

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

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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.

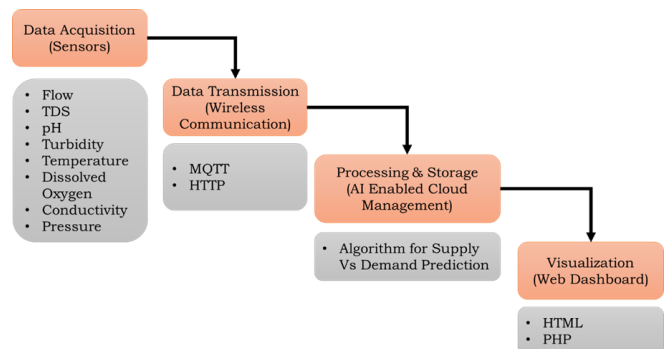


Fig. 1. Design Research Modules

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

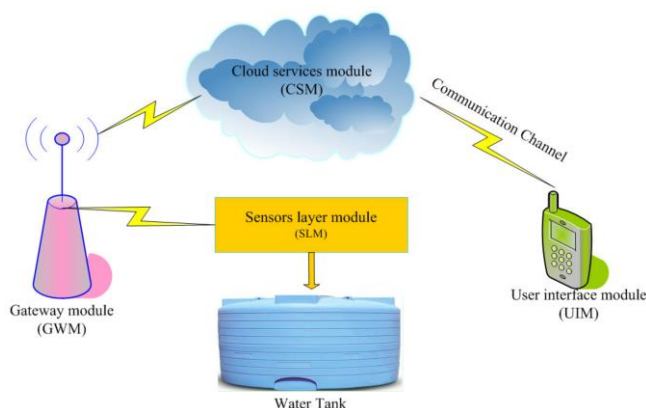


Fig. 5. Basic Modules in IoT

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.

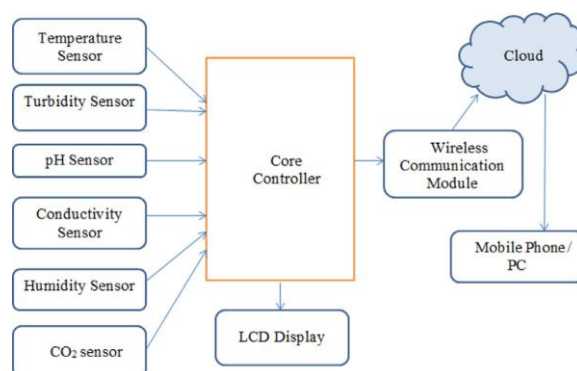


Fig. 6. Block Diagram

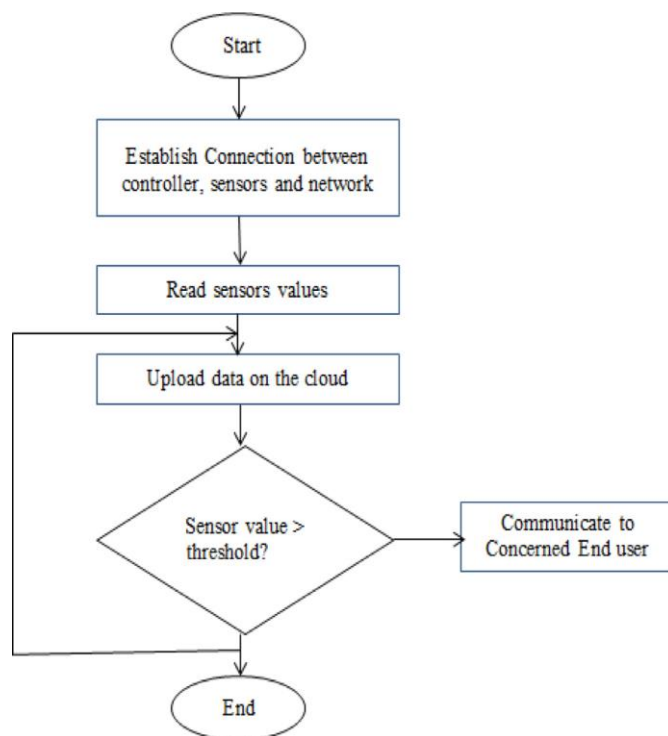


Fig. 7. Block Diagram

TABLE 1. REAL TIME MONITORED WATER QUALITY DATA

Kurinj 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. CONCLUSION

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.

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