, reproducibility, and accuracy characteristics for digital PCR (DPCR) for water quality monitoring. Together, these standards examine the dependability, precision, and consistency of DPCR in identifying and measuring target DNA, ensuring its usefulness in determining the quality of water.

19.4 Datasets Used

The study analyzes the effectiveness of digital PCR (DPCR) for monitoring water quality utilizing specific information about ambient water samples, including sample type, volume, processing techniques, target gene, target gene copy number, and target gene concentration. The analysis of DPCR's effectiveness in guaranteeing water quality for public health benefits from the analysis of these data variables.

19.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/pii/S0048969722027590.

20 Paper 20: Water quality assessment using NSFWQI, OIP and multivariate techniques of Ganga River system, Uttarakhand, India.

Journal/Conference Rank: Q1
Publication Year: 2020
Reference: [20]

20.1 Summary

The research "Water Quality Assessment using NSFWQI, OIP, and Multivariate Techniques of Ganga River System, Uttarakhand, India" examines the assessment of the water's quality of the Ganga River while taking into account its cultural and ecological value as well as the difficulties faced by pollution. It makes use of a number of approaches, including the Organic Pollution Index (OIP) and the National Sanitation Foundation Water Quality Index (NSFWQI), along with multivariate methodologies, to thoroughly assess water quality. The study's conclusions are essential for responsible water resource management and environmental protection in the Ganga River basin, emphasizing the value of a comprehensive strategy to address water quality issues in this renowned river system.

20.2 Software Architecture

The research suggests a software architecture for evaluating the Ganga River system's water quality. It includes data collection, which involves utilizing conventional techniques to assess 19 parameters at 20 different places; data analysis, which makes use of SPSS, PCA, and a modified NSFWQI model; and data visualization, which makes use of GIS tools for mapping and graphical findings. The strategy improves data interpretation and decision-making while following to the principles of software design to guarantee quality and reliability.

20.3 Data Parameters

The research's data parameters include physico-chemical measures of water quality, including pH, dissolved oxygen (DO), BOD, COD, TSS, TDS, nitrate (NO3), phosphate (PO4), and coliform bacteria. The OIP model only uses four parameters, whereas the NSFWQI model takes into account nine. Principal Component Analysis (PCA) and Cluster Analysis are also used in multivariate statistical analysis to determine the elements that affect water quality and to categorize sampling sites based on similarity.

20.4 Datasets Used

In Dataset 1, physico-chemical parameters such as pH, DO, BOD, COD, TSS, TDS, NO3, and PO4 were gathered from 20 different sampling sites along the Ganga River system in Uttarakhand, India, over the course of three different seasons. Dataset 2 contains Water Quality Index (WQI) data that was calculated using the NSFWQI and OIP models, which, respectively, each have nine and four parameters. These models were used to classify the water and determine its pollution levels.Principal Component Analysis (PCA) and Cluster Analysis are used in Dataset 3 to identify important factors and group sampling locations according to their water quality features.

20.4.1 Paper Link

Access the full paper at https://link.springer.com/article/10.1007/s13201-020-01288-y.

21 Paper 21: Smart water quality monitoring system with cost-effective using IoT.

Journal/Conference Rank: Q1
Publication Year: 2020
Reference: [21]

21.1 Summary

Due to the population increase, urbanization and pollution, the water quality has been declining over the course of time. Freshwater is becoming scarce for human life and agriculture. The decline of water quality leads to waterborne diseases from industrial pollution, fertilizers, and chemicals from factories. The usual methods of water quality monitoring is not strong enough to control water quality. Without real-time data, these methods are weak.

21.2 Software Architecture

Four sensors are used which are pH, turbidity, ultrasonic, DHT-11, microcontroller unit which is the processing module and ESP8266 as data transmission module and a Wi-Fi module. The Arduino Mega, which is the microcontroller unit consumes low power and is compact in size. The entire system is built in Embedded- C and simulates the written code using Arduino IDE. ThingSpeak is a data gathering tool for the Internet of Things (IoT) that is used to analyze a variety of sensor data, including pH, turbidity, voltage, temperature, moisture, and distance, among others. It gathers information from edge node gadgets like the NodeMCU/ESP8266 and provides the ability to alter and examine historical data in a software environment. Users must log in using their server credentials to utilize ThingSpeak. In ThingSpeak, a channel with data fields and a status field serves as the main component. Following the creation of a ThingSpeak channel, data may be analyzed and interpreted using MATLAB code, and the platform can then be used to launch activities like tweeting and other notifications depending on the gathered data. For monitoring water quality, the ThingSpeak smartphone app is a useful resource, especially for water quality commission authority. By checking in using the app with their user identification ID and password, authorized users may access crucial information. This makes it possible for individuals to access and evaluate data on water quality within of their accounts, making it an easy and useful method of controlling and monitoring water quality.

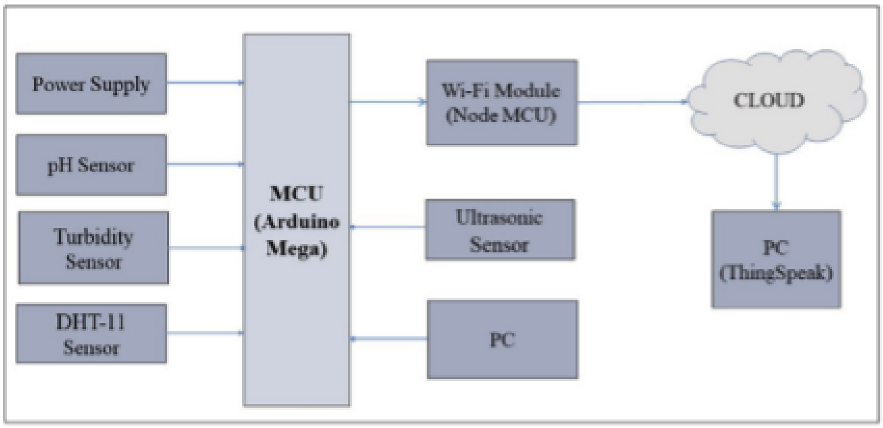

Figure 10: System Block Diagram for Paper 21.

21.3 Data Parameters

The proposed Water Quality Monitoring (WQM) system primarily measures key water quality parameters, including:
- Water's pH value.
- Turbidity of the water.
- Water level in the tank.
- Temperature and humidity of the surrounding atmosphere.

21.4 Datasets Used

Not explicitly mentioned. But the concept is to collect sample water from different locations and extract WO.

21.4.1 Paper Link

Access the full paper at https://sci-hub.se/https:/doi.org/10.1016/j.heliyon.2020.e04096.

22 Paper 22: Multi-step ahead modelling of river water quality parameters using T ensemble artificial intelligence-based approach.

Journal/Conference Rank: Q1
Publication Year: 2019
Reference: [22]

22.1 Summary

Hydro-environment is a hot topic as water quality maintenance has come significant with the growing world population. Low Dissolved Oxygen contents degrades the habitat of aquatic animals. This paper discusses collecting precise water quality data for management using AI.

22.2 Software Architecture

There is no information on the software design. But the basic concept is to make a precise calculation of the water quality using the AI model. Data is collected from parts of a river and collected in a database, which is the predicted system.

But the System Architecture is as follows:

• BPNN - The Back Propagation Neural Network (BPNN) is a well-liked neural network for Levenberg-Marquardt algorithm training. Based on a multi-layer feedforward structure, it processes inputs and generates outputs. The network adjusts the weights on connections between neurons to lower the mean square error as much as feasible while also learning from training data.
• ANFIS- Jang created the ANFIS (Adaptive Network-Based Fuzzy Inference System) AI model in 1993. It incorporates the advantages of fuzzy logic and artificial neural networks (ANN) to handle complicated non-linear interactions between inputs and outputs. Due to its capacity to manage uncertainty, ANFIS is particularly promising for tasks like river prediction, hydro-climatology, and reservoir modeling, making it a useful tool in these domains.
• SVM- Using the AI-based Support Vector Machine (SVM) model, regression, prediction, classification, and pattern recognition challenges may all be successfully resolved.
• ARIMA: Also known as the Box and Jenkins model, it is one of the most widely used traditional time series forecasting models.

There is no information on the software design. But the basic concept is to make a precise calculation of the water quality using the AI model. Data is collected from parts of a river and collected in a database, which is the predicted system.

22.3 Data Parameters

The data includes majority of the WQM such as pH, Dissolved oxygen and ammonia

22.4 Datasets Used

The survey carries data collected from specific places in India, from the Yamuna River.

22.4.1 Paper Link

Access the full paper at https://sci-hub.se/https:/doi.org/10.1016/j.jhydrol.2019.123962.

23 Paper 23: Real-time remote monitoring of water quality: a review of current applications, and advancements in sensor, telemetry, and computing technologies.

Journal/Conference Rank: Q2
Publication Year: 2022
Reference: [23]

23.1 Summary

Due to the rising effects of population expansion and industrial pressures in coastal and inland locations, monitoring has become effective. Assessment of the condition of the world's water resources, implementation of preservation and cleanup programs, and evaluation of program performance become difficult without precise and continuous data collecting. The restricted temporal and geographical coverage of traditional field measurements makes it challenging to address problems like damaging algal blooms and pollution of oyster beds. In situ detectors are now being used for continuous data gathering throughout recent monitoring activities, both locally and remotely. This method enables early identification of trends and changes in crucial water quality indicators, giving decision-makers the knowledge, they need in real time to take appropriate action. Technology advances have increased the effectiveness, uniformity, and accessibility of data collecting.

23.2 Software Architecture

Does not specify in the paper.

23.3 Data Parameters

The main metrics that the planned Water Quality Monitoring (WQM) system measures are the pH and turbidity of the water. Tank's water level, outside air temperature, and humidity levels.

