IoT Product on Smart Water Quality Monitoring System (Iot Wq-Kit) for Puducherry Union Territory

2023 Second International Conference on Advances in Computational Intelligence and Communication (ICACIC) | 979-8-3503-1845-6/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICACIC59454.2023.10435019

Manikannan Govindasamy
Research Scholar
Department of Electronics and Communication Engineering
Puducherry Technological University
Puducherry, India
kannan.gr18@gmail.com

K. Jayanthi
Professor
Department of Electronics and Communication Engineering
Puducherry Technological University
Puducherry, India
jayanthi@ptuniv.edu.in

S. Rajagopan
Professor
Department of Chemistry
Puducherry Technological University
Puducherry, India
rajagopan@ptuniv.edu.in

***Abstract*—Availability and quality of water is becoming global demand and has started to apply enormous pressure on usage of natural resources which increases day by day. As Puducherry is a tourist city, the need for ensuring water quality and conserving the water resources is also reaching greater importance. Pollution concentration increased due to domestic sewage and industrial effluents ceases the Quality of Water. These confronts arise due to heavy population and low natural water resources. If quality parameters are identified during the initial stages, it enables the implementation of appropriate actions, thus preventing critical situations. The Internet of Things (IoT) is the recent technological solution for monitoring and management of water resources available. The majority of methods aimed at mitigating water pollution involve biological and laboratory-based techniques, which result in extended time and resource utilization. To Control Water Quality Pollution, water quality monitoring is required in real time. In order to tackle this problem, we have created an IoT based Water Quality monitoring kit (WQ Kit) system designed for monitoring various water quality parameters such as pH, Dissolved Oxygen (DO), Alkalinity, Salinity, Total Dissolved Solids (TDS), Conductivity, Temperature, Turbidity, and additionally quantifying water consumption in the Puducherry Region. The system stores historical readings on a cloud platform in real time. The developed IoT system leads to data acquisition, wireless data transmission and processing the data in the cloud in real time. The IoT system will provide the ability to automatically react based on the changes in Water Quality to attract many more tourists to Puducherry. This provides an easy user-friendly interface with graphical representation and Mobile Application to illustrate the acceptable quality factors values.**

Keywords—IoT, Water Quality, Sensor, pH, TDS, Turbidity, Conductivity, DO, Quality Analysis

I. INTRODUCTION

India receives an annual precipitation of approximately 4000 billion cubic meters (BCM), but only one-third of this abundant resource is effectively harnessed. With the ongoing urbanization and rising water demands, it is projected that per capita water availability could decline by an additional 20% by the year 2050, thereby classifying India as a water-scarce nation. A significant proportion, almost 85%, of water usage in India is attributed to the agricultural sector. According to projections from the TERI-World Sustainable Development Summit 2022, by 2030, the country's water demand is anticipated to double the available supply. This looming water deficit is expected to result in severe scarcity, impacting millions of people, as well as disrupting industrial operations and significantly hampering overall economic

The integration of diverse devices and sensors enables comprehensive data collection, subsequently processed to enable the system to make informed decisions based on predefined rules[1]. Such capabilities open up new opportunities, such as enhancing the sustainability of vital resources like water.

Efficiently managing and controlling this invaluable resource will significantly impact the water system's lifecycle. Real-time wireless water quality data collection simplifies the task of maintaining water quality according to consumer preferences and facilitates year-round assessment of water quality.

The proposed system aims to optimize manual data collection efforts and the logistics associated with sending samples to chemical laboratories for analysis. Traditional laboratory results often arrive after a considerable delay, rendering them outdated as water characteristics may have changed by then. Implementing real-time monitoring ensures that water quality adheres to the required standards for specific applications.

This paper is organized as follows: it begins with an introduction and then delves into the topics covered in subsequent sections, including a literature review. The paper explores the concept of industrial revolution [2], [3] and the evolution of smart systems for water quality evaluation. Furthermore, it introduces various IoT applications and areas of interest, along with relevant prior work. This research paper presents the proposed system architecture and its components, complemented by design diagrams. Lastly, the paper outlines anticipated model outcomes, identifies opportunities for future research, and offers concluding remarks.

