A Comprehensive IoT Architecture for Water Level Management, Irrigation Automation, and Quality Monitoring

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Abstract- An inventive approach to effective and automated water management in a variety of contexts, such as households, businesses, and farms, is the Internet of Things (IoT)-based water level monitor with automatic pump control. Conventional techniques for keeping an eye on and replenishing water tanks frequently need physical intervention, which results in inefficiencies like shortages and overflows. In order to automate pump operations based on predetermined thresholds, this system combines real-time water level monitoring using sensors like float or ultrasonic sensors with microcontrollers like Arduino or ESP32.An OLED display for local feedback and Wi-Fi connectivity for remote monitoring and management via a smartphone app are important features. By tracking soil moisture, the device also facilitates intelligent irrigation, expanding its range of uses. This solution improves accuracy and safety by combining dependable sensors, internet connection, and pH monitoring for water quality assurance, in contrast to traditional systems that use resistive sensors or mercury switches. Applications that provide real-time monitoring, water conservation, and operational efficiency are found in home automation, industrial water management, agricultural, and disaster management. In addition to reducing human participation and addressing water waste, the suggested approach promotes environmental sustainability. In order to further advance effective resource management, it will eventually be integrated into water quality monitoring systems and smart city systems

Keywords - IoT (Internet of Things), Water Level Indicator, Automatic Pump Control, Water Management, Overhead Tanks, Ultrasonic Sensor, Water Level Sensor, Arduino, ESP32, OLED Display

I. INTRODUCTION

Water level indicator with automatic pump control based on the Internet of Things is a creative solution to autonomously and efficiently regulate the water levels in overhead tanks. A consistent supply of water is necessary in places like homes, businesses, and farms, therefore water management has long been a big concern. The manual nature of conventional methods for monitoring and refilling water tanks renders them vulnerable to human error and can lead to inefficiencies such as overflows or water running out at inappropriate times. This technology uses the Internet of Things (IoT) to create an automated, intelligent water management system that operates without human intervention in order to address these issues.

At the heart of this system is a water level sensor that continuously measures the tank's water level. These sensors send data in real time to a microcontroller and can be either floating or ultrasonic, depending on the design. like an ESP32 or Arduino. The microcontroller utilizes predefined thresholds to make judgments after digesting this input. If the water level falls below a preset threshold, the device will automatically activate a water pump to refill the tank, indicating that it is getting low. However, once the tank is full, the microcontroller will cut the pump to prevent overflow.

Among its main features is the ability to operate in Auto Mode, which enables the system to automatically control the water level without ervention.

Potential for human mistake ensures that the tank never runs dry or overflows by only using the pump when needed, saving water and energy.

The system also features an OLED display that provides local real-time information on the operating

mode and water level. The tank's water level is shown on the display, giving the user immediate feedback on the system's condition. It also indicates whether the tank is being actively filled by the pump or whether the system is in autonomous mode.

The Wi-Fi connectivity of this machine is another crucial feature. Through a web interface or a mobile application, users can remotely monitor and regulate the water level by connecting the microcontroller to the internet. Users may monitor their water consumption with this feature from any location giving them the assurance that their water tank is always properly maintained, even when they are not present or at home. If there is an issue or the system requires maintenance, alarms and notifications can also be delivered to the user's smartphone.

II. LITERATURE REVIEW

The design of an automatic water level controller was reported in the author's article in [1]. A mercury flow switch is used in the design system. Two electrified contactors are incorporated into the system to enable a direct online start of the motor. While the mercury flow switch uses the Archimedes principle of flotation to create electrical contact to switch ON and OFF supply to the motor when the tank is empty or full, respectively, an over-load relay detects the presence of excess current and cuts the supply. This system is reasonably priced, long-lasting, and reasonably priced. The primary drawback of this method is the usage of the mercury switch.Because of mercury's inertia, mercury switches operate at a very slow rate, but they are also extremely poisonous and build up in any food chain. A digital logic processing circuit or integrated circuit, a seven-segment display unit, a JK flip flop sequential circuit, and a motor drive circuit managed by a relay-based driver were used to construct a water level sensor with voltage output readings.