23.4 Datasets Used

This study is based on the historical significant technological advancements and improvements that resulted in the introduction of real-time remote monitors for hydrologic parameters. In situ meteorological and hydrological technology has significantly advanced during the past 10 years, enabling real-time remote monitoring (RTRM) networks. In order to continually monitor faraway areas, these networks pair powerful sensors with small, dependable board-level CPUs. Researchers looking into water quality may now collect, analyse, and transmit data while on the road or from distant labs thanks to advancements in sensor technology, mobile computing, and wireless communications. RTRM systems have also been used more widely and are now better able to identify a wide range of contaminants and factors thanks to the usage of molecular and live organism-based monitoring technologies. RTRM systems offer a number of advantages, including faster data collection, reduced human error and time delays, lower data collection costs, and enhanced data quantity and quality on temporal scales. Integrated RTRM systems that have been developed and are in use globally are essential tools for collecting environmental data. A range of hydrological and meteorological sensors, as well as software and hardware components that facilitate wireless, mobile, and internet-based computing, are commonly integrated. The ability to handle and distribute data more widely has recently been made possible by two-way data transfer and web-based visualization tools. Since they include several operating systems, computer programs, and communication devices, they are flexible tools for water quality monitoring. Numerous companies that monitor water quality all around the world rely on or are transitioning to RTRM technology. These applications make the most of real-time data collection's advantages.

23.4.1 Paper Link

Access the full paper at https://sci-hub.se/https:/doi.org/10.1016/j.jembe.2004.02.022.

24 Paper 24: Heavy metal water pollution: A fresh look about hazards, novel and conventional remediation methods.

Journal/Conference Rank: Q1
Publication Year: 2021
Reference: [24]

24.1 Summary

Climate change, industrialization, urbanization have become major reasons in the 21st century for water pollution. Among all the contaminants, Heavy metals are one of them. This work discusses the sources for heavy metals, the detection, removal, and water quality control.

24.2 Software Architecture

Although the paper does not mention anything about the system, a general idea can be deduced on how the system can be made. The system potentially can be a data collector of Water Quality Products along with the Removal Products in datasets. The system can be a data collection where users can update data. The software/database can be built using MySQL. .

24.3 Data Parameters

- pH
- Temperature
- Natural Organic matter
- Heavy Metal: - Lead, Cadmium, Mercury, Nickel, Zinc, Chromium, Copper, Arsenic

24.4 Datasets Used

The paper does not specify.

24.4.1 Paper Link

Access the full paper at https://sci-hub.se/https:/doi.org/10.1016/j.eti.2021.101504.

25 Paper 25: A Generalized Additive Model approach to evaluating water quality: Chesapeake Bay case study.

Journal/Conference Rank: Q1
Publication Year: 2019
Reference: [25]

25.1 Summary

In coastal and estuarine systems, efforts have been made to limit nutrient imports, battle problems like eutrophication, improve water quality, and protect aquatic ecosystems. Examples include European nutrient reduction directives and Danish Action Plans, which lowered nutrient imports into Danish coastal waterways. In the US, efforts to improve the Chesapeake Bay's water quality have been underway for more than three decades, including the establishment of a TMDL to control nutrients and sediment. It is challenging to explain how complex systems affected by physical, biogeochemical, and anthropogenic factors affect water quality. It is essential to comprehend how variables like freshwater flow, nutrient loading, climatic change, and dynamics of sediment-nutrient interactions interact. Since 1984, the Chesapeake Bay area has monitored the water quality, first with a seasonal Kendall-based methodology.

25.2 Software Architecture

The 'mgcv' package, developed by Wood in 2018 for use with the statistical program R, is used to fit generalized additive models (GAMs). This choice was made because penalized thin plate regression splines are valuable, especially for extensive research. "mgcv" delivers uncertainty estimates and enables fitting smooths with many variables using a Bayesian approach. Although there isn't much information available, it is possible to infer that the system will consist of a database that gathers WOP from particular locations. Certain techniques will be used once the data has been processed.

25.3 Data Parameters

The data parameters include Nitrogen content, such as inorganic nitrogen, phosphorus, and inorganic phosphorus. Other parameters considered for the research are water temperature, salinity, and total suspended solids.

25.4 Datasets Used

There are 147 tidal monitoring stations in the Chesapeake Bay and its estuarine tributaries, which encompass sections of Maryland, Virginia, and Washington, D.C. Teams from Virginia, Maryland, and the Chesapeake Bay Program have been working together since 1984 on a long-term monitoring and laboratory analysis program. The Chesapeake Environmental Data Repository routinely analyzes the information gathered from these stations, which includes variables like nitrogen, phosphorus, chlorophyll-a, and dissolved oxygen, and makes it accessible online. A subset of these stations' water quality data is utilized for trend evaluations, with an emphasis on variables. Modifications across the 30-year monitoring program, such as laboratory modifications, parameter estimates, and technique detection limitations, have been considered when transforming this data for analysis to guarantee reliable trend detection.

25.4.1 Paper Link

Access the full paper at https://sci-hub.se/https:/doi.org/10.1016/j.eti.2021.101504.

26 Paper 26: Scale relationship between landscape pattern and water quality in different pollution source areas: A case study of the Fuxian Lake watershed, China.

Journal/Conference Rank: Q1
Publication Year: 2022
Reference: [26]

26.1 Summary

Exploring the intricate link between landscape configuration and water quality holds paramount importance in combating water pollution and informing watershed land use strategies. While previous studies typically take a holistic watershed approach, this investigation zeroes in on the multi-scale dynamics of landscape patterns within distinct pollution source areas, offering invaluable insights for local river management. Our study is anchored in the Fuxian Lake basin, a representative plateau lake locale, dissecting how landscape structure influences water quality through advanced analytical techniques such as redundancy analysis and multiple regression modeling.

26.2 Software Architecture

The paper does not provide specific details about the software architecture used in the research.

26.3 Data Parameters

Typical data parameters used in this research encompass landscape metrics, water quality indices (e.g., TP, COD, TN), and geographic information.

26.4 Datasets Used

The paper does not specify the dataset used.

26.4.1 Paper Link

Access the full paper at https://www.sciencedirect.com/science/article/pii/S1470160X2031075X.

27 Paper 27: River Water Quality Index prediction and uncertainty analysis: a comparative study of machine learning models.

Journal/Conference Rank: Q1
Publication Year: 2020
Reference: [27]

27.1 Summary

This journal delves into the intriguing realm of river water quality index prediction and conducts a comprehensive comparative analysis of various machine learning models. With a focus on unraveling the complexities of water quality assessment, the research seeks to enhance our understanding of how machine learning can contribute to the prediction of water quality indices, a critical aspect of environmental management and sustainability. The study meticulously investigates a diverse array of machine learning models, each armed with its unique strengths and capabilities. Through rigorous evaluation and comparison, the research aims to shed light on which models excel in the task of forecasting water quality indices and which exhibit proficiency in uncertainty analysis. These insights are invaluable for environmental scientists, policymakers, and water resource managers who rely on accurate water quality predictions to make informed decisions about resource allocation, risk assessment, and environmental protection. In essence, this research promises to not only advance our understanding of water quality prediction but also to provide practical guidance for those entrusted with safeguarding our precious water resources.

27.2 Software Architecture

Although the paper doesn't delve into specific intricacies of the software architecture used, it's reasonable to infer that a contemporary framework underpins the implementation of machine learning models for WQI prediction and the crucial task of uncertainty analysis. Within this implicit architecture, one can surmise the presence of a typical machine learning workflow, encompassing essential stages such as data preprocessing, model training, thorough evaluation, and rigorous uncertainty analysis. This systematic approach ensures the robustness and reliability of the predictive models and enhances the credibility of the research's findings.

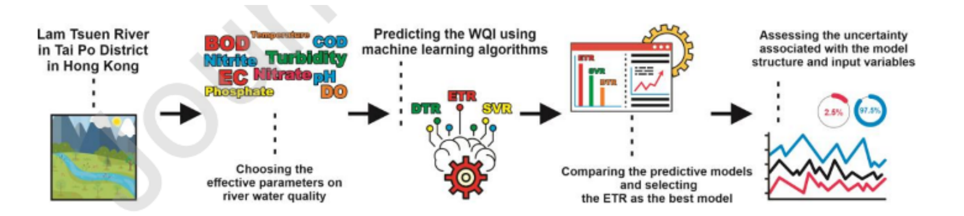

Figure 11: System Diagram for Paper 27.

27.3 Data Parameters

The research leverages a comprehensive array of data parameters, meticulously tailored to unravel the complexities of river water quality prediction and uncertainty analysis. These parameters encompass a multifaceted dataset, including various water quality indicators such as pH levels, turbidity, dissolved oxygen, and the concentration of specific contaminants. Additionally, climatic data, such as temperature and precipitation, hydrological data, and essential geographical information are integrated into the analysis. This rich and diverse dataset forms the backbone of the comparative study, enabling an in-depth exploration of machine learning models' efficacy in forecasting water quality indices and managing uncertainty.

27.4 Datasets Used

The research hinges upon the utilization of a distinct and meticulously chosen dataset. This dataset serves as the cornerstone for training, testing, and validating the machine learning models deployed in the pursuit of accurate WQI prediction and the comprehensive analysis of uncertainty. This deliberate selection ensures that the models are not only effectively calibrated but also rigorously scrutinized for their predictive capabilities, contributing to the robustness of the study's conclusions.

27.4.1 Paper Link

Access the full paper at https://sci-hub.se/10.1016/j.jece.2020.104599.

28 Paper 28: A survey on river water quality modelling using artificial intelligence models: 2000–2020.

Journal/Conference Rank: Q1
Publication Year: 2020
Reference: [28]

28.1 Summary

The surge in river contamination, attributed to the combined effects of climate change and human interventions, has spurred a growing body of research into river water quality prediction, risk assessment, and pollutant categorization. In confronting the intricate web of water-related data, artificial intelligence (AI) models have emerged as potent tools. These AI systems exhibit remarkable prowess in handling the nonlinearity, non-stationary, and unforeseeable fluctuations inherent to natural environments. Moreover, their attributes encompass robustness, cost-effectiveness, and adept decision-making capabilities, rendering them indispensable for river water quality surveillance, governance, and the pursuit of environmental sustainability. This comprehensive survey embarks on an exploration of the untapped potential of AI models in addressing these multifaceted challenges.

28.2 Software Architecture

While the paper omits precise details regarding the software architecture, it's reasonable to infer that a diverse array of AI and machine learning frameworks was likely deployed for model development and analysis. Given the broad spectrum of AI models discussed in the survey, it's plausible that these frameworks encompass popular tools like Python. These versatile resources offer a robust foundation for constructing, training, and assessing a wide array of machine learning models, underscoring the research's adaptability and comprehensiveness.

