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Abstract - *Water quality-based billing systems have attracted a lot of attention among the novel technologies that have emerged in response to the growing demand for effective management of water resources. The study explores the incorporation of sensor networks and Internet of Things (IoT) devices in water quality monitoring, clarifying their function in gathering the data. In addition, the study includes the challenges and possibilities related to the implementation of water quality-driven billing system, taking into factors like accuracy, reliability, and flexibility. In this paper a detailed review of latest works that were implemented in the arena of Water quality-based billing system is presented. The paper briefs about the different sensors used, use of recent technologies, its working and future work.*

Key Words: Arduino UNO, Internet of Things (IoT), pH Sensor, Quality, TDS Sensor, Temperature Sensor.

1.INTRODUCTION

An innovative and an alternative for the current water billing system is offered by the "Water Quality-Based Billing System" project. Water is an essential resource, and the quality of it matters just as much as the amount. Water quantity has been the primary focus of traditional billing systems, which have ignored the significant changes in water quality. Through the use of modern sensor technology, this project is able to monitor factors related to water quality, providing a more precise indication of the value of the water supplied. Water is not a homogeneous resource, its quality can differ significantly, affecting its value for a range of uses, including industrial, agricultural, and drinking. Due to the inability of traditional water billing methods to account for these changes in quality, customers have frequently been left with an unfair cost distribution. Customers are frequently charged only for the amount of water they use, regardless of the chemical composition, purity, or presence of contaminants in the water.

By employing water quality monitoring technology, the Water Quality Based Billing System aims to address this imbalance. In order to gather information on different aspects of water quality, this project incorporates a network of sensors that are linked to a microcontroller. After that, the data is sent to a central server for processing and analysis. Billing invoices that take into account both the amount of water used and the quality of the water are given to customers. This system promotes equity and equality for all by factoring in water quality when determining charges.

As the review progresses, it will also highlight the real-world case studies that have successfully adopted water quality-based monitoring systems. These will provide valuable insights into the practical obstacles encountered during implementation.

The objectives of Water Quality-Based Billing System are:

i. To develop a system that seamlessly integrates water quality assessment with the traditional water billing process, allowing for a more accurate representation of the value of water supplied.

ii. To ensure that consumers are billed fairly based on both the volume and quality of water they receive, reducing disparities in water billing and promoting fairness.

iii. To reduce the strain on water resources and infrastructure by promoting water conservation, ultimately contributing to environmental sustainability and cost savings.

iv. To make informed decisions about billing, resource distribution, and water quality control by utilizing data analytics.

2.WATER QUALITY BASED BILLING SYSTEM

In general, Water Quality-Based Billing System consists of various sensors such as TDS sensor, pH sensor, temperature sensors and many other sensors. All sensors are connected to a controller and this controller controls the operation, gets data from sensors and compares it with that of the standard values and sends the values to the concerned end user or authorities through wireless modules. With the advances in IoT technology, the water quality-based billing system is becoming more smarter with reduced power consumption and ease of operation. The project points out to significantly provide the water bill according to the quality of water received by the customers.