[2] Electrode resistive sensors that relied on the conductivity of the water were used to measure the water level. It will conduct electricity between a probe and the tank wall or between two fixed probe positions at the chosen points of level detection. The sensor's output can be utilized to turn on or off a water pump or open or close an electronic switch, and the water will complete the circuit. Metallic conductors or probe sensors, placed at various levels along the tank height to serve as sensors, have been used in the design of an electric water pump controller and level indication. As with the previously cited books, water's electrical conductivity is used to its advantage. The extra elements that are employed are the comparators to monitor the water content at the microcontrollers and probes, and to stimulate digital outputs that activate visual display LEDs that show different tank water levels.

[3] In practice, the automatic water level management has been used in the central air conditioner's water replenishment tank.

[4] And in the Qinshan nuclear power plant's computerized water level control system for the system generator.

[5] When the tank is full or empty, an operator uses the manual technique to manually turn the power supply to the pump motor on and off. This technique is frequently used in home water supply systems, such as borehole water supplies, where water is pumped from a well to an above tank. This method's drawback is its propensity for overflowing and cavitation, which wastes resources. Time lost opening and closing valves is the result of human error.

Therefore, an automated or "human-less" solution is required to boost productivity. Designing and building a portable automatic water level control switch that can turn on the pump is the aim of this project when the above tank's water level drops. low and turning it off as soon as the water level hits a preset level to avoid the pump drying up in the case that the subterranean tank's level falls below the suction level.

[6] Designing and creating an automatic water level control system is one of the better ways that hardware and software architectures can work together for interface goals, as this study paper explains. The gadget makes use of cutting-edge sensing technologies to determine the water level. It uses a relay and an Arduino to control the motor. Separate wires are linked at the different connections of the beaker. when water is added to the beaker. The water level in the tank is shown when the water comes into touch with the wire. The water level is now displayed on an LCD as a result. A relay is used to turn the engine on and off.

III. SPECIFICATIONS

This automatic water level controller has the following specifications:

- ✓ This model has a dry run prevention feature, which means it will only turn on the motor if there is water in the underground tank or sump.
- ✓ Because our controller is unloaded, it is suitable for any single-phase motor. The load is passed on to the existing starter.
- ✓ A motor on/off LED indicator is included.
- ✓ For both tanks, there is a water level indicator.
- ✓ There is an option to choose one of auto and manual mode.
- ✓ In Auto Mode, the motor will start and stop on its own.
- ✓ In manual mode, the user can start and stop the motor by pressing the controller's start and stop buttons.
- ✓ No manpower is required because the controls are fully automated from the underground tank to the overhead tank.
- ✓ Long service life.

Ⅳ. METHODOLOGY

[7] Despite being one of the most essential necessities for life, water is squandered. We will use this technique to examine both the water level and the quality of the water in the tank. The quality of the water is also crucial. Dust and dry leaves will eventually contaminate the tank's water. The ultrasonic sensor in the current system is first connected to the core controller and positioned atop the tank. The ultrasonic sensor is a moderately priced sensor that has a non-touch size range of 2 to 400 cm and a range accuracy of up to 3mm. The pH sensor determines the water's alkalinity level. Any liquid should always have a pH range of 0–14. It is considered acidic if the pH value falls between 0 and 6.9. A liquid is neither acidic nor basic and is suitable for domestic use if its pH is between 6.9 and 7.9. A conventional glass electrode will be used in the pH sensor since these electrodes are more dependable and economical for long-term monitoring. Doped to be ion-selective, the bottom glass membrane is only delicate to one particular ion. The pH electrode functions similarly to a single-cell battery, and the voltage output of the electrode and the pH of the water being measured are directly correlated. [8] Although there are a number of methods for building an automated water level management system with a switching mechanism, each one necessitates human involvement. In order to replace the water without the need for human intervention, this project builds an autonomous water level control system with an electrical control and a switching device for both above and subsurface tanks. The mechanism cuts the electric pump and stops the water pump when the water tank drops below a predetermined level. The system stops the water pump and the electric pump when the tank is full. Function block diagrams were used for the division of the overall design. A segment of the circuit that carries out a particular function is represented by each block in the diagram. The block diagram illustrates how the system was constructed utilising functional blocks. In this way, the circuit is made to show two different levels by using three sensors to track the water entering the tank. However, the size of these panels can be altered based on the level of resolution needed. Changing the number of level detectors and associated components will do this. The system is powered by a 9V step-down transformer equipped with full-wave The output of sequential correction is filtered by the condenser.