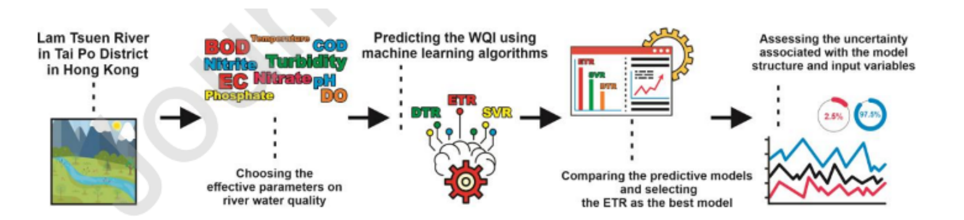

Figure 12: System Diagram for Paper 27.

28.3 Data Parameters

The summary indeed omits the explicit specification of the data parameters employed in this research. In the context of water quality analysis, these data parameters conventionally encompass an array of water quality indicators, ranging from pH, turbidity, and dissolved oxygen to contaminants. Additionally, they might extend to encompass climatic data, such as temperature and precipitation, hydrological information, and pertinent geographical details. The precise assortment of data parameters, naturally, hinges on the individual studies and datasets scrutinized within the research, ensuring a tailored and contextually relevant approach to water quality assessment.

28.4 Datasets Used

The survey meticulously examines an extensive array of more than 200 research articles sourced from Web of Science journals. Each of these articles is likely underpinned by its unique dataset, which in all likelihood comprises historical water quality data gleaned from diverse rivers and aquatic ecosystems. These datasets exhibit inherent variations shaped by geographical locations and the specific research objectives at hand. These repositories of data are paramount, serving as the lifeblood for the training and validation of AI models, thereby fostering comprehensive river water quality simulation.

28.4.1 Paper Link

Access the full paper at https://sci-hub.se/10.1016/j.jhydrol.2020.124670.

29 Paper 29: Microbial Indicators and Their Use for Monitoring Drinking Water Quality—A Review.

Journal/Conference Rank: Q2
Publication Year: 2020
Reference: [29]

29.1 Summary

This comprehensive review paper delves into the importance of microbial indicators in the surveillance of drinking water quality. It delves into the critical role that these indicators play in ensuring safe and potable water. The paper discusses the importance of microbial indicators, which are microorganisms used to assess the microbiological quality of drinking water. Common microbial indicators include coliforms, Escherichia coli (E. coli), and enterococci, among others. These microorganisms are valuable in indicating potential fecal contamination and the presence of pathogens that could pose health risks to consumers.

29.2 Software Architecture

Not explicitly mentioned.

29.3 Data Parameters

The paper is anticipated to focus on essential data parameters crucial for the monitoring of microbial indicators in drinking water quality. These parameters would encompass the quantification of specific indicator microorganisms, water temperature, pH levels, and a suite of other water quality attributes that collectively offer insight into potential contamination or safety issues. This comprehensive data array forms the linchpin of robust microbial monitoring, ensuring the safety and quality of drinking water.

29.4 Datasets Used

While the summary does not provide specific details about the dataset used, it can be assumed that the review paper references various sources of data related to microbial indicators in drinking water quality. These sources may include studies, government reports, and research findings that provide insights into the prevalence and trends of microbial indicators in different drinking water sources.

29.4.1 Paper Link

Access the full paper at https://sci-hub.se/10.3390/su12062249.

30 Paper 30: Hybrid decision tree-based machine learning models for short-term water quality prediction.

Journal/Conference Rank: Q1
Publication Year: 2020
Reference: [30]

30.1 Summary

This research is dedicated to the development of innovative hybrid machine learning models, rooted in decision trees, designed to forecast short-term water quality. These models play a pivotal role in facilitating timely and efficient water resource management and safeguarding water safety for diverse applications. The study harnesses the power of decision tree models, renowned for their capability to handle intricate datasets and render transparent predictions. The "hybrid" nature of these models suggests their potential integration of components from various machine learning techniques or a fusion of diverse models, all aimed at enhancing the precision of water quality predictions. This research focuses on the critical task of predicting shifts in water quality parameters over relatively short time horizons, a fundamental element in managing and promptly responding to fluctuations in water quality conditions.

30.2 Software Architecture

Although not explicitly delineated in the paper, it is reasonable to infer that this study leverages a software architecture for the implementation, training, and assessment of the machine learning models. This software framework likely encompasses essential components for data preprocessing, model training, evaluation, and potentially, the integration of real-time data to facilitate short-term predictions. This implicit infrastructure underpins the operational backbone of the research, ensuring the robustness and effectiveness of the machine learning-based water quality forecasting system.

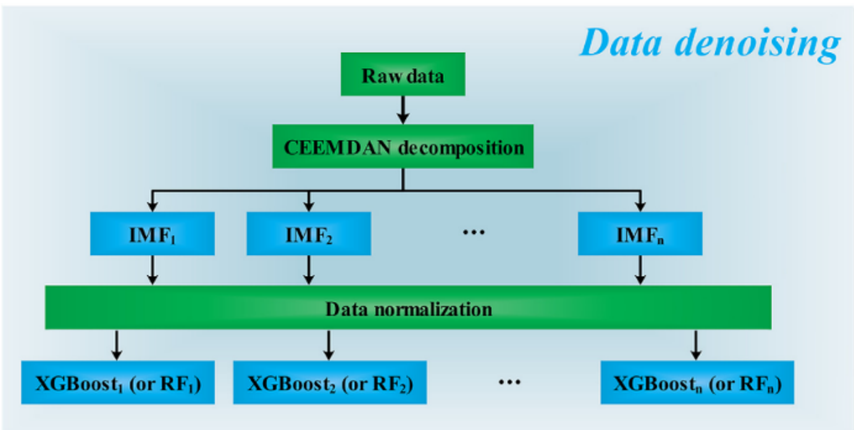

Figure 13: Data denoising process and prediction for Paper 30.

30.3 Data Parameters

Within the realm of water quality prediction, data parameters typically encompass a diverse array of water quality indicators. These may encompass pH levels, turbidity, dissolved oxygen, temperature, as well as the concentrations of specific contaminants or pollutants. It's important to note that the choice of specific parameters in this research is contingent upon the dataset at hand and the unique water quality characteristics being scrutinized. Tailoring the selection of parameters to the specific context ensures the most pertinent and accurate insights into the dynamic intricacies of water quality, allowing for precise and informed predictions.

30.4 Datasets Used

It can be inferred that this research involves the utilization of historical water quality data for training and testing the machine learning models. The dataset would likely contain information on water quality parameters collected at regular intervals, allowing for the development of predictive models for short-term water quality forecasting.

30.4.1 Paper Link

Access the full paper at https://sci-hub.se/10.1016/j.chemosphere.2020.126169.

31 Discussion and Future Planning

The papers cover various aspects of water quality monitoring and assessment, such as sensors, platforms, technologies, indicators, methods, frameworks, regions, water bodies, challenges, and opportunities.

Some common themes are the need for real-time, remote, and low-cost water quality monitoring systems; the importance of water quality indicators and standards; and the role of water quality monitoring and assessment in supporting water resource and ecosystem management.

Some differences are the choice of sensors, platforms, technologies depending on the objectives, requirements, constraints, availability, quality, and characteristics of each application and user; and the evaluation of water quality status and trends.

Some trends are the development and integration of novel sensors, platforms, and technologies; the advancement and application of artificial intelligence models; and the improvement and adaptation of water quality indicators and standards.

Some gaps and potential areas for future research are the validation and verification of the sensors, platforms, technologies, and artificial intelligence models; the optimization, customization, evaluation and comparison of the indicators, methods, and frameworks.

Some ideas and methods we are planning to implement are:

• To build a simple water quality monitoring web app that uses an SQL server to store water quality data from various sources; Node.js for server-side scripting; HTML, CSS, and JavaScript for front-end design; and SQL for database management. We plan to evaluate and compare different water quality indicators for different regions and water bodies using the data stored in the database.

Rich Picture and Data Model

32 Rich Picture

32.1 As-is

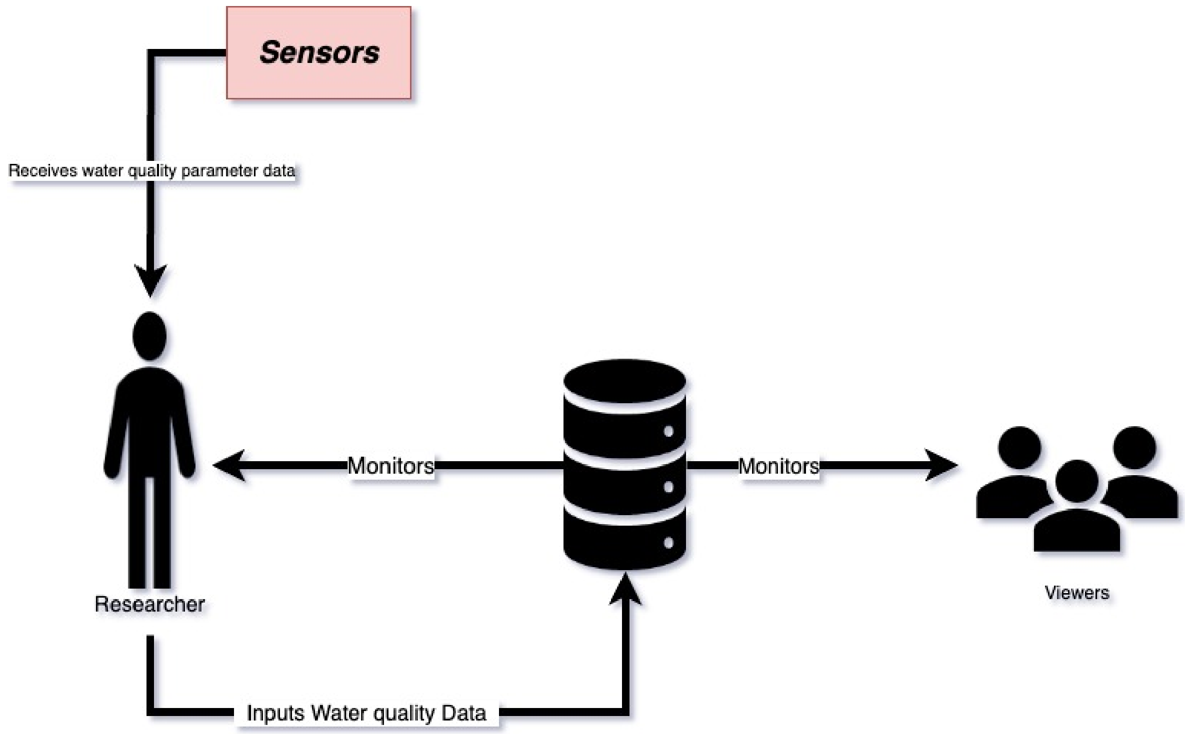

Figure 14: As-is

The pre-existing system is a simple one where sensors present in various water bodies detect and gather relevant water parameter values. The researcher can then input the gathered data into the database. The data is then shown in a structured manner which both researchers and viewers can monitor.