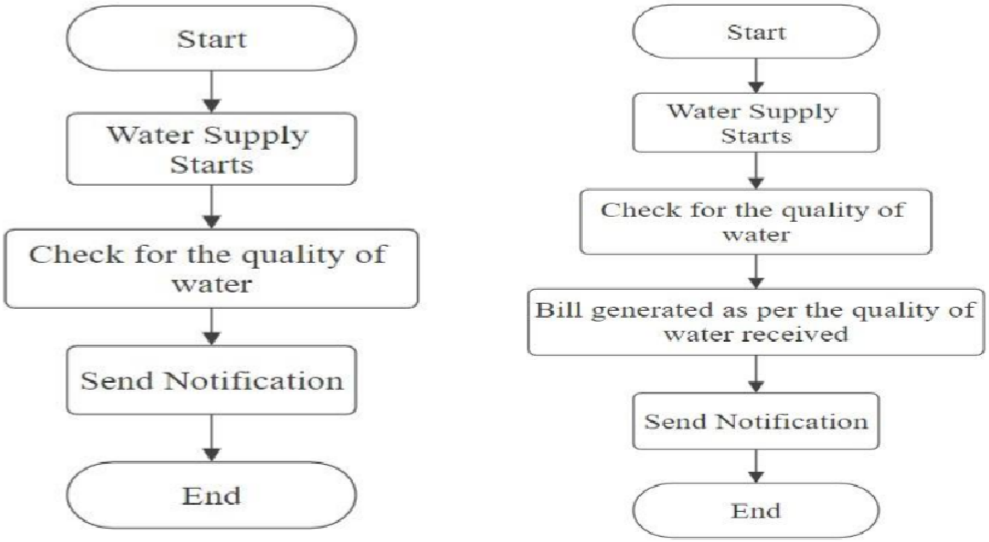

FiG -1: Comparison of the reviewed methodology and proposed methodology

3.LITERATURE REVIEW

Sabari M et.al [1] proposed a monitoring system which monitors the quality of water with the help of several sensors and a controller. It highlights how crucial it is to preserve high water quality for both ecological balance and human health. A microcontroller, a Wi-Fi module, and a number of sensors that detect things like pH, turbidity, and conductivity make up the system. The sensors are configured with the microcontroller unit and additional processing is executed by the computer. The acquired data will be directed to the cloud by means of Wi-Fi module for monitoring the quality of the water under test. The suggested system is extensible for usage in other industries like pollution control and agriculture and attempts to provide continuous monitoring of water quality indicators.

Rajan Sarraf et.al [2] developed an IoT based Smart Quality Water Monitoring System which highlights the need for efficient water distribution and monitoring due to water scarcity. The traditional manual meter reading method is deemed inconvenient and inefficient, necessitating real-time monitoring techniques to enable sustainable water resource management. The proposed system involves a smart water monitoring system using IoT technology to make users aware of their water consumption, reduce usage, and detect abnormal water usage to prevent water loss. The system utilizes sensors, a Raspberry Pi controller, and cloud storage to monitor water flow, quality, leakage, and billing. The data is accessible via an Android application on smartphones. The proposed system is compared to existing methods and found to be efficient in terms of cost, accuracy, and manpower.

Manish Gavande et.al [3] proposed an Automatic Water Reading and Billing System by GSM Module where the proposed system includes an Arduino Mega 2560 as a controller, load cells for measuring water weight, a solenoid valve for water control, and a GSM module for automatic billing and communication with the user. The system works by using the Arduino Mega to control all operations, displaying them on an LCD. Load cells measure the water weight in the tank, and a solenoid valve controls the water flow to the user. The GSM module is used to send automatic billing information to the user. The future scope of the system includes the development of an Android app for comprehensive billing information and quality monitoring using TDS sensors. Additionally, the system will process penalties for late payments and generate custom invoices. It will focus on improving the present billing and collection process, ensuring security and access control, and checking the quality of water using TDS sensor.

Dr. Nageswara Rao Moparthi et.al [4] proposed a Water Quality Monitoring System Using IoT where the methodology involves the use of specific sensors such as pH sensor, temperature sensor and the data collected from various units will be then assembled and sent to an Arduino. The required result will be sent to the user with the help of a GSM module. The system aims to enhance water quality, reduce maintenance, prevent waterborne diseases, and provide real-time data on a website. The unit testing process involves testing individual units of code to ensure their functionality. The system's future work includes extending monitoring to include parameters such as temperature, turbidity, and dissolved oxygen levels. The system also has the flexibility to swap sensors and change relevant programs.

Thamarai Selvi D and Anitha S.R [5] developed a system called Portable Water Quality Monitoring and Automatic Billing System where the proposed methodology consists of some sensors to monitor water quality parameters such as pH, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), colour of water, and Dissolved Oxygen (DO). The customer's water usage is measured using a flow sensor and the desired values are displayed on an LCD. If the values exceed the threshold, an alarm is triggered. The monthly water usage is sent to the municipal corporation office via GSM Modem, and the billing amount is calculated based on the water consumed. If the bill is paid on or before the due date, the water supply remains connected otherwise, it is disconnected. This system has some of the advantages such as, potential cost reduction and power consumption benefits of the proposed system, achieved through programming it to be in active mode only once a month for the billing cycle.

Qiuchan BAI and Jiahao Wu et. al [6] developed a system in which the development of a water quality monitoring system based on wireless sensor network technology. The hardware structure of the system comprises five major modules: information acquisition, coordinator, host computer, GSM, and mobile terminal. The information acquisition module includes sensors and microcontrollers for data collection, while the coordinator module utilizes ZigBee technology for data transmission. The host computer module facilitates data processing and analysis with the GSM module enabling data transfer to mobile devices. The software structure involves the development of the ZigBee sensor network and the host monitoring system software. It focuses on the system's capability to enable real-time monitoring and document highlights the successful development of a Water Quality Online Monitoring System based on a Wireless Sensor Network.