[8] Phase 1: Hardware Implementation:

- Circuit design

Create a circuit diagram that connects the water pump, sensors, relay, and microcontroller, making sure that each part receives the proper voltage and current. A well-designed power supply system that satisfies the requirements of every component will be necessary for this.

Use optocouplers or relays to ensure appropriate isolation between the microcontroller and high-power components.

- Assembly of Components:

For prototyping, put the parts together on a PCB or breadboard. To measure the water level precisely, the water level sensor or sensors will be placed in the tank at the proper height.

To show the water level and operational condition, connect the OLED display to the microcontroller. For simple integration with the microcontroller, use SPI or I2C connection.

- Hardware Requriments

Three Pin Terminal Connector

An electrical component called a 3-pin terminal connector is used to connect three wires or circuits. Usually, it is made up of three metal pins that are fastened with screws or spring devices, each of which is designed to accommodate a wire or cable. In a range of applications, including consumer electronics, automotive, and industrial settings, these connectors are frequently used to establish reliable and safe electrical connections. In addition to being made of various materials, such as brass and copper, they can be insulated to provide protection from the elements and shorts.

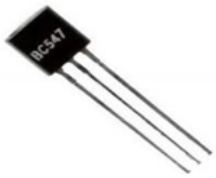
220 Capacitor:

Energy storage, filtering, and smoothing are common uses for a 220µF, 25V electrolytic capacitor in electrical circuits. Its capacitance is 220 microfarads (µF), and its maximum voltage rating is 25 volts. These typically polarized capacitors are ideal for circuits requiring bulk capacitance, such audio equipment and power supplies. Because of its comparatively high capacitance, it has a significant amount of energy storage capacity, and its 25V rating ensures safe operation in circuits with voltages up to 25V.

2-Pin Push Button :

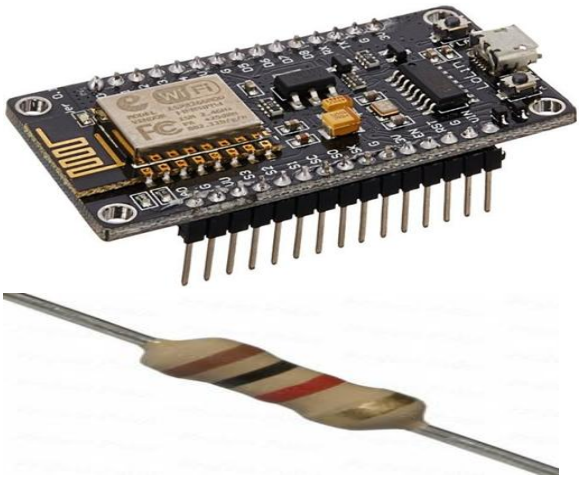
When pressed, a 2-pin push button, a straightforward switch, can establish or destroy an electrical connection. Usually, it has two pins, or terminals, that are connected to a circuit. The internal mechanism either completes or interrupts the circuit, permitting or prohibiting the flow of current, when the button is pressed. These push buttons are frequently seen in many different applications, including control panels, electronics, and appliances. They can be classified as either brief or latching by whether a button returns to its place of origin after being released.

