**Smart water overflow monitoring and autonomous control with individualised water tax**

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**Abstract**

**Water, along with air, is one of the most basic resources. Fresh water accounts for approximately 3% of all water on the planet. As a result, there is an urgent need to manage existing water resources and reduce waste and loss. We propose a method for detecting water waste in apartment complexes and homes caused by leaky taps or someone inadvertently leaving a tap open for an extended period. In addition, we propose a system for remotely cutting off the water supply to an individual apartment in the event of water waste under extreme conditions. We will use a microcontroller to collect data about the flow of water from a water flow sensor, transmit the data using a long-range wireless communication protocol, and activate a solenoid valve to turn off the flow of water to the individual flat. The water flow meter is based on a hall effect sensor and provides the best balance of accuracy, parasitic drag losses, and price.**

**Keywords: *ESP8266, Solenoid Valve, Waterflow Sensor, IOT, IOT Cloud.***

1. **Introduction**

Measuring water consumption is critical for understanding how and where water waste occurs. Many times, people leave their taps open or fail to completely close them, resulting in a lot of waste. In some cases, open or leaky taps can remain in the same state for extended periods of time ranging from a few hours to several days. This waste has reached absurd proportions, and the resulting shortages can cost some regions up to 6% of their GDP. As a result, it is critical to control water waste. Manually checking each apartment is impractical and violates the occupants' privacy.

A consumer's water consumption is currently being monitored using outdated analog water meter readers. which are also not tailored to each apartment in the housing society and the water tax is not calculated on a house/flat basis. The department hires people to go door-to-door and read water meters to bill customers. This strategy could lead to irregular water meter checking and ineffective systems to notify the department of any differences in real-time water meter readings. Consistencies cause billing mistakes, which can cause the department to lose money or have the consumer pay an exorbitant bill because of the mistakes.

We suggest developing a smart water overflow detection and metering (SWODM) system that can identify and notify the customer and the department of any potential leaks in the customer's property.

We propose the development of a smart water monitoring device capable of detecting and alerting the customer and the local government body of the amount of water used by any specific flat which can be used for calculating water tax. The entire procedure is automated, with human interaction required only to restart the water supply after the system has been switched off due to overflow detection. The main feature of the system is the ability to customize the time limit within which users are warned of a water leak, turn off the supply of water to the entire flat with a single click, and limit the flow of water to particular litters after which the supply is immediately shut off. It is particularly cost effective because the system uses very little hardware while still functioning as an excellent replacement to the currently available manual solutions.

1. **Literature Survey**

The purpose of the literature review is to investigate the most recent technologies that aim to solve the problem of water leakage.

In February 2022, Shatabdi Basu, Afaq Ahmed, Hitarth Pareek, and Pradeep Kumar Sharma published a paper. This paper presents an autonomous system for reducing water waste through real-time water flow control and monitoring. The prototype's design employs infrared sensors to automatically stop water discharge from overflowing faucets and taps. The system monitors water usage with a water flow sensor. This real-time water consumption data in a given area can be saved in a cloud server for analysis. [1]

In February 2022, Gaurav Gosavi, Gajanan Gawde, and Gautam Gosavi published a paper. In this paper, an autonomous system for monitoring water consumption via the Internet is presented using Raspberry Pi and Arduino. The flow rate of water is measured using a Hall Effect sensor-based flow meter. The data is received by the Raspberry Pi, a microcomputer, from the Arduino microcontroller, which is connected to the flow meter. They save data on water consumption by users.[2]

In September 2016, Sahil Adsul, Ashok Kumar Sharma, and R. G. Mevekari published a paper. In this paper, they propose solutions for industrial leakage in thermal power plants, boilers, water distribution systems, and so on. Various parameters such as temperature, humidity, sound detection, pressure, and gas detection were taken into account when developing the system. Zigbee is used to transmit data across systems and to create a personal area network. [3].