32.2 To-be

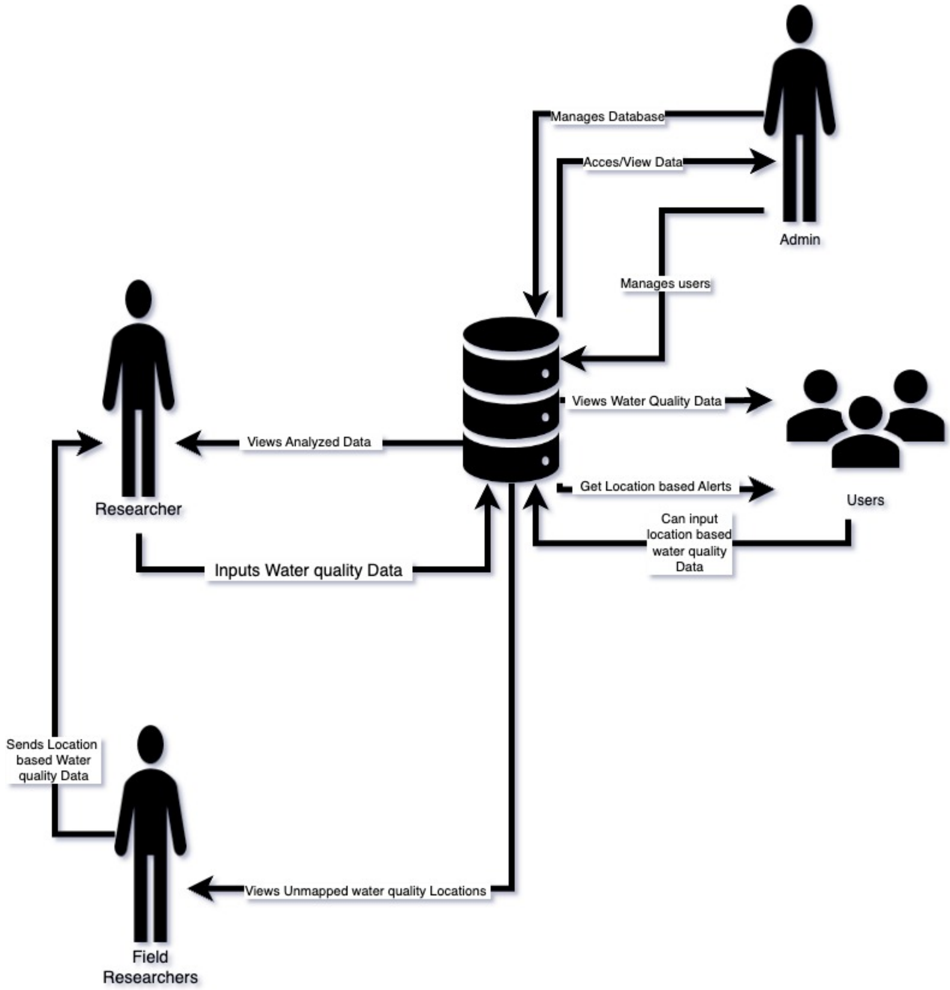

Figure 15: To-be

In our proposed system, Users can be of two types but not limited to Researcher and Viewer.

All users will be identified using their user ID and they can access the database by providing their password.

Field researchers can view which water bodies have not yet been probed from the database and gather the data accordingly. The gathered parameter data is then sent over to the researchers as "WATER QUALITY DATA" and they will be able to input the data into the database for the appropriate location and water body. WATER QUALITY DATA can be identified using a unique ID and will contain its location as a foreign key along with all the relevant parameters and their values.

Viewers can also input data of water bodies yet to be collected and researched. Viewers are also allowed to view the quality index and all other relevant information about all water bodies, the data of which are already pre-existent in the database. Viewers will also be alerted about the risks and dangers of different water bodies based on their location.

The alerts will be generated through determining factors by comparing the pre-existing water quality data for each respective body and the values from RECOMMENDED STANDARD. RECOMMENDED STANDARD will be identified using a unique ID and it will also contain a name, description and the minimum and maximum value for each parameter which will be termed as “Recommended Range” for that respective parameter.

An admin will have omnipotent control of the entire database. Admin will be able to access and view all data present in the database, he will also be able to manage or manipulate its different characteristics. Admin will also be able to manage all users present in the database.