Transistor:



For applications involving switching and amplification, the BC547 is a popular NPN bipolar junction transistor (BJT). Its three terminals are the emitter (E), base (B), and collector (C). It is suitable for low-power applications in signal processing, audio, and general-purpose switching because to its 45V voltage rating and 100mA maximum collector current. The BC547 is commonly used in oscillators, amplifiers, and logic circuits. Due to its gain (hFE) range of 110 to 800, it can be used for a variety of electronic projects.

1K Watt Resistor:



A common electronic component used in circuits to limit current and control voltage is a 0.25-watt, 1kΩ resistor. It is rated for 0.25 watts (250 milliwatts) of power and 1,000 ohms (1kΩ) of resistance. It will not overheat when dissipating up to 0.25 watts of

electricity, according to this. In a range of devices, including microcontroller circuits, LEDs, and amplifiers, it is frequently used in low-power applications like voltage dividers, current limiting, and signal conditioning. It is available in axial and surface-mount packages, among others.

Ultrasonic Sensor:

The SR04M is a waterproof ultrasonic sensor designed to measure distance in difficult circumstances. It measures the time it takes for ultrasonic waves to return from an object, sends out the waves, and uses that time to calculate the distance. Its detection range is typically between 2 cm and 4 meters, and it offers accurate measurements with minimal power usage. This sensor is widely used in robotics, level monitoring, and outdoor applications because of its durability and water resistance. VCC, GND, Trigger, and Echo are the four pins that are utilized for connections

NodeMCU ESP8266:

The inexpensive, Wi-Fi-capable NodeMCU ESP8266 microcontroller board is built on top of the ESP8266 chip. Its tiny size and wireless connectivity make it often used in Internet of Things (IoT) initiatives. A 32-bit processor, an integrated Wi-Fi module, and many GPIO connectors for attaching actuators, sensors, and other devices are all features of the board. Developers may create intelligent applications like web-connected devices, home automation, and remote sensing with ease since it makes programming possible using the Arduino ID

Two Pin Terminal Connector

Two wires or circuits can be securely joined with an electrical component known as a 2-pin terminal connector. It typically has two metal terminals, either screw or spring-based, where each wire is inserted and fastened. Consumer electronics, industrial machinery, and automobiles are just a few of the many applications that frequently use these connectors to establish reliable connections. They are composed of different materials, such brass or copper, and are designed to control specific current ratings, ensuring safe and efficient power transfer between two places.

SPDT Slider Switch :

SPDT (Single Pole Double Throw) slider switches are electrical switches that link a single input (pole) to one of two outputs (throws). It consists of common terminal and two switched terminals three terminals. The slider mechanism allows users to alternate between the two output connectors. SPDT slider switches are widely used in circuits, control panels, and electrical equipment to select between two options or settings, such as different voltage levels or on/off activities.

LED 5mm :

Small, spherical, and energy-efficient, a 5mm LED (Light Emitting Diode) is frequently used in electronic projects and displays. These 5mm diameter LEDs come in a range of colours, including red, green, blue, and white. They are perfect for low-power applications since they usually require a low forward voltage (around 2-3V) and use little power. In both consumer electronics and enthusiast projects, 5mm LEDs are utilised in indication lights, status indicators, digital displays, and ornamental lighting.

0.96-inch OLED Display :

A 0.96-inch OLED display is a tiny, energy-efficient screen that shows text and images with great contrast using organic light-emitting diodes (OLED). Depending on the model, it can support either full-color or monochrome displays and usually has a resolution of 128x64 pixels. These displays are frequently used for information readouts, status displays, and user interfaces in microcontroller-based projects like Arduino or Raspberry Pi. The 0.96-inch OLED is perfect for small and portable devices because of its bright output, broad viewing angles, and low battery consumption.