Within this article, we introduce the conceptualization of a Wireless Sensor Network (WSN) that has been exclusively crafted for the purpose of water quality monitoring, facilitated by submerged sensors [4]. This innovative system employs an array of sensors, each proficient in collecting a wide spectrum of water characteristics, encompassing pH, dissolved oxygen, turbidity, conductivity, temperature, and various others.

The rapid advancements in WSN technology offer an innovative solution for data acquisition, data transmission, and data processing. This allows clients to access continuous water quality information from remote locations.

In contemporary times, the Internet of Things is emerging as a groundbreaking technological phenomenon with widespread applications across various fields, facilitating data collection, monitoring, and analysis from remote locations. IoT networks are being implemented in a multitude of areas, ranging from smart city and power grids to provide smart supply chains and wearable technology. While IoT adoption in environmental contexts is still evolving, it holds tremendous potential [5]. IoT can be employed for identifying air pollution level, forest fires, earthquake warnings, reducing air pollution, monitoring snow levels, prevention of landslides, avalanches, & notably, enhancing monitoring of water quality.

Water quality kit (WQ Kit) has garnered significant interest among many researchers in the 21st century, with many projects focusing on different views in this field. The common point of these endeavours is towards development of an cost-effective, efficient, real-time WQ kit that integrates WSN and IoT [6]. In our study, we employ an IoT-based sensor network to closely observe the physical and chemical characteristics of water bodies located within the Puducherry vicinity.

II. Related Work

Achieving sustainable water management necessitates the preservation of equilibrium between water demand and supply, with a particular focus on addressing water needs in urban, agricultural, and natural settings. Gaining an understanding of water supply prediction and water consumption forecasting can prove invaluable in formulating an efficient water distribution strategy. Researchers globally have been studying various methods to optimize the water usage and identify suitable water management system. Several nations across the globe, have implemented different approaches for water management are listed below.

In Cairo, a deployment of intelligent water meters took place, involving their distribution and installation within a specific geographical zone. These meters facilitated the collection of data at regular intervals, which was then promptly transmitted to the cloud. A secondary layer was employed to analyze the gathered data, utilizing a well-known AI technique known as Long Short Term Memory (LSTM) algorithm [7]. This LSTM model was meticulously validated and tested to assess its suitability for predicting future water consumption trends.

In Nepal, a dedicated framework has been established for the management of water supply. The effectiveness of water supply chain. can be assessed through the monitoring of factors such as leakages [8], water overflows, automated meter readings, online billing, and water consumption patterns across households, regions, communities and ultimately, the entire nation. Additionally, IoT technology enables the automatic cutoff of water supply lines when necessary.

In Iraq [9], the precise forecasting of water quality (WQ) parameters is regarded as a crucial and essential tool for ensuring the sustainable management of water resources. In this research, we have constructed various ensemble machine learning (ML) models, which encompass Random Forest (RF), Stochastic Gradient Boosting (GBM), Radial Support Vector Machine (SVM), Quantile Regression Forest (QRF), and Gradient Boosting Machines, aimed at forecasting monthly values of biochemical oxygen demand (BOD).

In Ethiopia, a research project conducted aimed to determine the most suitable ARIMA models for fitting water consumption data within Tepi town. The primary objective was to accurately forecast future water consumption trends [8] within the city. This predictive model was instrumental in projecting water usage for the upcoming ten months and offering valuable guidance to the Tepi Town Water Company Limited, assisting them in addressing the city's water demand effectively.

In Mumbai, developed a predictive model that enables us to forecast water consumption for at least the next decade, allowing us to proactively implement necessary measures. This effort contributes significantly to addressing water scarcity issues in the Mumbai region [10], [11]. These collective endeavors emphasize the crucial role of innovative strategies in achieving sustainable water resource management on a global level.

III. Methodology

The following section presents an overview of the methodologies and strategies employed in shaping the model design, procuring and processing data, as well as assessing and validating the proposed solution architecture. In order to conduct this research initiative, it is essential to have a comprehensive understanding of the water distribution network within the Puducherry region. To narrow down our water analysis, we have utilized water data obtained from a preliminary study area, as identified by our collaboration with the PWD team. The research focus has been directed towards the Kurinji Nagar and Lawspet areas of Puducherry for this study.

The design phases of this research study has been pictorially represented as shown in Fig 1.