Rizqi Putri Nourma Budiarti et.al [7] developed an Internet of Things (IoT) system for automated water quality monitoring. The system involves the use of sensors, a Raspberry Pi as an embedded system, and remote communication technology to facilitate data transmission between devices. The results of the research demonstrate successful data collection from both active and passive sensors. The data is transmitted to a database server using MQTT protocol. Web-based user interfaces are developed to monitor sensor data in real-time. The system also includes a watermond application that manages the transmission of sensor data, storing it locally if the connection is offline and transmitting it to the database server when the connection is restored.

Raji C.G et.al [8] proposed a system using various sensors such as pH, conductivity, temperature, and turbidity, connected to an Arduino Uno board. The values obtained from the sensors were then transmitted to an Android application through a Wi-Fi module. A cloud platform, ThingSpeak, was used to receive and display the sensor data in graphical format. The system aims to provide real-time monitoring of water quality, making it more accessible and understandable for users. Overall, the study provides a comprehensive and detailed overview of the implementation and results of an IoT-based water quality monitoring system, highlighting its potential benefits for public health and environmental monitoring.

S.Jayalakshmi et.al [9] proposed a document the primary objective is to identify the quality of water using sensors such as TDS meter, DC motor, LM35 temperature sensor, and GSM. The collected data is stored in a centralized database, and if the water quality falls below accepted levels, an alert message is sent to landowners via GSM. The data collected by the sensors are processed by the microcontroller and sent to GSM using the network. It also suggests the inclusion of additional parameters for measuring water purity in future developments. In summary, they discuss the importance of monitoring water quality, presents a proposed system for real-time.

Chenwei Feng et.al [10] proposed a water quality monitoring system which consists of various sensors, Arduino, and Bluetooth technology. It discusses the application of these technologies for monitoring and maintaining water quality. This system explains the use of sensors and Arduino devices for real-time water quality monitoring, with a possible focus on Bluetooth connectivity for data transmission and analysis. The various parameters such as pH, turbidity, conductivity and temperature of water was calculated by the sensors and the data gathered by the sensors are processed by the micro-controller unit such as Arduino. The processed data was sent to the end user's smart phone with the help of the Bluetooth module.

S Pallavi et.al [11] proposed the assessment of drinking water quality and hazard events in the water supply system of Mysuru city, Karnataka, India. The study conducted comprehensive evaluation of water quality parameters and hazard events impacting water quality. Physico-chemical and bacteriological analyses were performed on water samples collected during pre-monsoon, monsoon, and post-monsoon seasons. The important water quality parameters considered in the study include temperature, pH, total dissolved solids (TDS), conductivity, alkalinity, total hardness, calcium, magnesium, chloride, sulphate, nitrate, nitrite, and trace elements such as aluminium, arsenic, lead, cobalt, mercury, and cadmium. These parameters were analysed in water samples collected from various regions of Mysuru city during different seasons to assess their impact on water quality.

S Srikantaswamy et.al [12] proposed the study assessed the seasonal variation of drinking water quality in Mysore, Karnataka, India. The research focused on physico-chemical and bacteriological assessment of drinking water samples from different areas of Mysore. The findings revealed high concentrations of fluoride, iron, copper, magnesium, and nitrate in the water, exceeding permissible limits. Total Dissolved Solids (TDS) and Alkalinity were also high in all seasons.

Bacteriological studies indicated that the water samples were unsafe in all seasons, with widespread variation in the quality of drinking water supply across different areas of Mysore city. The study concluded that the quality of drinking water supply varied from moderate to extensive contamination.

Manish kumar Jha et.al [13] proposed a Smart Water Monitoring System (SWMS) designed for real-time water quality and usage monitoring. The system consists of two main components: a Smart Water Quantity Meter and a Smart Water Quality Meter. The quantity meter aims to conserve water by monitoring consumption, implementing a three-slab billing system, and notifying consumers and authorities about their water usage. The quality meter checks five qualitative parameters of water to ensure purity and prevent health hazards due to contamination. An online monitoring system provides real-time data on the cloud and alerts users and authorities of any violations in usage or water quality via SMS and alerts. The hardware implementation involves Raspberry Pi as the microprocessor, interfaced with sensors for water quality and flow measurement. The system's software includes a web portal for remote monitoring of water quality and consumption. The portal displays real-time data and graphical representations of water quality parameters and consumption readings.