5v DC Buzzer :

A 5V DC buzzer is a little electronic gadget that emits sound when it receives electricity from a 5V DC source. Usually, a piezoelectric element or electromagnetic coil is used to produce sound. The internal mechanism vibrates when voltage is applied, producing alarms or audible tones. Alarms, notifications, and signal systems in a variety of products, such as electronics, appliances, and security systems, frequently use these buzzers. They can function at low power levels and are small and energy-efficient.

V. DISCUSSION OF WATER LEVEL INDICATORS

It is impossible to overestimate the significance of water level indicators, particularly in applications where water levels must be tracked and managed, such industrial operations, flood warning systems, and residential water level control. Numerous kinds of water level indicators are available, each with unique benefits and drawbacks. These indicators are used to monitor and regulate the water level in a variety of applications, including flood warning, industrial processes, and home water level control. There have been four different kinds of water level indicators described: conductivity-based, capacitance- based, float-type, and ultrasonic.[9] [10] Simple devices made up of a float, lever arm, and switch, float type water level indicators can activate or deactivate the

water pump in response to changes in the water level. The capacitance principle is used by capacitance-based water level indicators to determine the water level in a container. Ultrasonic type water level indicators use high-frequency sound waves to measure the distance between the sensor and the liquid's surface in a container, while conductivity type water level indicators use the electrical conductivity principle to determine the level of liquid in a container.[11] Every kind of water level indicator has pros and cons of its own. Although they are simple to install and maintain, float type water level indicators might not be appropriate for applications where water levels fluctuate quickly. Because they are unaffected by variables like temperature, pressure, or water contaminants, capacitance- based water level indicators can be used in both industrial and agricultural settings. Although conductivity-type water level monitors are quite accurate, they might not be appropriate for liquids with high impurity levels or poor conductivity. Ultrasonic water level indicators can be utilized with a range of liquids in tanks or containers of various sizes and forms and are very accurate and dependable. Conductivity type water level indicator: An electronic gadget that uses the electrical conductivity principle to determine the liquid level in a container is known as a conductivity type water level indicator. Two or more electrodes composed of conductive materials, such as brass, copper, or stainless steel, are placed into the liquid at various levels to form this kind of water level indicator. The conductivity of the liquid between the electrodes changes according to the liquid's level when an electrical current is run through them. When there is more liquid between the electrodes, the conductivity of the liquid is higher; conversely, when there is less liquid between the electrodes, the conductivity is lower. The electronic circuitry of the device detects the change in conductivity. device, and the liquid level is ascertained by the voltage or current signal that results. The device may be connected to a control system to activate pumps, alarms, or other devices in response to the liquid level, or it may include a visual display to show the liquid level. Applications requiring a high degree of accuracy, like chemical processing, water treatment plants, and fuel storage facilities, frequently use conductivity-based water level monitors. They might not work well with liquids that have high impurity levels or poor conductivity, though, as they could affect the measurement's precision.

VI. PROPOSED SYSTEM

1. With the recommended approach, customers can use a smartphone app with internet access to check the water level in the tank in real time. The user can use the mobile app to automatically cut off the water supply from anywhere as long as they have an internet connection. Consequently, shutting off the motor is no longer a time-consuming procedure. Farms can use a smart irrigation system to continuously monitor the moisture content of their soil. The sprinklers will activate on their own if the soil moisture falls below a predetermined level. Without personally visiting the farm, users may check if it is being watered enough by using a smartphone app. The usage of these would significantly raise farmers' level of living.
2. The Arduino microcontroller board is the central component of the system. It controls the digital connections and mediates conversations between the sensors and the smartphone app. The Arduino board with Internet access is connected to the local wireless network via the Wi-Fi module. Following measurement, the Arduino board transmits the data to the mobile app via the internet. The wireless LAN chip ESP8266 is put into use. Arduino can communicate with Android devices thanks to the ESP8266, which links the board to the internet. GPIO0, GPIO2, CH PD, RXD, RST, VCC, GND, and RST are the eight input/output pins of the module. The device needs an external voltage of no more than 3.3V to avoid overheating. Before coding can start, the module needs to be flashed so that The firmware can be updated using the proper baud rate. An Arduino's 3.3V pin or a specific 3.3V, 500mA power source can be utilized. However, Arduino only needs 5V to operate. The circuit may become unstable or perhaps suffer damage if the Wi-RX Fi pin is connected to the Arduino's TX pin. Consequently, a battery eliminator is required to supply power to the Arduino (which requires 5V) and the Wi-Fi module (which requires 3.3V). Sensors are also used to track the water levels in the tank and the soil. The waterproof ultrasonic JSN SR04T sensor

