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Development of Sustainable Coin Based Drinking Water Vending Machine

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Abstract: *The rapid advancement of electronics has significantly transformed daily life, impacting industries such as medicine, telecommunication, and home automation. This research presents a fully automated, coin-based water dispenser system utilizing a microcontroller and sensors. The system efficiently dispenses water or cola, integrating IR sensors to detect the presence of a glass and prevent wastage. A coin detector ensures only valid coins trigger the dispensing process, with the motor operating only when a glass is present. If the glass is removed mid-process, the system halts water flow until it is replaced. This smart dispenser enhances automation and promotes water conservation.*

Keywords: Automated water dispenser, microcontroller, IR sensors, coin-based system, water conservation, smart dispenser, home automation

I. INTRODUCTION

Vending machines have existed since the 1880s, with the first commercial coin-operated machine introduced in London, England, for selling postcards. These machines offer a more accessible and practical alternative to traditional purchasing methods and are now widely used for dispensing tickets, drinks, and snacks in various locations such as railway stations, schools, and offices. Water is an essential resource for human survival, and managing water scarcity is a growing global challenge. Currently, only about 0.08% of Earth's freshwater is utilized for various purposes. With water supplies depleting, the demand for clean water continues to rise. According to the International Water Management Institute, by 2025, most of Central and South America, Asia, Africa, and the Middle East may either face severe water shortages or be unable to afford water. In the past, water was abundant and met population needs, but due to blocked basins and restricted access, it has become scarce. Implementing new regulations, such as improved agricultural water management and rainwater harvesting policies, could help address these water management challenges.

The field of water resource management must continue to evolve to address both current and future challenges related to water allocation. Overdependence on groundwater, which serves as the primary source of water, risks leading to its overexploitation. Therefore, innovative and sustainable water management solutions are essential to meet these growing concerns. One such initiative is the development of a "Coin Operated Water Dispenser," which, with the aid of technological advancements, offers a convenient and efficient method of water distribution.

Water is an essential resource, vital for both economic development and human survival. However, the issue of water scarcity has become one of the most pressing global challenges. Presently, only 0.08% of the Earth's freshwater is utilized by humans for various purposes. The increasing demand for clean and high-quality water, coupled with the depletion of available resources, has intensified this problem. According to the International Water Management Institute, by 2025, most regions in Central and South America, Asia, Africa, and the Middle East are projected to face severe water shortages or may lack the financial capacity to access water. Water dispensers are available in various configurations, including wall-mounted units, bottle-filling station combinations, and bi-level designs. They are primarily categorized into two types: point-of-use (POU) dispensers and bottled water dispensers. POU dispensers are directly connected to a water supply, while bottled water dispensers require water delivery or self-pickup in large

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bottles. Depending on the design, bottled water dispensers can be top-mounted or bottom-loaded and typically accommodate 11- or 22-liter (5- or 10-gallon) bottles placed on top of theunit. Additionally, pressure coolers, a subtype of water dispensers, encompass drinking water fountains and direct-piping dispensers, offering various options for water dispensing solutions.

II. LITERATURE REVIEW

[1] Hommalee C. et al. proposed a thermoelectric module system (TMS)-based cold-hot water dispenser consisting of a cold-water loop, a hot-water loop, a coolant loop, and thermoelectric modules. The system incorporates nine thermoelectric plates for cooling and three for heating, along with corresponding water blocks. Performance comparisons with conventional compression refrigeration system (CRS) dispensers indicate that the TMS-based dispenser achieves a cold-water temperature of 10–13°C and a hot-water temperature of up to 65°C. The study provides recommendations for optimizing TMS-equipped water dispensers.

[2] Sateesh Kumar Kanagala et al. developed a voice-controlled hot-cold water dispenser using Arduino and a solenoid valve to automate water distribution. The system employs IR sensors to detect the presence of a glass, preventing wastage. A microcontroller processes sensor data to verify glass placement before dispensing. Additionally, an RFID reader authenticates tags, ensuring only valid users access the dispenser. If the glass is removed during dispensing, the system halts water flow until it is replaced.