Lim Yong Li et.al [14] proposed the development of a wireless water quality monitoring system (WQMS) using Wi-Fi technology is proposed to address the limitations of current systems, including high cost, limited coverage, and unsuitability for agriculture. The system integrates microcontroller, sensors (temperature, pH, Total Dissolved Solids), and a Wi-Fi shield for data transmission to an Internet of Things (IoT) platform. WQMS involves hardware and software development. The hardware includes the selection of suitable components such as Arduino Uno as the microcontroller, specific sensors for water quality parameters, and a Wi-Fi shield for data transmission. The software development utilizes Arduino IDE for programming and the ThingSpeak IoT platform for data aggregation and visualization.

R.B. Dhumale et.al [15] proposed the methodology of The Automatic Water Billing (AWB) system where it is a methodology that involves implementing an Android-based water billing system. This system measures water flow rate through household pipes and sends SMS notifications at the end of every month. The system is comprised of two modules. The main tank module and the user module. The main tank module includes a level sensor, flow sensor, valve, main water tank, and reserve tank. Additionally, the user module includes similar components mounted on the supply pipe for each user. The system utilizes a cloud platform called Thing Speak for a graphical representation of water usage and provides payment options through a mobile app. The AWB system is designed to automate water level control, pump control, and valve control to avoid water wastage. The system includes a Water Billing Management Application (WBM-App) for real-time billing and payment.

Vaishnavi V Daigavane and Dr. M A Gaikwad [16] proposed the system which is a low-cost water quality monitoring system based on IoT technology. It consists of sensors to measure physical and chemical parameters such as pH, turbidity, temperature, and flow of water. The core controller, Arduino, processes the sensor data, and the information is accessible over the internet using a Wi-Fi system. The system's working involves the sensors measuring water parameters, the Arduino processing the data, and the Wi-Fi module transmitting the information to a web server. The results and discussion indicate that the system can monitor water quality automatically, it is low in cost, and does not require constant human monitoring. Additionally, it also highlights the system's advantages, including cost-effectiveness, flexibility and discusses potential future extensions such as incorporating more parameters for secure monitoring.

Table -1: Comparison of reviewed methodologies

Sl no.	Title	Methodology	Limitations
1	Water Quality Monitoring System Based on IoT	IoT based	Need for a stable Wi-Fi connection
2	IoT Based Smart Quality Water Management System	IoT based	Maintenance
3	Automatic Water Reading and Billing System by GSM Module	GSM based	Power Consumption
4	Water Quality Monitoring System Using IoT	IoT based	Expensive
5	Potable Water Quality Monitoring and Automatic Billing System	GSM based	Expensive
6	The Water Quality Online Monitoring System Based on Wireless Sensor Network	WSN technology	Energy consumption
7	Development of IoT for Automated Water Quality Monitoring System	IoT based	Expensive
8	IOT Based Water	IoT based	Expensive

	Quality Monitoring with Android Application		
9	Measuring the Water Quality in Bore well Using Sensors and Alerting System	Sensor based	Latency
10	Design of Water Quality Monitoring System	Bluetooth technology	Sensitivity
11	Assessment of Drinking Water Quality and Hazard Events in Water Supply System in Mysuru city, Karnataka, India	Analysis	Contamination
12	Assessment of seasonal variation of drinking water quality in Mysore, India	Assessment	Contamination
13	Smart Water Monitoring System for Real-time water quality and usage monitoring	Design based	Expensive
14	Preliminary Study of Water Quality Monitoring System	WSN technology	Need for a stable Wi-Fi connection
15	Automatic Water Billing System based on Android Application	Android based	Power consumption
16	Water Quality Monitoring System Based on IOT	IoT based	Need for a stable Wi-Fi connection

4.CONCLUSION

Water Quality-Based Billing System presents an innovative approach for managing water resources and promoting sustainable practices. Through a comprehensive review of the current literature and the analysis of various case studies and implementations, it is evident that integrating water quality parameters into the billing system can lead to more accurate and equitable billing practices. This promotes the maintenance and enhancement of water quality in addition to encouraging responsible water consumption. The reliable sensor technology, accurate collection techniques, and advanced analytics are essential for the success of such a system. For water quality-based billing systems to be widely used, it is vital that issues with data accuracy, system scalability, and public acceptance be resolved.

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