is used to achieve non-contact range detection. to determine the distance between two objects. Its closest range is 2 cm, while its farthest range is 4 m. A 5V DC power supply is appropriate for use with this gadget. A sensor is used to measure the soil's moisture content. You may modify the resistance by adjusting the two probes on it.

VII. DIAGRAMS

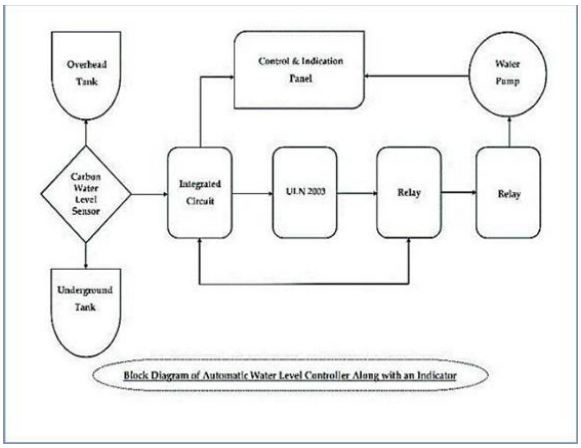


Fig 1.1 Block Diagram

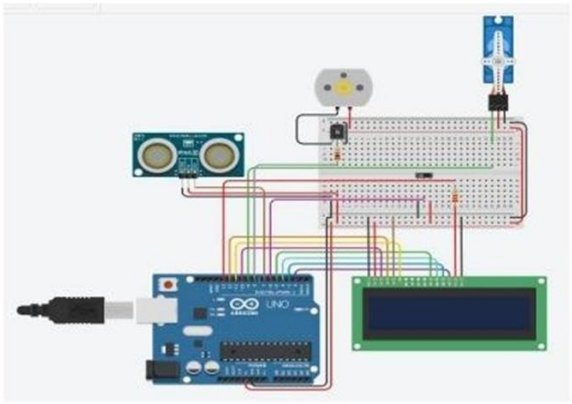


Fig 1.2 Circuit Diagram

VIII. APPLICATIONS

1. Water Management at Home

Real-time water level monitoring is done by home water management in storage tanks. It regulates the water pump automatically, preventing overflow when the tank is full and refilling it when the levels are low. By sending alerts to the homeowner's phone, water management is made more effective, waste is decreased, and manual intervention is minimized.

2. Campuses of schools and colleges

Water levels in several storage tanks used for irrigation, drinking, and sanitation are monitored on school and college campuses. It sends real-time alerts when water levels are low, automating replenishing and preventing overflow. This helps with sustainable water management on campus, minimizes manual monitoring, optimizes water usage, and guarantees a steady supply of water.

3. Office/Business Structures

Automating the maintenance of water tanks in office and business buildings guarantees a steady supply of water for a variety of applications, including kitchens, cooling systems, and bathrooms. It keeps an eye on water levels in real time, warns when replenishing is necessary, and stops overflow. This technology minimizes manual oversight, optimizes water usage, and lowers operating expenses.