[3] Roselle Y. Pascual et al. proposed a low-cost dispenser-type water filtration system (LCDTWFS) to provide accessible clean drinking water, particularly for households in remote coastal and island communities. The system, made of clay with a 10L capacity, functions as a ceramic filter free from harmful substances. Six weeks of testing confirmed that the filtered water met Philippine National Standards for Drinking Water (PNSDW) in bacteriological, chemical, and physical quality, ensuring it is safe for consumption.

[4] Mohd Huszaizzi Pengiran Hussin et al. developed an automatic water, soap, and tissue dispenser to reduce COVID-19 transmission via contact at washbasins. The touchless system dispenses 1ml of soap for 0.2 seconds and water for 15 seconds upon detecting a hand near the sensor. This innovation promotes effective hand hygiene and minimizes contamination risks.

[5] ÇağlarAhmet designed and experimentally analyzed a novel thermoelectric water dispenser capable of simultaneously providing hot and cold water. The system utilizes Peltier modules with heat sinks attached to cold and hot water tanks. Performance was evaluated under three conditions: glass-walled tanks without insulation, polyethylene-walled tanks without insulation, and insulated polyethylene-walled tanks. Results showed that polyethylene tanks offered superior thermal efficiency, with insulation significantly enhancing the coefficient of performance (COP), especially for heating. The study suggests thermoelectric dispensers can compete with traditional models, offering benefits such as compact size, lower noise, and renewable energy compatibility.

[6] Zamberlan da Silva et al. compared the bacteriological quality of 20L bottled mineral water from dispensers, municipal tap water, and freshly opened 20L bottled mineral water. Tests identified Escherichia coli, fecal streptococci, Pseudomonas aeruginosa, Staphylococcus spp., and coliforms. Findings showed contamination in 36.4% of municipal tap water samples and 76.6% of 20L bottled mineral water from dispensers. Municipal tap water demonstrated better bacteriological purity than bottled mineral water from dispensers.

[7] Yonghwan Cho et al. developed a smart water dispenser for companion animals using IoT technology to ensure a continuous supply of fresh, oxygen-rich water in the owner's absence. The system allows remote monitoring and control via a smartphone app, providing alerts on water levels and dispenser status. A prototype and conceptual illustrations of key components were also presented.

III. AIM

Coin-based water dispenser systems provide advantages in accessibility, hygiene, cost-effectiveness, and environmental sustainability. However, addressing challenges related to equitable access, maintenance, security, and evolving payment methods is essential for effective implementation. Research should focus on enhancing user experience, integrating

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smart monitoring, and improving system efficiency. A comprehensive understanding of these systems will aid stakeholders in promoting clean drinking water access and sustainable practices in public spaces.

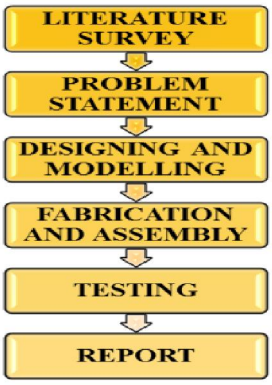
IV. OBJECTIVES

- To provide safe and affordable drinking water, reducing reliance on costly packaged water, particularly in rural areas.
- To lower waterborne disease rates among disadvantaged populations and minimize plastic waste from bottled water
- To design and implement a cost-effective, open-source automation system with an intuitive Android app for easy operation and maintenance.

V. PROBLEM IDENTIFICATION

- Limited Access to Clean Water – Many public spaces lack affordable, purified drinking water.
- High Cost & Environmental Impact – Bottled water is expensive and contributes to plastic waste.
- Unhygienic Water Sources – Public taps and street vendors may supply contaminated water.
- Restricted Payment Methods – Traditional coin-only systems may not support digital transactions.
- Maintenance & Refill Challenges – Regular upkeep is essential to ensure hygiene and functionality.
- Vandalism & Security Risks – Machines in open areas are vulnerable to damage and theft.
- Power Supply Dependence – Machines requiring constant electricity may be unsuitable for rural locations.
- Water Quality Monitoring – Real-time tracking of filter conditions and water quality is necessary for safety

VI. METHODOLOGY



6.1. Literature Review

- Analyze existing research on vending machines, focusing on automated water dispensers.
- Study various coin-operated mechanisms, automation techniques, and filtration systems.
- Compare different materials, structural designs, and electronic components used in water dispensers.
- Identify the strengths and limitations of previously developed systems to improve upon them.