A paper was published in April 2018 by DeviceBheki Sithole, and others. The system architecture of a low-cost smart water metre that can also identify leaks on the customer's property and provide real-time use reporting is described in this study. The amount of water a consumer uses is measured using flow metre sensors. For taxation based on water flow rate, a thorough mathematical method is given. [4]

A paper was published in 2020 by Manoharan, H., Basha, A.R., Teekaraman, Y., and Manoharan, A. The authors have outlined the need for autonomous water management in the agricultural sector in this paper. They detail the amount of water and energy wasted by traditional methods. They also developed a method for establishing a wireless sensor network to aid in the automation of an agricultural province.[5]

Prachet Verma, Akshay Kumar, and their colleagues published a paper in 2020. The authors discuss the planning and early findings of an IoT-based system for controlling the water distribution system on a large campus in this paper. They talk about how to get a long sensing distance so that their system can be installed across overhead tanks and reservoirs below ground level. The wireless network connects to a gateway, which uses sub-GHz radios to send data online for visualization and analytics.[6]

Manish Kumar Jha, Rajni Kumari Sah, and colleagues published a paper in January 2019. The authors designed a system in which a Smart Water Quantity Meter was used to ensure water conservation by monitoring the amount of water consumed by a household and notifying the consumer and the authority. The Smart Water Quality Meter checks the purity of the portable water that the consumer receives by measuring pH, temperature, turbidity, dissolved oxygen, and conductivity.[7]

In October 2015, S.A.M. Matiur Rahman and his coworkers released a paper. In order to conserve water without the actual presence of a user, this paper outlines the design and development process of an autonomous tap water control system. This sensing system makes use of a solenoid valve, an electromagnetic relay (a sort of electrical switch), a floatless level controller (61F), and electrodes (used to sense the watery level electrically). The created system may automatically regulate the water tap when the level sensor notices a decreased level in the water tank. [8].

In October 2018, Xianqun Jiang; Mingmin Chen and others published a paper. The paper provides a detailed description of the system architecture as well as the intelligent controller implementation. There are two modules in the system: the remote-control module and the main control module. A ZigBee module and a user interface comprise the remote-control module, while a microcontroller, a ZigBee module, and a solenoid valve driver circuit comprise the main control module. The results show that the system can control the solenoid valve remotely via ZigBee wireless communication. Because of its quick response time and high accuracy, the system is suitable for a wide range of industrial applications. The system's power consumption is also low, making it an energy-efficient solution. [9]

In October 2017 Chanda Rajurkar; S R S Prabaharan; and others published a paper. The system that is suggested in the study is made up of a few sensors, including pH sensors, temperature sensors, level sensors, and water flow sensors, all of which are placed throughout the water distribution network at various points. These sensors gather real-time information about the water's flow, quality, temperature, and level. This information is sent to a cloud server and may then be shared with the home's owner or any relevant government agency. [10]

Table 1 Learning’s of the literature review

|  |  |  |
| --- | --- | --- |
| **S. No** | **Author** | **Learning’s** |
| 1 | Basu S, Ahmed A, Pareek H, Sharma PK[1] | Infrared sensor usage for stopping water leakage |
| 2 | Gosavi G, Gawde[2] | Water consumption details using Hall effect sensor |
| 3 | Adsul S, Sharma AK, Mevekari RG[3] | Parameters used for water leakage, Usage of ZigBee |
| 4 | Sithole B, Rimer S, Ouahada K, Mikeka C[4] | Usage of flow meter |
| 5 | Verma P, Kumar A[6] | Connection with wireless network |
| 6 | Jha MK, Sah RK[7] | Monitoring household water consumption |
| 7 | Mamun AA, Ahamed NU, Ahmed N, Ali S[8] | Usage of solenoid valve and relay |
| 8 | Rahman SAMM, Mamun AA, Ahamed NU[8] | Usage of solenoid valve and relay |
| 9 | Jiang X, Chen M, Chen W | Remotely control Solenoid Valve |
| 10 | Rajurkar C, Prabaharan SRS, Muthulakshmi S | Use of cloud for storing real time data from the sensors |

1. **Objectives of the system**

Water business losses are primarily caused by running taps, leaking faucets, pipe leaks, and invoicing problems. Three sub-objectives were chosen to help solve the issue.

The first goal was to create a system that could automatically and continuously inform the customer about the water consumption levels at the dwellings they specified as well as identify any potential water leaks in their property.

The second goal is to create a system that communicates data about a customer's water usage levels to the neighbourhood water utility for billing purposes and to help with real-time evaluation of the region's water use.

The third objective is to generate an application that will notify the owner if there is a leak or overflow of water in his property. The application will also allow the owner to turn off the water flow. As a result, physical operation is no longer required.

The common purpose of these three sub-objectives is to lessen water losses, which increase water consumption and losses.

