Aqua Smartify: Smart Water Monitoring in Smart Cities with Leakage Detection and Automatic Billing

Mrs. Anjana H S[1], Rakshitha B[2], Rakshitha G[3], Sanjana Mugdur[4], Sneha G[5]

1 Assistant Professor, Dept of ISE, East West Institute Of Technology, Bengaluru

2,3,4,5 Student, Dept of ISE, East West Institute Of Technology, Bengaluru

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Abstract: Innovative management solutions for water-scarcity and wastage are urgent global concerns. The present study develops a Smart Water Metering System using IoT, Arduino Microcontrollers, and renewable energy to manage and use water efficiently. The system monitors water quality and flow in real time using flow sensors, pH meters, and turbidity sensors.

A model of tariff-based billing that uses the lowest rates for basic consumption and higher rates for excessive use draws customers towards the efficient use of water. The system also includes a cutting-edge leakage detection tool with a holiday mode that suspends the water supply for a limited period. Integration of the solar panel makes it energy sustainable, thus reducing dependence on conventional power. Real-time notifications and updates to users are done via Telegram, which improves user awareness and participation in the conservancy efforts.

Testing data indicated that the system could reduce water wastage up to 30% with an assurance of more than 95% accuracy in monitoring. Although costs associated with installation and dependence on the internet have been hurdles, the long-term benefits outweigh them, making this a practical answer for cities and rural areas alike. Future enhancements could include the incorporation of AI for predictive analytics and blockchain-powered billing that enables high-security transactions.

Keywords: IoT, Smart Water Metering, Water Quality Monitoring, Arduino, Solar Energy, Tariff-Based Billing.

1.INTRODUCTION

Water scarcity and wastage have become a global peril that is affecting billions of people's livelihoods worldwide out of 71% of the earth's surface which is covered with water only 0.08 is available in the form of fresh water for human purposes. The demand thus arising through urbanization and industrialization, as well as the increasing density of populations, is putting even greater stress on the resource. It is estimated that in the next decade, around 25% of the world population will be suffering from chronic water shortages, thus making it all the more pressing for effective management of water resources.
Most traditional water management systems are old and inefficient, dependent on manual readings and flat rate billing instead of real-time water usage, leakage detection, or flexibility in billing-all of which lead to wastages and revenue losses. Moreover, immediate monitoring of water quality has an adverse effect on human health.

The futuristic Smart Water Metering System aims to change the whole dimension of water resource management. The system is designed keeping in mind IoT (Internet of Things) and renewable energy, where different sensors attached with an Arduino microcontroller have made such an efficient automatic solution for water metering and management. In addition to conserving water through tariff-based billing and user involvement, this novel system provides real-time monitoring, leakage detection, and quality assurance to some of the other features.

Using solar power, the system sustainably serves the environment. The system is capable of giving

updates at real-time intervals through a notification system based on Telegram, thus paving the possibility of transparency and awareness to the individuals and organizations for the effective management of their water consumption and the implementation of hardware, as well as environment friendly.

2. LITERATURE REVIEW

IoT in Water Management cloud platform technologies, are witnessed by researchers like Gaurav et al. (2018) for monitoring water with efficiency in management through real-time data collection from mobile applications and sensor networks.

Water Quality Monitoring:

As for Pragati et al. (2019), both ultrasonic and pH sensors were used in monitoring water quality, furthermore emphasizing the need for integrating such sensors into an IoT framework to ensure the exactness of any quality assessment done.

Leak Detection System:

A similar system was presented by Michel R. Machado et al. in the year 2020 which used microcontrollers in monitoring and triggering water pipeline leakages to the authorities. Their work thus gives hope in wasting little water and even put aside the chances of contaminations.

Automated Billing Mechanisms:

An IoT-enabled Water Metering proposed by Ashok Kumar Sharma et al. (2021) in which flow sensors keep pretty measuring data based on usage. This eradicated the possible manual errors and improved the payment process.

Sustainable Energy Integration:

Carlos Kamienski among others(2022) conducted a study in which solar-powered IOT integrated with the water distribution network forms part of a study focused on efficiently cost saving and sustainability.

Vacation Mode and Quota Management:

Bhavya P. et al. (2020): This defined a quota-based water allocation system that included holiday modes to prevent wastage during periods without use. Their work emphasized the significance of functionalities focused on the user.

Sensor-Based Detection and Control:

Flow sensors and machine learning algorithms were used by Alexandru Predescu et al. (2019) to detect theft and leakage in water with high efficiency. The system showed very good real-world accuracy.

Telegram: For Immediate Notifications.

3. METHODOLOGY

The current framework called Smart Water Metering System integrates with its new proposed development, all existing concepts of IoT, renewable energy, and even advance in sensor use as enhancement means for water management. Thus, the entire methodology has divided into essential components:

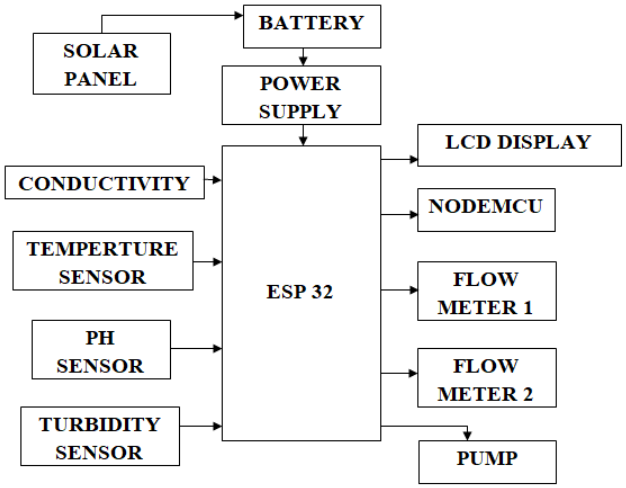


Fig.1. System Architecture.