33 Entity Relationship Diagram

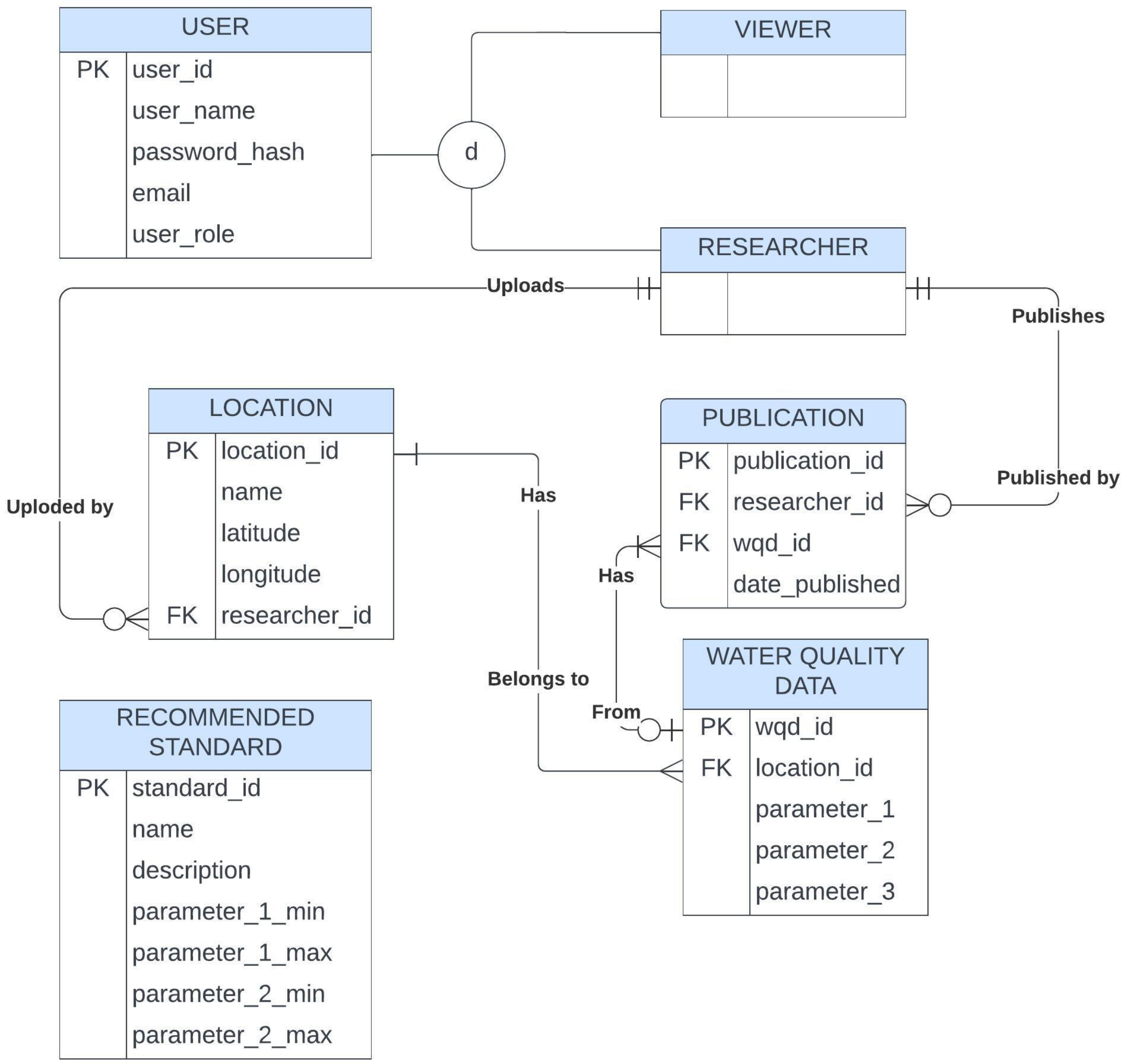

Figure 16: Entity Relationship Diagram

34 Schema

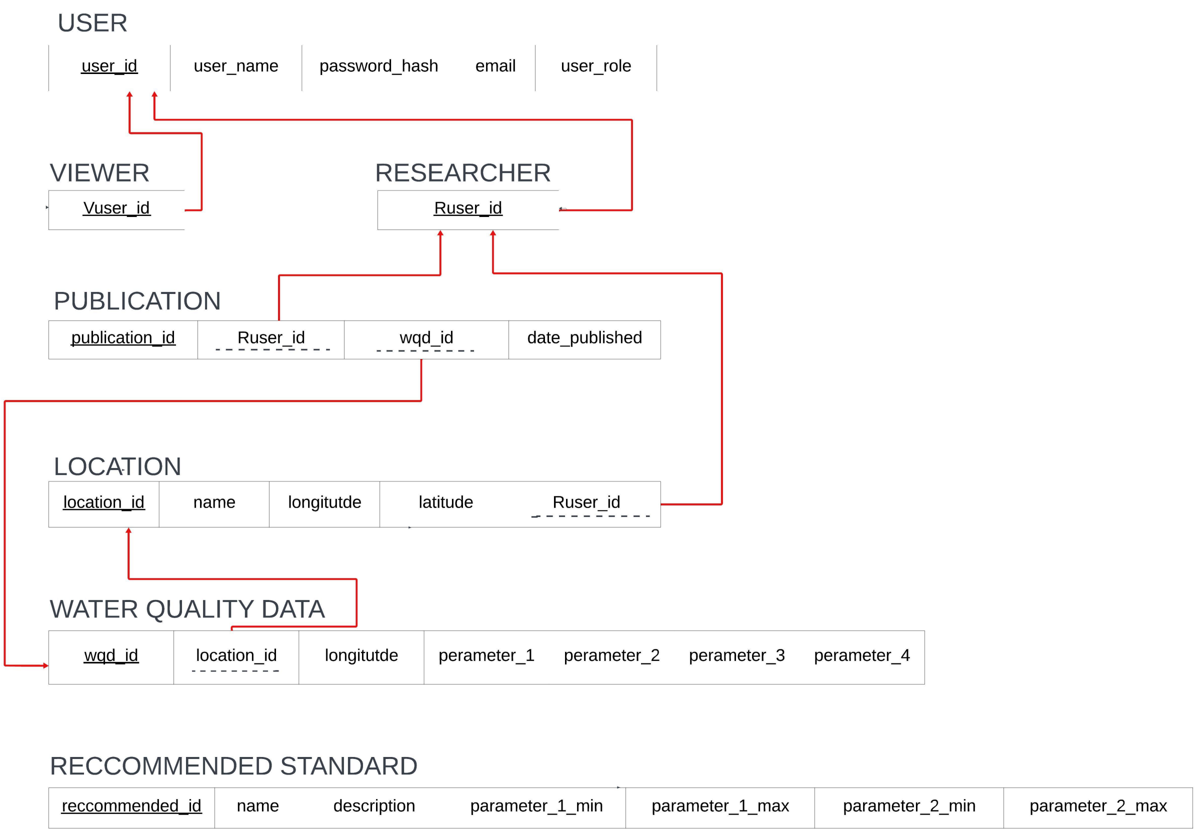

Figure 17: Schema

35 Data Dictionary

USER

Name	Data Type	Size	Remark
user_id	Number		This is the primary key of this table. EG(1, 2, 3 ..)
user_name	Text	255	Unique username of each user.
password_hash	Text	255	Hashed password of the user.
email	Text	255	Email of the user.
user_role	Text	255	The role that the user has. EG(Admin, Researcher)

VIEWER

Name	Data Type	Size	Remarks
viewer_id	Number		This is the primary key of this table. EG(1, 2, 3 ..)
user_id	Number		The foreign key that relates to the USER table.

RESEARCHER

Name	Data Type	Size	Remark
researcher_id	Number		This is the primary key of this table. EG(1, 2, 3 ..)
user_id	Number		The foreign key that relates to the USER table.

LOCATION

Name	Data Type	Size	Remark
location_id	Number		This is the primary key of this table. EG(1, 2, 3 ..)
name	Text	255	Name of each Location.
latitude	Number		Latitude values of the location
longitude	Number		longitude values of the location
researcher_id	Number		The foreign key of the table RESEARCHER table.

PUBLICATION

Name	Data Type	Size	Remark
publication_id	Number		This is the primary key of this table. EG(1, 2, 3 ..)
researcher_id	Number		The foreign key of the table RESEARCHER table.
wqd_id	Number		The foreign key of the table W.Q.D table.
date_published	Date	Date type.	Date of the data upload.

WATER QUALITY DATA

Name	Data Type	Size	Remark
wqd_id	Number		This is the primary key of this table.
location_id	Number		Name of each Location.
parameter_1	Number		Placeholder for the parameters.
parameter_2	Number		Placeholder for the parameters.
parameter_3	Number		Placeholder for the parameters.

RECOMENDED STANDARD

Name	Data Type	Size	Remark
standard_id	Number		This is the primary key of this table.
description	Text	255	The description of the standard.
parameter_1 min	Number		Placeholder for the parameters.
parameter_1 max	Number		Placeholder for the parameters.
parameter_2 min	Number		Placeholder for the parameters.
parameter_2 max	Number		Placeholder for the parameters.
parameter_3 min	Number		Placeholder for the parameters.
paranmeter_3 max	Number		Placeholder for the parameters.

Figure 18: Data Dictionary

36 Methodology and Implementation

36.1 Front-end

End User Interface

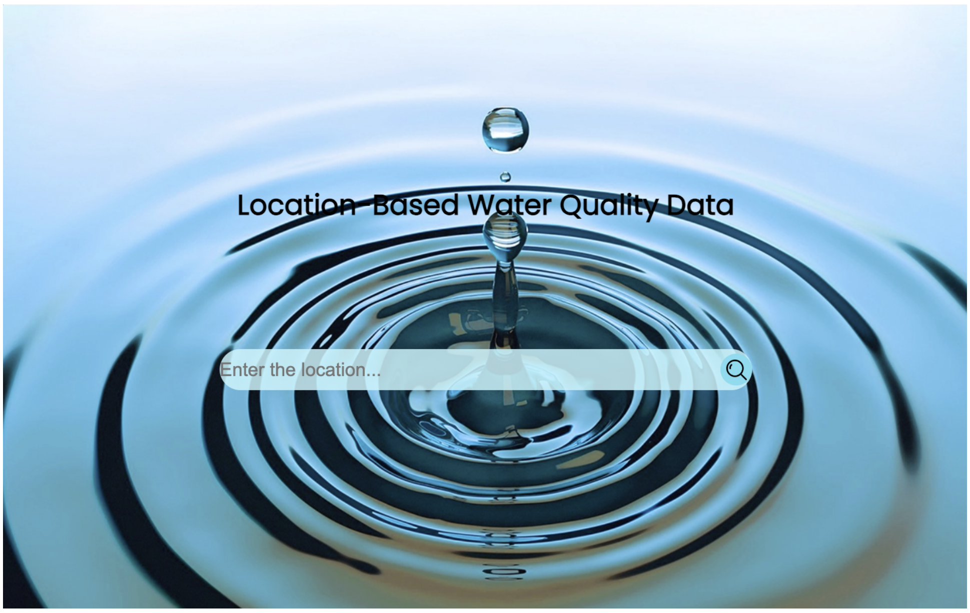

Figure 19: Location Search Interface

The "Search Data" page lets users quickly look for details about the water quality in particular locations. Users input their desired location into a clean and intuitive search bar, triggering a search process upon clicking the search button. Users are guided to a different page with detailed information on the location's water quality via the UI with ease. The page offers a visually appealing layout, responsive design, and theme components that guarantee a fun and captivating experience. The interface maintains a user-centric approach throughout the study of water quality data, gracefully navigating visitors to an error page in the event that the location cannot be found.

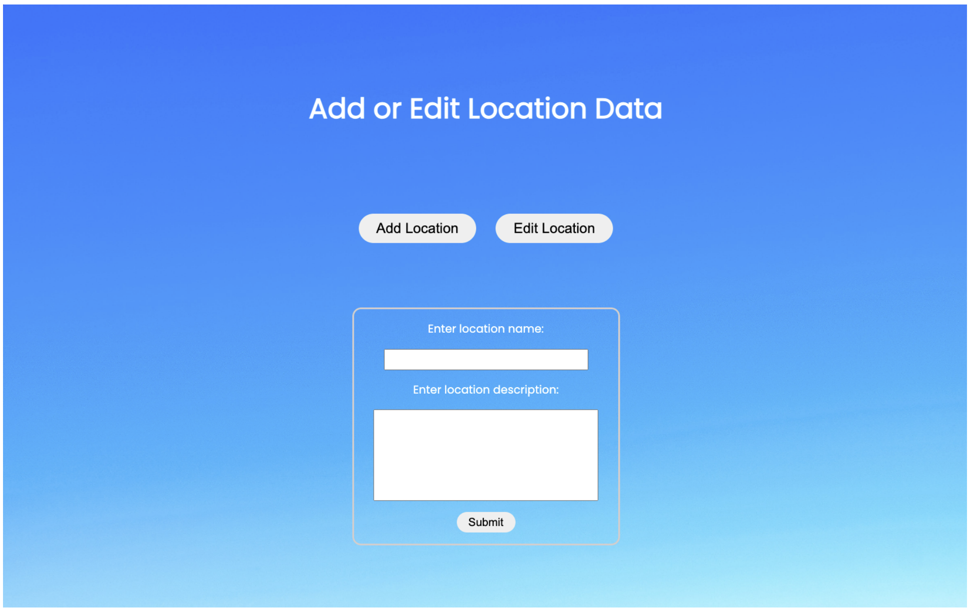

Figure 20: Add location data Interface

The "Add or Edit Location Data" page is designed for researchers to input new location data or edit existing information. Two prominent buttons on the interface, "Add Location" and "Edit Location," cause dynamic information to shift. Users add a location name and description when adding. Researchers can choose a location to update using a dropdown menu. The design is simple, with fashionable buttons and a background with a theme. The user experience is improved on all devices with responsive design. All things considered, the page offers researchers an easy-to-use platform for organizing water quality data for various places by smoothly integrating form elements and dynamic content updates.