6.2. Problem Statement

Many public areas lack **clean and affordable drinking water.**
Bottled water is expensive and contributes to **plastic waste pollution.**
Public water sources may be unhygienic and lead to waterborne diseases.
Traditional water vending machines lack digital payment integration and real-time monitoring.
Maintenance and security issues can affect the reliability and usability of vending machines.

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6.3. Design & Modelling

Develop a **conceptual design** considering accessibility, durability, and ease of use.
Use **CAD software (SolidWorks, AutoCAD, or Fusion 360)** to create 3D models and technical drawings.
Design the **frame, coin mechanism, piping, water storage, and dispensing unit**.
Perform **finite element analysis (FEA)** for structural integrity and optimization.
Select suitable materials:
Frame & Enclosure: Stainless steel or mild steel (corrosion-resistant).
Water Tank: Food-grade stainless steel or high-density polyethylene (HDPE).
Piping & Valves: Non-toxic, corrosion-resistant PVC/stainless steel.
Electronics: Coin acceptor, microcontroller (Arduino/PIC), solenoid valve, IR sensors, LCD display.

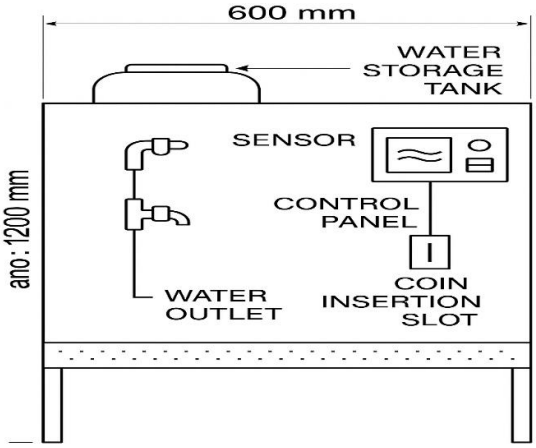

Fig:-Line Diagram of Proposed Machine

6.4. Fabrication & Assembly

Structural Fabrication:

- Cut and weld metal sheets for the frame and enclosure.
- Install support structures for the tank, coin acceptor, and dispenser.
- Apply anti-corrosion coating and paint for protection.

Plumbing & Water Dispensing System:

- Install the water storage tank and connect it to the dispensing nozzle.
- Attach filters for water purification (if applicable).
- Set up the solenoid valve and flow control mechanisms.

Coin Mechanism & Electronics Integration:

- Integrate the **coin acceptor module** with the microcontroller.
- Program the **microcontroller (Arduino/PIC)** to process coin signals and control water dispensing.
- Install **IR sensors** for glass detection to prevent water spillage.
- Configure the **LCD display** for transaction details and user guidance.

6.5. Testing & Performance Evaluation

- **Coin Validation Test:** Ensure the system accurately detects and processes valid coins.
- **Sensor Test:** Verify the IR sensors detect glass placement correctly before dispensing water.
- **Water Dispensing Test:** Check for proper flow control and valve operation**.**

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- **Leakage Test:** Inspect all pipe connections for potential water leakage.
- **Durability Test:** Assess machine performance under different usage conditions.
- **Power Efficiency Test:** Measure energy consumption and backup power options.
- **User Interface Test: Evaluate ease of use and responsiveness of the system.**

6.6. Report & Documentation

- Literature review findings.
- Problem identification and objectives.
- Design specifications and CAD models.
- Fabrication process and material selection.
- Testing results and system optimization.

VII. WORKING

The **coin-operated water dispenser** functions based on the principles of **coin detection and water dispensing,** utilizing four key interfacing components: **IR Sensor, LCD, Water Pump, and Coin Sensor**. These components are individually programmed using **Arduino IDE**, with the execution following a sequential process.

The **coin sensor** consists of four colored wires: **White, Black, Red, and Grey**. The **White wire** is connected to**pin 2**of the Arduino board, while the **Red and Blackwires** are linked to **Vcc and Ground,** respectively. The coin sensor is programmed to recognize a specific **valid coin**. Upon detecting the correct coin, the system proceeds to verify the **presence of a glass** using the **IR sensor**.