System Architecture

This architecture is powered by the Arduino UNO Microcontroller that collects data from several sensors.

Among these sensors is the following:

Flow Sensors: Measure the real-time water consumption.

pH and Turbidity Sensors: Identify the water quality.

Solar Panels ensure renewable and self-energy with a battery backup for the uninterrupted operation of the system.

Water Monitoring and Billing:

Real-time water measurement using flow sensors.

The recorded data is then subjected to analysis, which enables the system to implement tariff-based billing-low rates for minimal usage and higher for excessive consumption.

Leakage Detection:

The system accumulates total flow at the source and compares it with distribution points to identify leakages. Alerts are then transmitted to users for immediate action.
Water Quality Assessment:
Continuous monitoring of water quality using pH and turbidity sensors.
In case the water quality parameters go beyond acceptable limits, the water supply can be stopped automatically by the system.
Automated Control and Notification:
Solenoid valves manage water supply based on usage, as well as by leakage detection.
Users are informed about their water consumption, their billings, and any issues that may arise through notifications sent using the Telegram API.
Sustainability and Energy Efficiency
Clean energy by solar panels for an eco-friendly operation.
Then, for added reliability, the stored energy was used during low sunlight periods.
Renewable Energy Integration:
This system is green, powered by renewable energy:
Solar Panels:
Gives the main power source for the system.
Give charge to the backup battery but only at peak sunlight times.
Battery management:
Provides power to run the unit through low sunlight periods or power interruption.
User Notification and Interaction:
The system is delivering IoT to keep users updated and connected to Node MCU.
Telegram API:
Enables real-time updates on water use, billing, leaks, and quality-related alerts.
User-Friendly Interface:
Would enable users to view consumption inwardly and enlighten themselves before deciding on wastage reduction.
Data Logging and Analysis:
All usage and quality data will then be uploaded to the Node MCU for future analysis.
Usage Patterns:
Determines peak consumption periods for resource optimization.
Sustainability:
Source of energy is solar to decrease dependency on fossil fuel.
Flow of Operations
Startup: Initialize sensors, valves, and connectivity once. The Arduino system will initialize everything when it is powered on.
Monitoring: Real-time data collected on water flow, quality and usage pattern Capture data.
Analysis and Alerts: Detect anomalies, calculate tariffs, and generate alerts.

4.HARDWARE SETUP

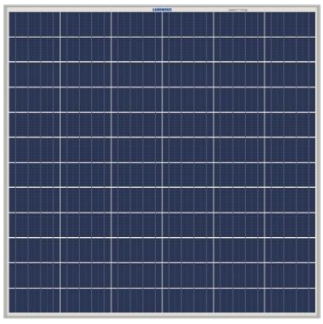
Fig.1.ESP 32 board

Fig.2. Level Sensor

Fig.3. Flow Meter

Fig.4. Turbidity sensor

Fig.5. LCD Display



. **Fig.6** Solar Pannel

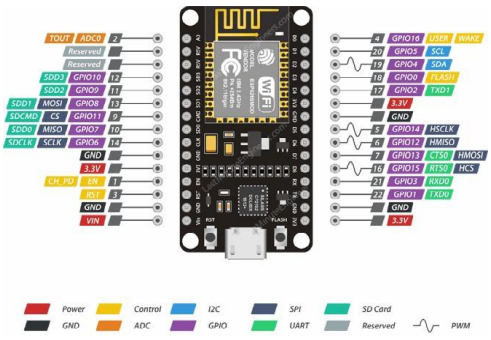


Fig.7.: Node MCU

5. RESULT

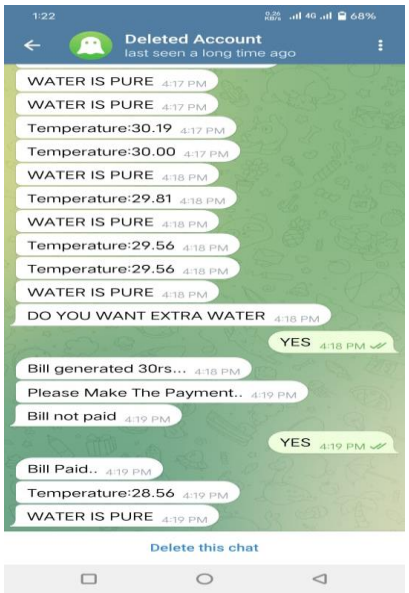


Fig.8.: Telegram Notification System.

6. CONCLUSION

The **Automated Water Billing System** successfully combines IoT and renewable energy to tackle challenges in water management. Its ability to detect leaks, ensure water quality, and promote conservation through transparent billing sets it apart from traditional systems. While initial installation requires investment, the long-term benefits outweigh the costs, making it a suitable solution for sustainable water management in residential, commercial, and municipal sectors.

7. REFERENCES

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