4. Management of Industrial Water

Water levels in reservoirs, cooling systems, and storage tanks are tracked by industrial water management. Water waste is decreased, overflow is avoided, and water replenishing is automated. In factories or other industrial facilities, real-time warnings guarantee prompt intervention, maximise water use, and preserve operational effectiveness. In large-scale industrial processes, this lowers operating costs and conserves water.

5. Water Purification Facilities

Water treatment facilities keep an eye on the water levels in reservoirs and treatment tanks. By automatically regulating pump operations to avoid overflows or underfilling, it guarantees the best possible water distribution. Operators can maintain a steady water supply, increase productivity, and minimise manual intervention in plant operations by using real-time notifications to let them know when water levels are essential.

IX. REQUIREMENT

❖ Hardware Requirement

The Virtual Mouse application requires the following hardware for development and execution:

- Laptop or Computer Desktop

-To display what the webcam has taken, the virtual software will be started on the laptop or computer desktop.

-The system will make use of (minimum requirements) Core2Duo processor (2nd generation) 2 GB RAM (Main Memory) 320 GB hard drive 14-inch LCD monitor

❖ Software Requirement

The following software is required for the development and execution of the Virtual

- Python Language

The Virtual Mouse application is coded in Python with the helpof Microsoft Visual Studio Code, an integrated development environment (IDE) for programming computer applications Basic arithmetic, bit manipulation, indirection, comparisons, logical operations, and more are all available in the Python library.

X. FUTURE SCOPE

Water is one of the most essential necessities for all living things and a basic human need. Unfortunately, unchecked use and our carelessness are wasting a significant amount of water. Although there are already alternative automated water level monitoring systems available, most of the methods are not very practical. In an effort to address these issues, we put in place a productive automated system for monitoring and controlling water levels. The primary goal of this research project is to create a system that can address water loss issues in a way that is adaptable, affordable, and simple to configure. A web-based water level monitoring and control system that can be operated from any location using a mobile device and the internet is soon to be developed as part of home automation. This research could have a significant positive impact on effective water management.

1. Home Automation: As smart home technology advances, this technology can be included into the ecosystem of smart homes, allowing customers to use their smartphones to regulate the water flow in their houses.
2. Agriculture: By using this technology, farmers can effectively control irrigation and keep an eye on crop water levels. Farmers can also receive real-time information on the water needs of their crops via the web interface.
3. Industry: A lot of industries need a lot of water for their activities. Water levels in sectors like food and beverage, pharmaceutical, and chemical industry can be tracked with this technique.
4. Conserving water: Real-time water level monitoring allows for the implementation of water saving strategies. efficiently, and it is possible to prevent water loss from leakage or overflow.
5. Smart city: Information from the web interface can be utilized to better manage water distribution systems, and smart water level indicator technology can be included into smart city projects.
6. Disaster management: Residents in areas vulnerable to flooding can receive early warnings thanks to this technology, which can be used to monitor lake and river water levels.
7. Water quality monitoring: This technology can be used to identify changes in water quality and guarantee that the water supply is safe for human consumption by tracking water conductivity.

XI. CONCLUSION

An inventive way to alleviate inefficiencies in conventional water management systems is the Internet of Things-based water level indicator with automated pump control. The solution guarantees effective water level monitoring and control in above tanks by integrating IoT technologies. Automatic pump operation, real-time sensor monitoring, OLED displays for local feedback, and Wi-Fi remote access are some of the key features. These improvements increase operating efficiency, decrease resource waste, and lessen the need for human involvement.

Numerous methods for controlling water level are highlighted in the literature, such as resistive sensors, mercury switches, and sophisticated microcontroller-based devices. By combining automation, internet access, and pH monitoring for water quality assurance, the suggested solution outperforms these. It provides accurate measurements while maintaining environmental safety by utilizing dependable sensors such as pH electrodes and ultrasonic sensors.

All things considered, this solution fits the demands of homes, businesses, and farms for efficient water resource management while optimizing water usage and addressing environmental issues.

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