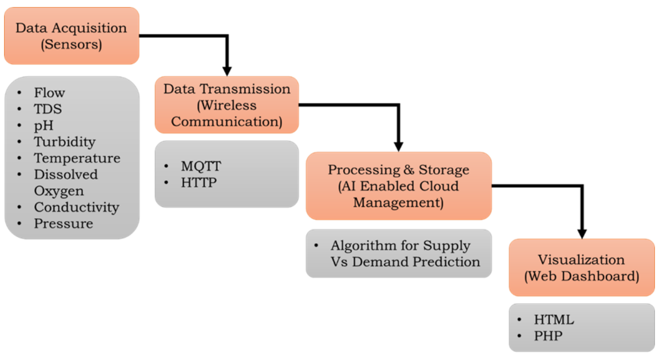

Fig. 1. Design Research Modules

The methodology is aiming to develop an automatic monitoring system which is designed with IoT sensors to collect water usage and water quality parameters along with GPS information. This is carried out in two phases/ levels.

- Macro level : Data Acquisition / Quality parameters monitoring at the borewells/huge distribution tanks , which serves as the water supply source for the entire region.
- Micro Level: Data Acquisition / Quality parameters monitoring at the overhead tanks of every household/ other

connections , which serves as the water supply source for the entire region

This system was installed and connected via internet in 20 sample houses/ others overhead tank (micro level) and at Kurinji Nagar Supply tank (macro level) to monitor the required data for analysis. The block diagram of the autonomous system is shown below in Fig 2 with detailed description.

The following are the sequential steps involved in this research study:

1. The IoT [12] elements placed in the test region forms a network and periodically transfer the quality and flow level to the sink node, which serves as a coordinating node. In this case a powerful microcontroller (sink node) is placed for data acquisition.

2. The sink node then transfers the real time data to the Cloud.

3. This cloud data is pre-processed and available for remote monitoring through the web access tool, which is designed and available for public usage.

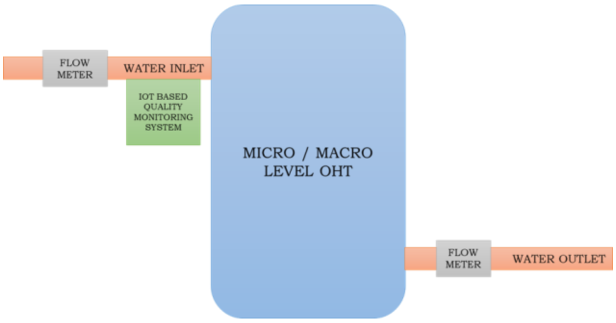

Fig. 2. Block Structure of Prototype

Initiatives have been taken to estimate the feasibility of this study by testing this process in one household connection and the snapshot of the hardware water quality kit is as well shown Fig. 3.

Fig. 3. Snapshot of Prototype Tested

It was observed to work well and the Data collected from the autonomous quality monitoring WQ kit is stored in spreadsheet for data analytics and demand supply prediction. The sample data acquired is presented in the spread sheet as shown in Fig 4.

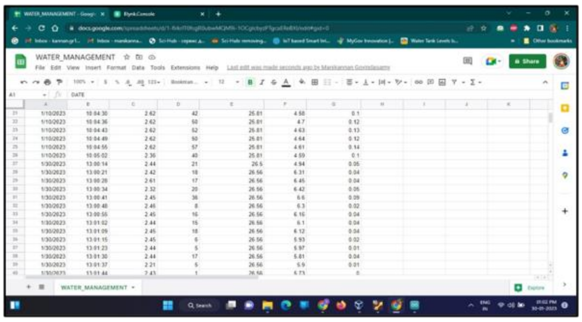

Fig. 4. Data Acquisition Through Iot Devices

The IoT enables water usage monitoring worldwide in real time, utilizing digital computing devices, portable sensors, communication protocols like TCP/IP, and different services through internet. This application of IoT for water quality monitoring is often referred to as smart water quality monitoring kit (IoT – WQ Kit). This system find applications in various domains, including domestic use, agriculture, aquaculture, municipal waste recycling, as well as monitoring water quality in natural bodies such as lakes and rivers. In comparison to traditional water monitoring systems, IoT-WQ Kit address several significant challenges. Key contributions of this technology include:

- Cost-effectiveness: IoT-WQ KIT leverages existing commercially available communication infrastructure, reducing overall development costs.
- Enhanced spatial resolution: IoT technology, reliant on the Internet, eliminates spatial limitations.
- Low Computational Demands: High computational tasks are offloaded to cloud servers, allowing the use of affordable, process based nodes (e.g.,ESP8266).
- Minimal energy consumption: By shifting load to cloud servers, nodes can operate in sleep mode, prolonging battery life in remote locations.
- Real Time feedback: This system offer feedback to end users and water authorities through SMS, application notification, email, Telegram and other means.
- Enhanced water quality data: Developers can seamlessly integrate many analytical tools, such as machine learning techniques, on cloud servers to derive water quality parameters from sensor data. Moreover, machine learning techniques can predict future water quality trends.

IV. IOT-WQ KIT ARCHITECTURE

A typical IoT Water Quality monitoring kit comprises 4 basic modules (Fig. 5):

i. Sensors module;
ii. Gateway module;
iii. Cloud service module;
iv. User interface module.

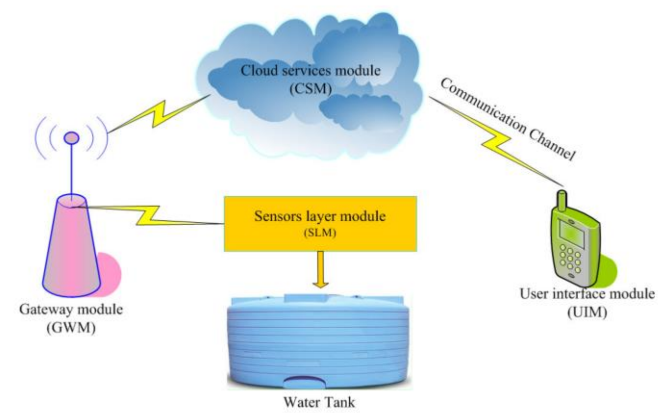

Fig. 5. Basic Modules in IoT

Sensor Module: It is a crucial component within the IoT – WQ KIT, as its output significantly influences the system's overall efficiency. Any issues, such as sensor biofouling, within this module can result in inaccurate water quality reporting. Typically, an SM comprises three submodules: the Sensors-module, Digital-module, and Communication-module. SLM-SM initially retrieves data from water quality sensors, such as pH sensors. Alternatively, a communication shield, like the ESP8266 transceiver module or DTMF-enabled SIM900 GPRS/GSM shield, can be added to another microprocessor-based electronic kit, such as the Arduino Uno, if required.

Gateway Module: It is responsible for transmitting data to a Gateway module, a local gateway. Gateways facilitate communication in between devices, clouds, other devices, or networks. While they may entail some costs, it's advisable for developers to consider using recently developed IoT-gateways for optimal performance and robust security[13].

Cloud Service Module: It provides a flexible, scalable and efficient model for delivering the services and infrastructure required to power IoT- enabled devices and applications in real time. Multiple cloud services are available, such as Think Speak, Blynk, Ubidots and Adafruit, IoT-Platforms. These platforms allow developers to easily store, visualize, and analyze sensor data. Moreover, they offer convenient management of IoT devices, such as water pumps[14]. Cloud servers can even predict future water quality trends and notify end-users through alerts, such as Twitter, in case of anomalies.

User Interface Module: Virtually all modern cloud IoT-Platforms offer user interfaces for end-users. Interface platforms can send notifications via SMS, pop-up messages, Facebook, Telegram call or message, email, and more. Additionally, service providers offer mobile apps that users can install on their smartphones[14]. For instance, by installing the Arduino IoT cloud app, end-users can easily connect, manage the devices, and control IoT devices, such as sensors, from anywhere in the world.

Typically, a water quality monitoring system comprises a variety of sensors to monitor various parameters, such as pH, humidity, turbidity, temperature, conductivity and others. Fig. 6 provides an overview of the fundamental block diagram for a smart water quality monitoring kit. As depicted in diagram, the central core controller serves as the system's centre. All sensors are connected to this ESP8266 controller, which manages their operation, collects data from them, compares the data with predefined standard values, and transmits the results to relevant end-users or authorities using wireless modules. With the continuous evolution of IoT technology, water quality monitoring (IoT WQ – Kit) have become more intelligent, offers reduced power consumption and enhanced ease of operation. Fig.7 illustrates the operational flowchart of a smart water quality kit [15], [16]. These sensors are submerged in the water to be tested. The sensor readings are processed by an Analog-to-Digital Converter (ADC), and the core controller reads and uploads these values to the cloud. Continuous monitoring occurs by assessing whether the sensor readings exceed predefined thresholds. If a sensor reading surpasses the threshold, appropriate actions are initiated. If sensor value is less than threshold value, then the parameters will check for different water source.