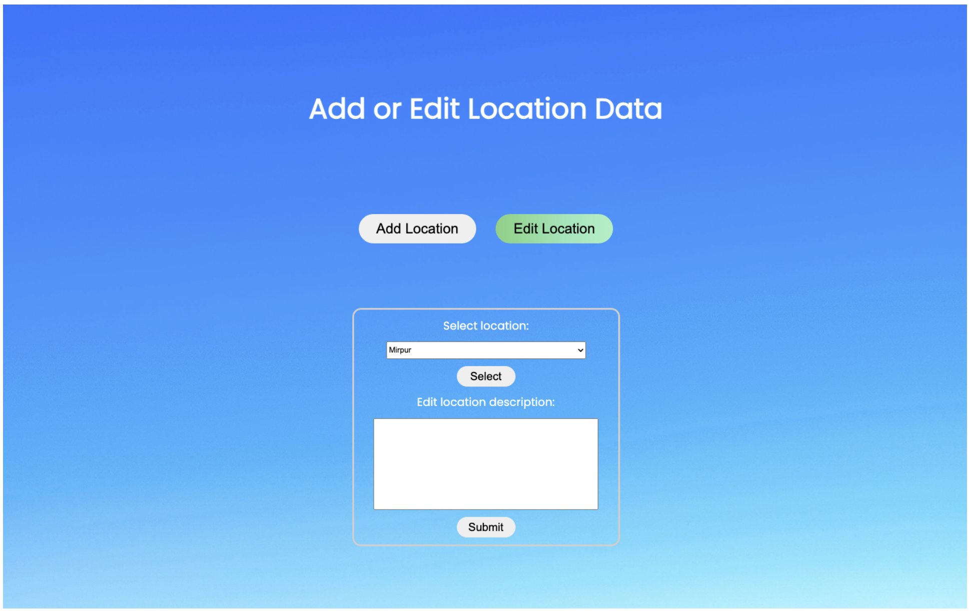

Figure 21: Edit location data Interface

View Water Quality Data

Location

#	Perameter	Recommended	Our Data
1	pH	Otto	@mdo
2	BOD	Thornton	@fat
3	COD		@twitter
4	Temperature	Otto	@mdo
5	pH	Otto	@mdo
6	pH	Otto	@mdo

Figure 22: View water quality data interface

On this page users are able to view the water quality data for a specific location chosen from the previous searching page. This data is derived from the latest submission done by a researcher or a user for this specific location. The table shows the values for all the relevant water quality parameters and also shows us the recommended values.

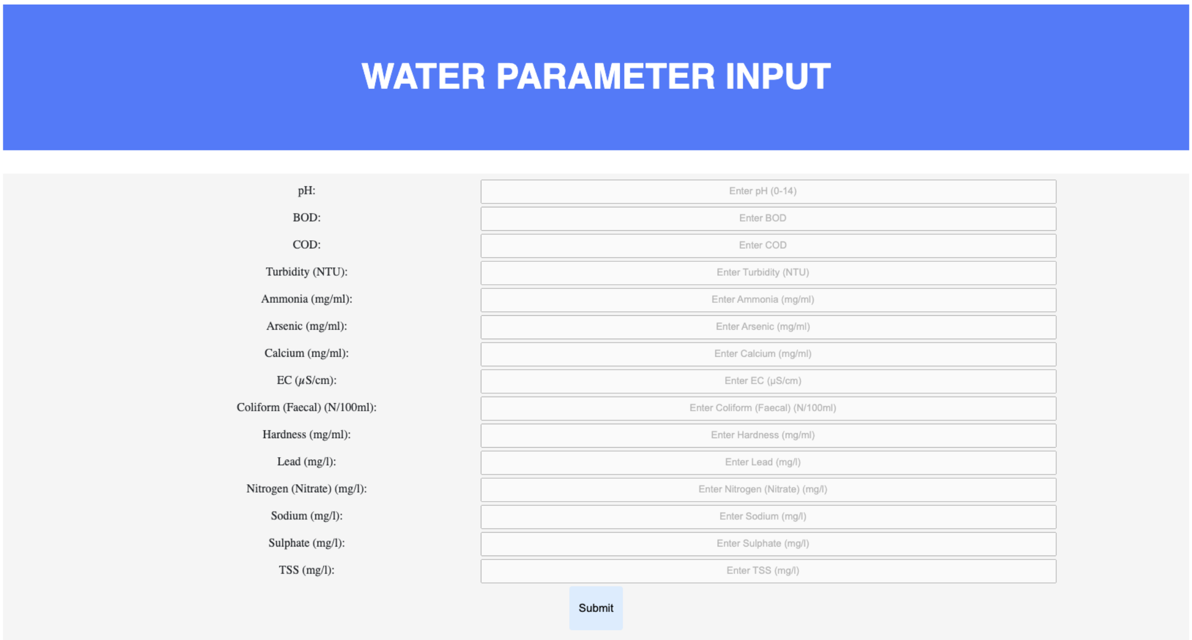

Figure 23: Input Parameter Interface

After adding a new location or choosing a pre-existing location, users will be redirected to the input form page. On this page users will be required to input all the available water quality parameter metrics for the chosen location and submit it. Once submitted this information will be saved in the database for later viewing and analytical explanations using graphs and charts.

Figure 24: Same Location Comparison

These interfaces will allow the users to analyse the data in a visual way using charts. Users through these pages will be able to view the water quality metrics of a chosen location and compare it by date. In this interface, the latest submission all the inputted parameters of a specific location is compared with the previous submission of the same location. This helps the user get a better understanding of the quality trend.

Users will also be able to compare the data between latest submissions of two different locations in the same manner.

Figure 25: Comparing Different Locations

Admin and Staff Interface

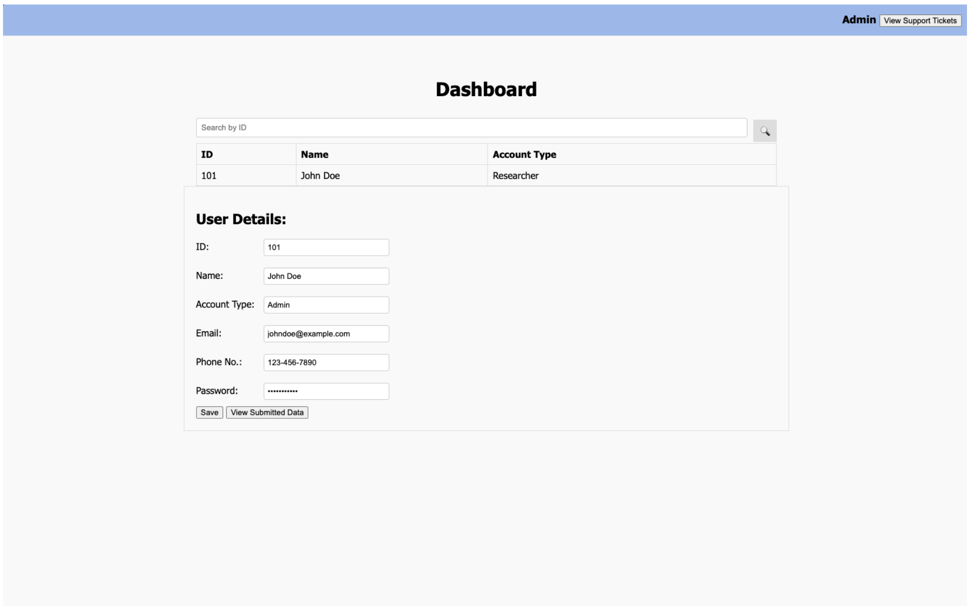

Figure 26: Admin Dashboard

The admin dashboard contains a search bar which allows admin users to search for any registered user in the database using their ID. Once a query is made, the result is shown below the search bar in a table which contains the id, name and account type of the searched user.

The detailed info is then shown below the table in input forms which allows the admin to edit any chosen info of his choice. The admin can then save the changes which will make the changes permanent in the database.

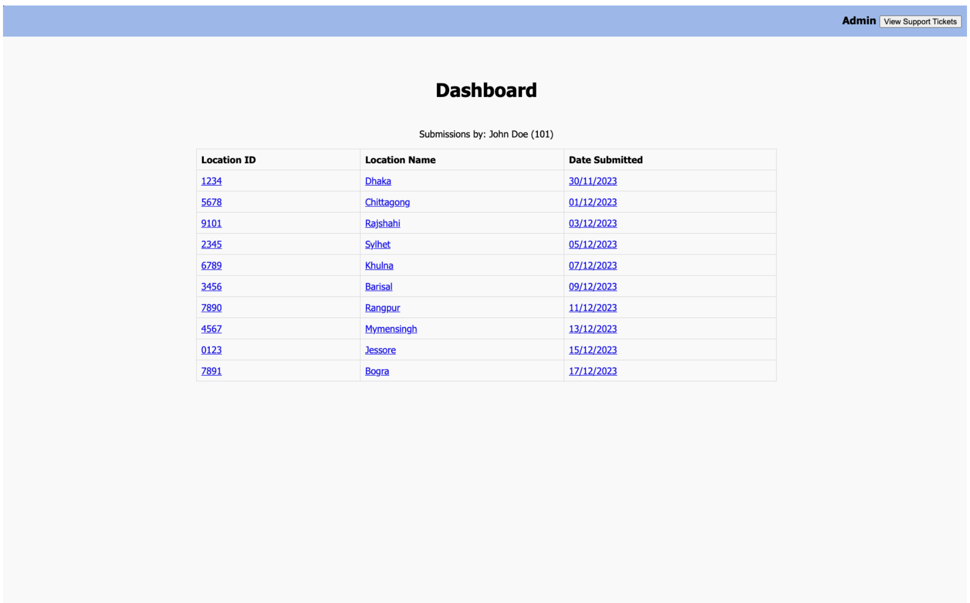

Figure 27: User Submission Viewing Interface

Pressing the "View Submitted Data" will take the user to this page which will show every single submission made by the chosen user. Clicking any of the given submissions will take the user to the water quality metrics viewing page.

The view support tickets in the top right corner of the page will take the user to a new page which will show all support ticket requests received.

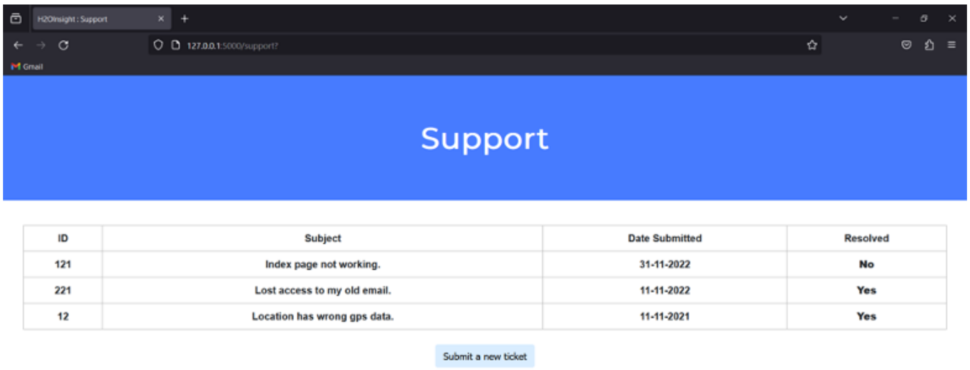

Figure 28: Support Ticket Interface

Purpose: This is the Support page. Where a user can view all the support tickets that he has. This page also has a button to take the user to the support page form.