* 1. **Functional requirements**

1. **Connectivity:** The connectivity to the components is a key component of any IoT system. The user should have no trouble connecting to all the components from any location or from a specific room. As long as the user is linked to mobile data or Wi-Fi, our solution allows him to access the solenoid valve from anywhere.
2. **Business Applications:** Everyone can utilize this device in their home to prevent water waste. The tap water automatically shutting off after a predetermined amount of time is the major feature.
3. **End users:** The application for opening or closing the solenoid valve is accessible by the owner of the home and the manager of the society. For each flat's unique cost calculation, a water meter is also offered.
   1. **Non-Functional requirements**
4. **Security:** Since no personal information is required for this system, it is safe. It is just a mechanism to make people’s lives simpler.
5. **Reliability:** The end users can rely on our system without any doubt as the system is tried and tested with all the connections for each component. If the tap is left open for a predetermined amount of time, a message alerting the owner that the tap has been open for considerably longer than usual is sent. It prompts him to choose between closing the tap and leaving it open.
6. **Scalability:** Our concept is only a rough prototype in this paper. The bigger picture shows that we can install this technology in every household to cut down on water waste. The whole flat and bungalow system can have this installed.
7. **Design And Implementation**

Our system will include a main controller that will be linked to a water flow sensor and a solenoid valve to control the flow of water. This system will be linked to an Android app via a long-distance wireless transfer protocol. When the system detects a water overflow, the Android application will be used to send notifications. This app would have the capability of shutting down a specific apartment's water supply. Various factors will be used to determine whether water is wasted in a home, including:

1) If the flow of water is continuous and constant over a given time.

2) Systems can accept user input about water usage during peak hours and tailor the duration of a warning message accordingly.

Diagram

Description automatically generatedIf any of these criteria are met, a message will be sent to the home's owner. It is up to the owner to decide whether to continue using water or to turn off the water supply. If the owner does not respond within three messages, the system will turn off the water supply to that flat.

This system would also include a programme for calculating the "Water Tax" separately for each flat in a building. Implementing individual water taxes for each flat can encourage people to conserve water and use it efficiently. With this system, people will be aware of their water usage and the cost associated with it. This awareness can motivate them to reduce their water consumption and adopt sustainable water usage practices. Moreover, the system can provide accurate billing for the water usage, which can prevent disputes and conflicts among the residents.

FIGURE 1 Levels of the system

The data collected from the system can also help the government to identify areas where water usage is high and take necessary measures to conserve water in those areas. The government can also use the data to plan and implement water conservation policies effectively. In addition, the system can help the government to generate revenue through the water tax, which can be used for water conservation initiatives.

The software app designed for the consumers can provide them with real-time data on their water usage and the associated cost. This can help them to track their usage and adjust their water consumption accordingly. The app can also provide alerts when the water consumption exceeds a certain limit, or when there is a leakage in the system.

Overall, the implementation of individual water taxes can be a significant step towards sustainable water management. It can encourage people to use water efficiently, promote water conservation, and generate revenue for the government to fund water conservation initiatives.

In the figure 1 levels in which the system is operated is represented. The Level 1 of the system consists of main hardware units like water flow sensor, solenoid valve etc. The Level 2 of the system consists of water flow meter and microcontroller which is used to communicate with the consumer. The Level 3 of the system consists of the consumer who can communicate with the system through the software app that we have created. It also consists of government database where the data regarding water consumption per house would be shared with the government so that they can calculate the “Water Tax” individually.

1. **Hardware/Software Requirements**

1. Microprocessor

The microcontroller serves as the system's central nervous system. The microcontroller will be connected to all of the sensors and other devices. The microcontroller will analyse sensor data and act accordingly. Microcontrollers such as the Arduino and the ESP8266 can be used.

2. Flow Sensors for Water

As we track water usage, we also want to monitor excessive usage. For this, water flow sensors that measure the volume of water used can be used.

3. A signal-controllable valve

When a situation arises that requires us to turn off the water supply to the apartment. To accomplish this, valves such as solenoid valves that can be controlled by microcontrollers to turn on and off the water flow can be used.

4. Application for Android:

If there is excessive water flow on the flat owner's property, an Android application can be used to send alerts. Additionally, functionality can be added so that the owner can remotely turn on/off the water flow in his property using an Android app.

Diagram

Description automatically generated

Figure 2 Circuit diagram of the system

Figure 2 shows the connections: a water flow sensor is connected to the ESP8266 and is powered by a 9V battery, and a relay is connected to the solenoid valve. The 12V Solenoid Valve is powered by an external 12V battery.