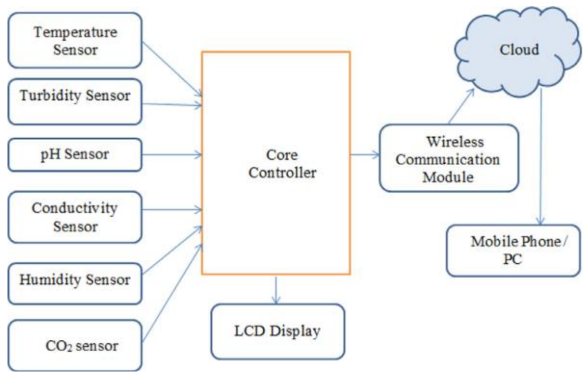

Fig. 6. Block Diagram

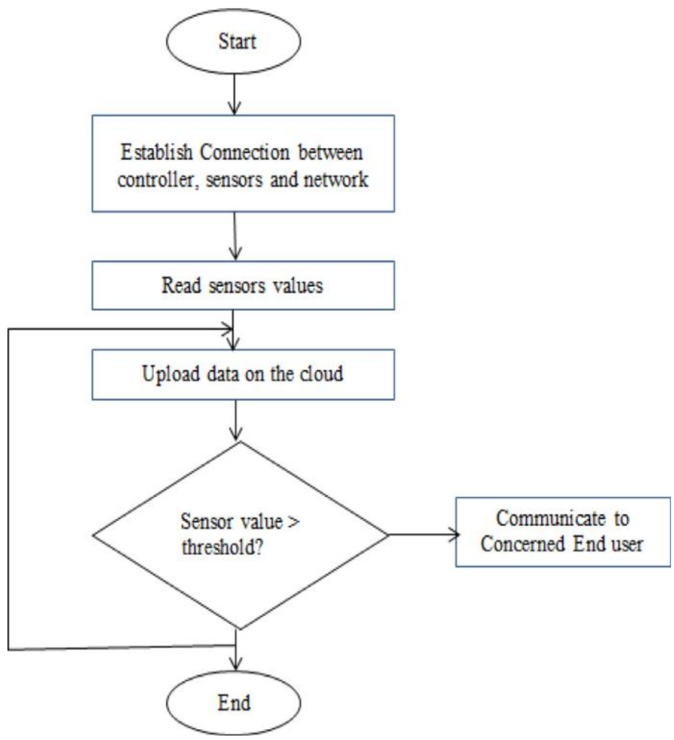

Fig. 7. Block Diagram

TABLE 1. REAL TIME MONITORED WATER QUALITY DATA

Kurinji Nagar Overhead Tank			
Parameter	**Acceptable Limit**	**Permissible Limit**	**Data**
pH	6.5 to 8.5	No relaxation	6.51
Electrical Conductivity @25C (us/cm)	---	---	1528
Turbidity (NTU)	1 max	5 max	---
TDC (mg/L)	500 max	2000 max	947
Alkalinity (mg/L)	200 max	600 max	158

Above shown tabulation Table 1 is the sample data collected in Pondicherry region though the design IoT – WQ Kit which is placed in Kurinji Nagar Over Head Tank. All the real time data collected is saved in Cloud service for further data processing and prediction.

V. CONLCUSION

In summary, the IoT-based water quality kit presented in this study represents a significant step towards safeguarding water resources in Puducherry particularly in Kurinji Nagar. In kurinji nagar Over Head Tank Distribution system, pH value is 6.51, EC is 1528, TDS is 947 and alkalinity is 158. By providing real-time data and facilitating proactive measures, this system not only addresses the immediate challenges but also contributes to the sustainable development and growth of the region, ultimately benefiting both residents and tourists alike.