Functionality: The user can see all the tickets that he has. Clicking the name of the ticket will take him to the ticket.

The Submit a new ticket will take the user to the new ticket form. Where the user will be able to make a new ticket.

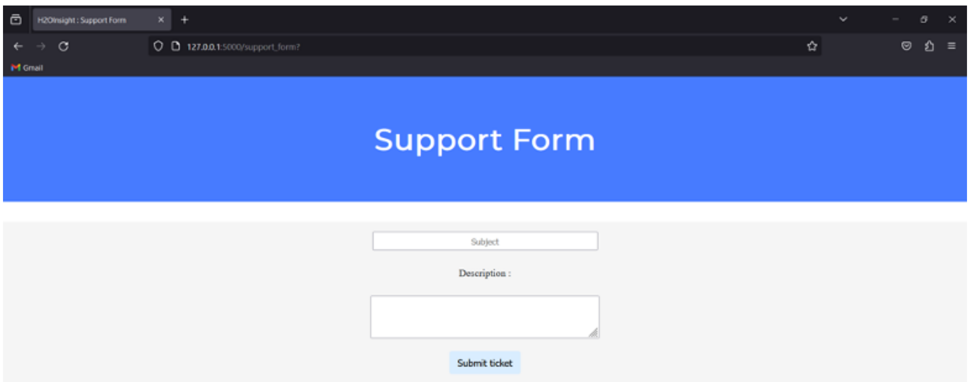

Figure 29: Support Ticket Submission Form

Purpose: Here users can make a new ticket. It has 2 mandatory input fields. the 1st one is the subject of the ticket and the 2nd one is a description of the problem.

Functionality: Input Validation: Ensure that all required fields are filled out.

Communication with Backend: When the user submits the login form, the front-end sends the data to the backend for processing.

Error Handling: A unified error-handling mechanism is implemented to provide consistent feedback to users.

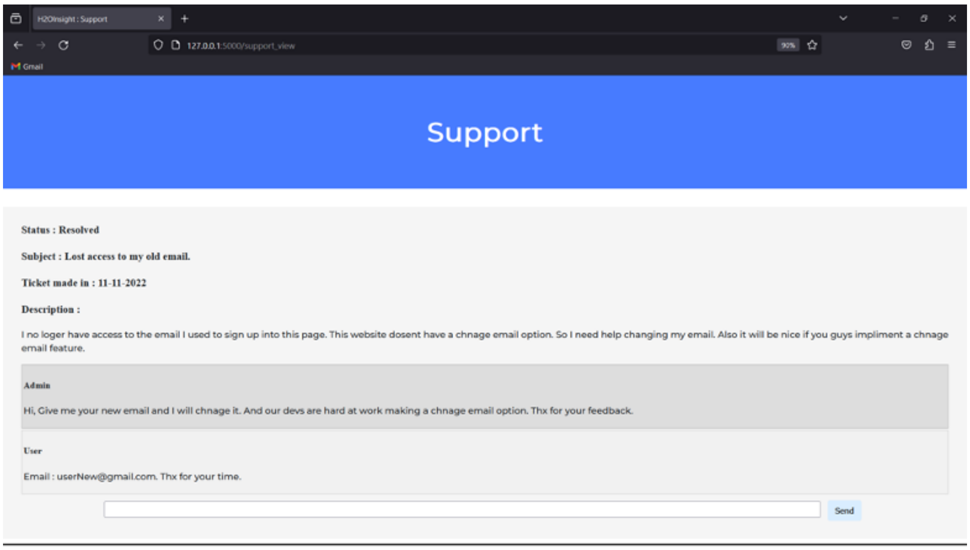

Figure 30: Ticket Viewing Interface

Purpose: In this page users can view any particular ticket and take part in one on one communication with the admins of this site.

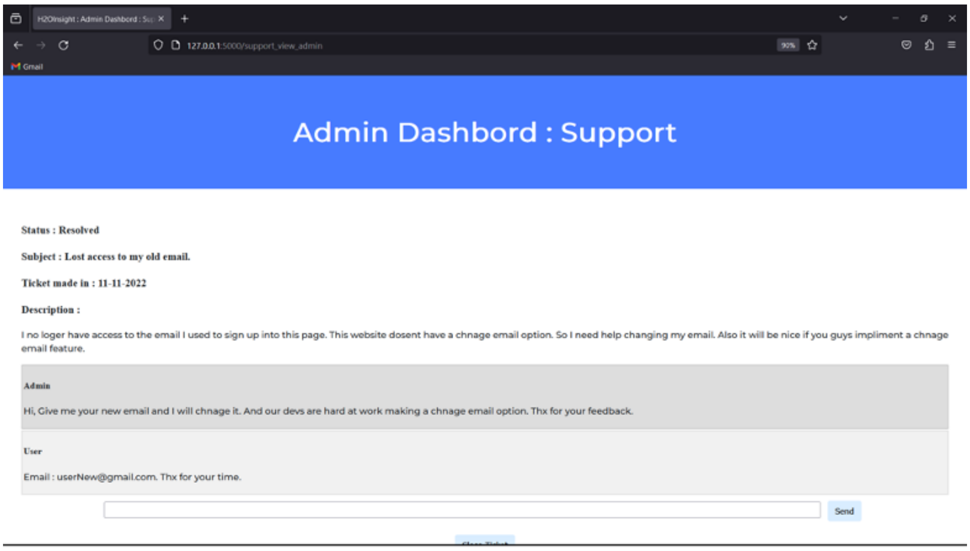

Figure 31: Admin Ticket Interface

Purpose: Almost the same as the previous page but has added functionality where a admin can close the ticket if he feels the requirements have been met.

Landing Page

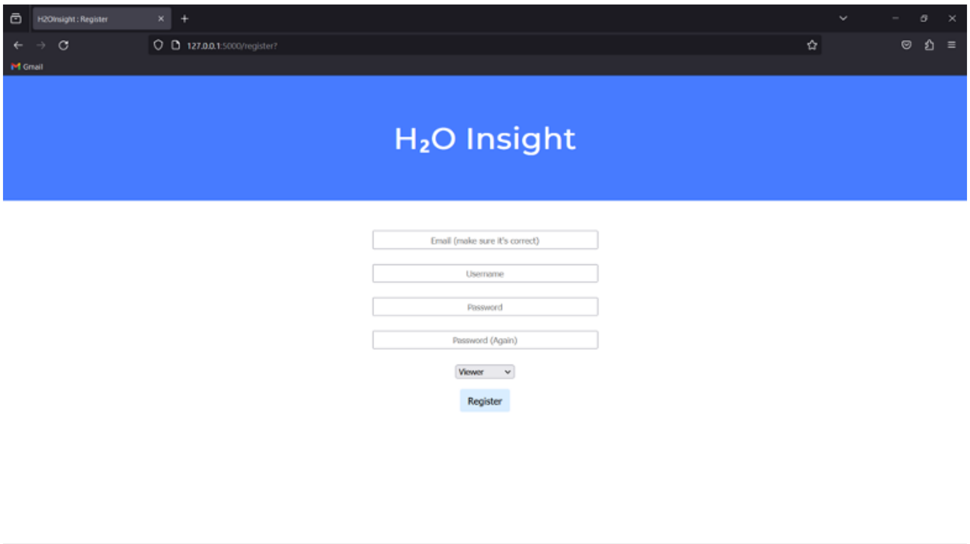

Figure 32: Registration Interface

Registration Interface: Purpose: The registration interface allows new users to create accounts by providing necessary information. This includes a username, email address, password, and a dropdown where they can select what type of account they want to create.

Functionality: Input Validation: Ensure that all required fields are filled out. Validate the password against security requirements.

Communication with Backend: When the user submits the registration form, the front-end sends the data to the backend for processing.

Error Handling: A unified error-handling mechanism is implemented to provide consistent feedback to users.

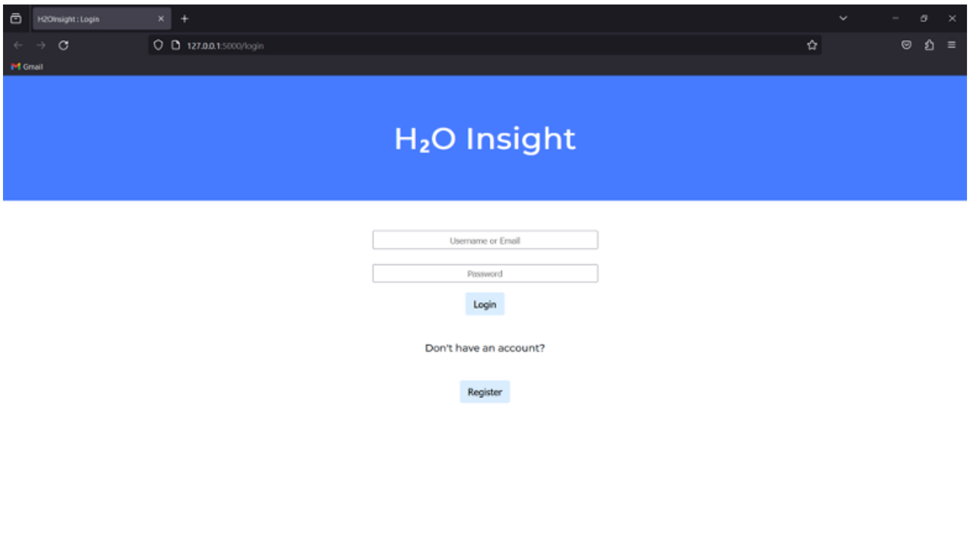

Figure 33: Log-in Interface

Login Interface: Purpose: The login interface serves the purpose of allowing registered users to access their accounts securely. This includes two main input fields.In the first one users can either input the username or email address. In the 2nd one they provide their password.

Functionality: Input Validation: Ensure that all required fields are filled out.

Communication with Backend: When the user submits the login form, the front-end sends the data to the backend for processing.

Error Handling: A unified error-handling mechanism is implemented to provide consistent feedback to users.