Components used in this system:

1. Solenoid Valve
2. Water Flow Sensor
3. Relay Module
4. ESP8266
5. External Batteries

Diagram

Description automatically generated

Figure 3 Flowchart of the working flow of the system

Figure 3 represents the working flow of the system in flowchart format. Following steps mentioned below will provide the exact working flow which is also depicted in Figure 3.

Overall Working Flow:

1. The NodeMCU microcontroller connects to the mobile application through the internet.
2. The water flow sensor starts to measure the flow of water in the pipe, and the counter is initialized to zero.
3. When the volume of the flow measured by the water flow sensor becomes more than zero, the value of the counter variable is incremented every second.
4. When the value of the counter variable becomes equal to the predefined alert count variable, an alert is sent to the user’s mobile phone on the app.
5. At this point, the user can remotely turn off the water supply via the app if the user chooses to. If the user doesn’t remotely turn off the water supply, the system will keep checking the value of the counter.
6. If the counter variable does not have a value equal to alert count variable, the counter variable’s value is compared to the predefined max count variable.
7. If the counter and the max count variable are not equal, the system will again check if the volume of the flow is greater than zero.
8. If the counter and the max count variable are equal, the water supply is automatically shut off using the solenoid valve and an alert is sent to the user.
9. The system will then wait for the water supply to be turned on again, and after the water supply is turned on it will start measuring the volume of the flow and set the value of the counter variable as 0.

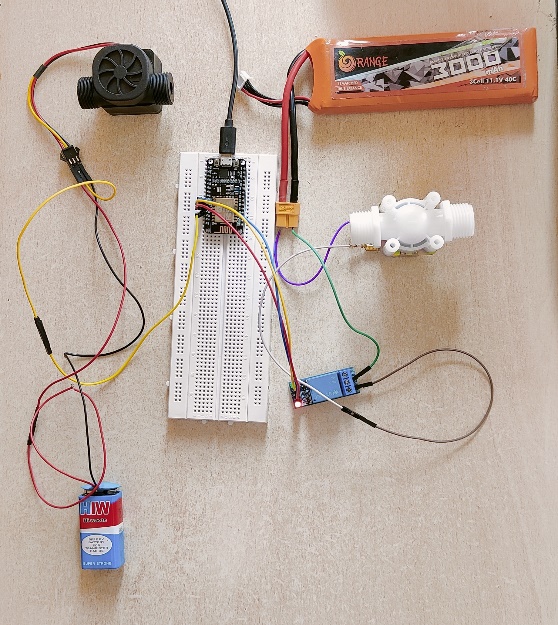


Figure 4 Actual System Photo that was constructed.

In the figure 4 the actual system that we made is represented. As mentioned above NodeMCU was used as the microcontroller. As NodeMCU only supports 3.3V of power Two external batteries were used 9V, 12V to power Water Flow sensor and Solenoid valve respectively.

**6. Results obtained.**

Formula used by the water flow sensor to convert the readings into liters/min:

(1)

(2)

OR

(3)

where Q stands for Total flow of water

Graphical user interface

Description automatically generated

Figure 5 Software Interface of the system

Figure 5 represents the Software interface of our system in which we have provided the consumer with the option to turn ON/OFF the water supply. The consumer will also be able to check water consumption details like total water consumed, water consumed per day represented in graphical form, the rate at which the water is consumed at that instance.

Wastage of water can be minimized using this system as well as water consumed can be tracked by the user. The real time monitoring system has levels of application where the consumer is the base of the system where he has an option to control the water flow of his house. Consumer will be notified by the application if there is any water wastage in his property and if the user doesn’t respond in the given amount of time, then the second level of the system comes into picture i.e. the central body , for e.g. it can be the management body of the flat who would be notified by the application about wastage of water and then the management will also have the option to turn of the water supply for that particular flat.

**7.Conclusion**

The flow of water through the domestic pipeline can be measured. Monitored, forecasted, and visualized from anywhere in the world via computer or smartphone The

The collected data can be analysed to make predictions about the future water consumption, as well as for demand management, asset management, and so on as well as leakage control the collected data can be used by local governments to levy a "Water Tax" on consumers based on their usage. This system would help save a lot of water by providing real-time monitoring of any water overflow.

**8.Future work**

This system can be improved to detect leaks in taps by using more accurate sensors and a low-power microcontroller. The collected data can be analyzed to make predictions about the user’s usage pattern. To capture data, the system may employ various software tools. The system can also be combined with other sensors that detect water quality and notify the owner; if the water quality is judged to be very poor, the flow of water can be shut off automatically.

**Conflicts of interest**

The authors have no conflicts of interest to declare**.**

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