REFERENCES

[1] Jos´eP´erez-Padillo, Francisco Puig, Jorge GarcíaMorillo PilarMontesinos, “IoT platform for failure management in water transmission systems,” Expert Systems With Applications, vol. 199, pp. 31-38, 2022.

[2] Ahmed Abdel Nasser, Magdi Z. Rashad, and Sherif E. Hussein, “A Two-Layer Water Demand Prediction System In Urban Areas Based On Micro-Services And Lstm Neural Networks,” IEEE Access, vol. 8, pp. 147647-147661, 2020, doi: 10.1109/ACCESS.2020.3015655.

[3] Shereen Ismail, Diana W. Dawoud, Nadhem Ismail, Ronald Marsh1, And Ali S. Alshami, “Iot-Based Water Management Systems: Survey And Future Research Direction,” IEEE, vol. 10, pp.8-19, 2022

[4] Akashdeep Bhardwaj, Mohammed Alshehri, Ismail Keshta, AhedAbugabah, “Smart water management framework for irrigation in agriculture,” Journal on Environmental Technology, vol.12, pp. 364-370, 2020.

[5] Ahmad Ali, “IoT-based automated water pollution treatment using machine learning classifiers,” Journal on Environmental Technology, vol. 8, pp. 98-103, 2022.

[6] Ganesh Gautam, BipinThapa Magar, Bhanu Shrestha, Seongsoo Cho and ChanghoSeo, “Usage of IoT Framework in Water Supply Management for Smart City in Nepal,” Journal on Applied Sciences, vol. 11, Issue 12, pp. 192-198, 2021.

[7] Matthew Lowe, Ruwen Qin, “A Review on Machine Learning, Artificial Intelligence, and Smart Technology in Water Treatment and Monitoring,” Journal on Water, vol. 14, Issue 9, pp. 964-970, 2022.

[8] G. Manikannan, P. Prabakaran, M. Selvaganapathy, “IoT enabled Smart Switch With user-friendly Electrical Interfacing,” in Proc. of ICSTSN 2022, vol. 12, pp. 87-93, 2022.

[9] Abílio C. Da Silva, María De Los Ángeles Quezada, Aloísio V. Lira Neto, Mohammad Mehedi Hassan, and Victor Hugo C. De Albuquerque, “Internet of Water Things: A Remote Raw Water Monitoring And Control System,” IEEE Access, vol. 9, pp. 35790-35800, 2021, doi: 10.1109/ACCESS.2021.3062094.IEEE, vol 40, pp. 24-30, 2020.

[10] Ali Omran, Aitazaz Ahsan, Khaled Mohamed Khedher and Zaher Mundher Yaseen, “Proposition Of New Ensemble Data-Intelligence Models For Surface Water Quality Prediction”, IEEE Access, vol. 9, pp. 108527-108541, 2021, doi: 10.1109/ACCESS.2021.3100490.

[11] Manmeet Singh, SuhaibAhmed, “IoT based smart water management systems: A systematic review,” Materials Today – Elseiver, vol. 65, pp. 51-59, 2020.

[12] Hongxun Hui, Yi Ding, Qingxin Shi, Fangxing Li, Yonghua Song, JinyueYan, “5G network-based Internet of Things for demand response in smart grid: A survey on application potential,” Applied Energy, Elseiver, vol. 257, 113972, 2020.

[13] G. Manikannan ; K. Mahendran, “Low Power High Speed Full Adder Cell with XOR/XNOR Logic Gates in 90nm Technology,” in Proc. of ICTACC, vol 162, Issue. 8, pp. 56-62, 2017.

[14] Anna Brdulak, “Characteristics of Narrowband IoT (NB-IoT) technology that supports smart city management, based on the chosen use cases from the environment area,” Journal of Decision systems, vol.8, pp. 76-84, 2020.

[15] G. Manikannan,T. Vijayalakshmi, P. Prabakaran, “Mobile - Air Pollution Monitoring System using Internet of Things,” International Journal of Scientific Development and Research (IJSDR),| vol 4, Issue 11, 2019

[16] Ke Wang, Yafei Zhao, Rajan Kumar Gangadhari and Zhixing Li, “Analyzing the Adoption Challenges of the Internet of Things and Artificial Intelligence (AI) for Smart Cities in China,” Journal of Sustainability, vol. 13, Issue 19, pp. 546-563, 2021.