References

[1] M. J. D. Arif Ul Alam, Dennis Clyne, “A low-cost multi-parameter water quality monitoring system,” *Sensors*, vol. 21, no. 11, p. 3775, 2021. [Online]. Available: https://www.mdpi.com/1424-8220/21/11/3775

[2] E. A. R. A. A. Z. M. H. S. S. H. G. Wong Jun Hong, Norazanita Shamsuddin and M. N. A. Noh, “Water quality monitoring with arduino based sensors,” *Environments*, vol. 8, no. 1, p. 6, 2021. [Online]. Available: https://www.mdpi.com/2076-3298/8/1/6

[3] M. A. L. S. A. R. Z. B. J. G. O. I. C. I. P. V. N.-B. J. A. B. J. L. P.-E. C. M.-P. Aldo G. Orozco-Lugo, Des C. McLernon and R. R. Vazquez, “Monitoring of water quality in a shrimp farm using a fanet,” *Internet of Things*, vol. 18, no. 12, p. 100170, 2020. [Online]. Available: https://www.researchgate.net/publication/338958530_Monitoring_of_water_quality_in_a_shrimp_farm_using_a_FANET

[4] E.-R. B. P. B. M Manoj V Dhilip Kumar, Muhammad Arif and O. Geman, “State of the art techniques for water quality monitoring systems for fish ponds using iot and underwater sensors: A review,” *Sensors*, vol. 22, no. 6, p. 2088, 2022. [Online]. Available: https://www.mdpi.com/1424-8220/22/6/2088

[5] N. D. C. R. P. V. K. G. R. S. M.M.J.G.C.N. Jayasiri, Sudhir Yadav, “Spatio-temporal analysis of water quality for pesticides and other agricultural pollutants in deduru oya river basin of sri lanka,” *Journal of Cleaner Production*, vol. 330, no. not specified, p. 129897, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0959652621040671

[6] M. C.-V. S. N. Razvan Bogdan, Camelia Paliuc and D. Barmayoun, “Low-cost internet-of-things water-quality monitoring system for rural areas,” *Sensors*, vol. 23, no. 8, p. 3919, 2023. [Online]. Available: https://www.mdpi.com/1424-8220/23/8/3919

[7] R. F. J. L. Zhining Shi, Christopher W. K. Chow and B. Jin, “Applications of online uv-vis spectrophotometer for drinking water quality monitoring and process control: A review,” *Sensors*, vol. 22, no. 8, p. 2987, 2022. [Online]. Available: https://www.mdpi.com/1424-8220/22/8/2987

[8] Y. Chen and D. Han, “Water quality monitoring in a smart city: A pilot project,” *Automation in Construction*, vol. 89, no. not defined, pp. 307–316, 2018. [Online]. Available: https://www.sciencedirect.com/science/article/abs/pii/S0926580517305988

[9] M. Silberbauer, “Internet-based applications for interrogating 50 years of data from the south african national water quality monitoring network,” *Hydrological Sciences Journal*, vol. 64, no. 12, pp. 1419–1430, 2019. [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/02626667.2019.1645334

[10] L. A. D. H. D. P. C. H. J. A. H. J. K. J. S. R. L. W. Emily K. Read, Lindsay Carr, “Water quality data for national-scale aquatic research: The water quality portal,” *Water Resources Research*, vol. 53, no. 2, pp. 1735 – 1745, 2017. [Online]. Available: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2016WR019993

[11] A. B. S. C. I. M. V. V. L. B. Meryem Jabrane, Abdessamad Touiouine, "Data conditioning modes for the study of groundwater resource quality using a large physico-chemical and bacteriological database, occitanie region, france," *Water*, vol. 15, no. 1, p. 84, 2023. [Online]. Available: https://www.mdpi.com/2073-4441/15/1/84/html

[12] M. T. D. X. Y. R. P. d. M. F. L. B. Elizabeth H. Altenau, Tamlin M. Pavelsky, "The surface water and ocean topography (swot) mission river database (sword): A global river network for satellite data products," *Water Resources Research*, vol. 57, no. 7, 2021. [Online]. Available: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2021WR030054

[13] T. Z. C. C. C. L. P. C. Tie Qiu, Zhao Zhao, "Underwater internet of things in smart ocean: System architecture and open issues," *IEEE Transactions on Industrial Informatics*, vol. 16, no. 7, pp. 4297 – 4307, 2020. [Online]. Available: https://ieeexplore.ieee.org/document/8863935

[14] A. G. A. Joshua O. Ighalo, "A comprehensive review of water quality monitoring and assessment in nigeria," *Chemosphere*, vol. 260, no. 127569, 2020. [Online]. Available: https://www.academia.edu/89497121/A_comprehensive_review_of_water_quality_monitoring_and_assessment_in_Nigeria

[15] S. T. G. Sathish Pasika, "Smart water quality monitoring system with cost-effective using iot," *Heliyon*, vol. 6, no. e04096, 2020. [Online]. Available: https://www.cell.com/heliyon/pdf/S2405-8440%2820%2930940-3.pdf

[16] S.-C. C. Y.-H. C. W.-C. L. W.-L. J. F.-H. N. S.-H. C. Hoang-Yang Lu, Chih-Yung Cheng and N. A. Ubina, "A low-cost ai buoy system for monitoring water quality at offshore aquaculture cages," *Sensors*, vol. 22, no. 11, p. 4078, 2022. [Online]. Available: https://www.mdpi.com/1424-8220/22/11/4078

[17] C. Z. Zilin Li, Haixing Liu and G. Fu, "Generative adversarial networks for detecting contamination events in water distribution systems using multi-parameter, multi-site water quality monitoring," *Environmental Science and Ecotechnology*, vol. 14, no. not defined, p. 100231, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2666498422000874

[18] M. T. M. D. A. I. O. Md Galal Uddin, Samsad Parween, "Assessment of urban river water quality using modified nsf water quality index model at siliguri city, west bengal, india," *Environmental and Sustainability Indicators*, vol. 16, no. 100202, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2665972722000344

[19] S. O. S. P. S. A. H. G. J.-S. L. S.-J. G. A. B. Ananda Tiwari, Warish Ahmed, "Application of digital pcr for public health-related water quality monitoring," *Science of the Total Environment*, vol. 837, no. 155663, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0048969722027590)

[20] A. K. P. K. Gagan Matta, Anjali Nayak, "Water quality assessment using nsfwqi, oip and multivariate techniques of ganga river system, uttarakhand, india," *Applied Water Science*, vol. 10, no. 206, 2020. [Online]. Available: https://link.springer.com/article/10.1007/s13201-020-01288-y

[21] S. T. G. Sathish Pasika, "Smart water quality monitoring system with cost-effective using iot," *Heliyon*, vol. 6, no. e04096, 2020. [Online]. Available: https://www.cell.com/heliyon/pdf/S2405-8440%2820%2930940-3.pdf)

[22] S. A. Gozen Elkiran, Vahid Nourani, "Multi-step ahead modelling of river water quality parameters using t ensemble artificial intelligence-based approach," *Journal of Hydrology*, vol. 577, no. 2-4, p. 123962, 2019. [Online]. Available: https://www.researchgate.net/publication/334556631_Multi-step_ahead_modelling_of_river_water_quality_parameters_using_ensemble_artificial_intelligence-based_approach

[23] R. E. R. A. J. L. J. E. K. Howard B. Glasgow, JoAnn M. Burkholder, "Real-time remote monitoring of water quality: a review of current applications, and advancements in sensor, telemetry, and computing technologies," *Journal of Experimental Marine Biology and Ecology*, vol. 300, no. 1-2, p. 409–448, 2004. [Online]. Available: https://sci-hub.se/10.1016/j.jembe.2004.02.022

[24] F. F. E. Z.-L. M. N. F. A. V. H. G. Camilo Zamora-Ledezma, Daniela Negrete-Bolagay, "Heavy metal water pollution: A fresh look about hazards, novel and conventional remediation methods," *Environmental Technology Innovation*, vol. 22, p. 101504, 2021. [Online]. Available: https://sci-hub.se/10.1016/j.eti.2021.101504

[25] J. H. J. L. K. Rebecca Murphy, Elgin Perry, "A generalized additive model approach to evaluating water quality: Chesapeake bay case study," *Environmental Modelling Software*, vol. 118, 2019. [Online]. Available: https://www.usgs.gov/publications/generalized-additive-model-approach-evaluating-water-quality-chesapeake-bay-case-study

[26] S. L. Shuangyun Peng, "Scale relationship between landscape pattern and water quality in different pollution source areas: A case study of the fuxian lake watershed, china," *Ecological Indicators*, 2020. [Online]. Available: https://www.researchgate.net/publication/346756423_Scale_relationship_between_landscape_pattern_and_water_quality_in_different_pollution_source_areas_A_case_study_of_the_Fuxian_Lake_watershed_China/fulltext/5fd030c2299bf188d403fec4/Scale-relationship-between-landscape-pattern-and-water-quality-in-different-pollution-source-area pdf

[27] Z. M. Y. Seyed Babak Haji Seyed Asadollah, Davide Motta, "River water quality index prediction and uncertainty analysis: a comparative study of machine learning models," *Journal of Environmental Chemical Engineering*, vol. 9, no. 1, p. 104599, 2021. [Online]. Available: https://www.scinapse.io/papers/3093998899

[28] Z. M. Y. Tiyasha, Tran Minh Tung, "A survey on river water quality modelling using artificial intelligence models: 2000–2020," *Journal of Hydrology*, vol. 585, p. 124670, 2020. [Online]. Available: https://www.sciencegate.app/document/10.1016/j.jhydrol.2020.124670

[29] Y. L. H. Z. F. Y.-D. K. Z. J. Z. Y. Xiaotong Wen, Feiyu Chen, "Microbial indicators and their use for monitoring drinking water quality—a review," *Sustainability*, vol. 12, no. 6, p. 2249, 2020. [Online]. Available: https://www.mdpi.com/2071-1050/12/6/2249

[30] X. M. Hongfang Lu, "Hybrid decision tree-based machine learning models for short-term water quality prediction," *Chemosphere*, vol. 249, no. 126169, 2020. [Online]. Available: https://europepmc.org/article/MED/32078849