The **IR sensor** is equipped with a **dedicated driver circuit** that includes an **LED indicator.** When an object (glass) is detected within the sensor's range, the LED **illuminates,** signaling a **positive detection**. This triggers the **water pump,** initiating the dispensing process. Water continues to flow as long as the **glass remains in place,** ensuring efficient and spill-free operation.

The operation of a **coin-operated water dispenser** follows a structured sequence of steps to ensure efficient and accurate water dispensing:

Step 1: Coin Insertion and Authentication

The user inserts a **coin** into the designated slot. The **coin acceptor** verifies the coin's authenticity:

Valid Coin → the system accepts the coin and sends a signal to the **microcontroller**.

Invalid Coin → the system rejects the coin and returns it to the user.

Step 2: Processing and Activation

The **microcontroller** processes the coin input and triggers the **solenoid valve** to open.

If a **pump-based system** is used, the microcontroller activates the pump to initiate water flow.

The system determines the **water volume** based on the value of the inserted coin.

Step 3: Water Dispensing

Upon activation, the **solenoid valve** opens, allowing water to flow through the outlet.

A **flow sensor or timer mechanism** regulates the dispensed water quantity.

For additional water, the user must insert another coin.

Step 4: Completion and System Reset

After dispensing the predefined volume of water, the **solenoid valve** automatically closes.

The system resets to its initial state, awaiting the next transaction.

A **digital display** updates the transaction status, providing feedback to the user.

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VIII. COMMON ISSUES AND MAINTENANCE

ISSUE	CAUSE	SOLUTION
Coin Rejection	Dirty coin acceptor or fake coins	Clean the coin acceptor regularly
No Water Dispensed	Blocked filter or faulty solenoid	Replace filter, check solenoid
Slow Water Flow	Clogged filters or low water pressure	Clean or replace filters
Power Failure	Electrical issue or low battery	Check power supply, use backup

IX. COMPONENTS SPECIFICATION

9.1 Infrared Sensor and LCD Interface

Fig: -**Infrared Sensor**

An **infrared (IR) sensor** is an electronic component that emits infrared radiation to detect objects in its path. It consists of an **IR LED (emitter)** and an **IR photodiode (detector)**. The **IR photodiode** is specifically designed to detect infrared light of the same wavelength as emitted by the **IR LED**.In the **coin-operated water dispenser**, the **IR sensor** plays a crucial role in detecting the presence of a **glass**. When a glass is placed beneath the **nozzle** or in front of the **IR sensor**, the infrared light emitted by the **IR LED** is reflected off the glass and detected by the **photodiode**. This detection triggers a **signal** to the **microcontroller**, which subsequently activates the **water pump** to dispense water.
Additionally, a **liquid crystal display (LCD)** serves as the **user interface** for the dispenser. The LCD is a **thin panel** capable of either transmitting or blocking light. It features **16 pins** for interfacing with an **Arduino/ATmega328 microcontroller**. Commands from the microcontroller control the **display functions**, providing real-time information to users.

9.2 Coin Sensor

A **coin sensor** is an electronic device designed to detect and validate a specific coin based on its programmed configuration. The sensor is pre-calibrated to recognize a particular coin and is interfaced with an **Arduino microcontroller** through **pin 2.** Upon detecting a **valid coin**, the sensor sends a signal to the **microcontroller,** confirming acceptance. The **LCD display** then updates the status by displaying **"Correct Coin".** The system proceeds to check for the presence of a **glass** using an **IR sensor**. If both conditions—valid coin detection and glass placement—are met, the **water pump** is activated to dispense water.

9.3 ATmega328 Microcontroller

The ATmega328 is a single-chip microcontroller from Atmel's mega AVR family, widely used in embedded systems. It is a RISC-based 8-bit microcontroller with 32 KB of ISP flash memory and is commonly implemented on Arduino development platforms, including Arduino Uno and Nano models.Housed in a**28-pin DIP package, t**he **ATmega328**operates at**5V**and features**14 digital input/output pins** and**6 analog inputs**labelled**A0 to A5**. It also includes**2 KB of SRAM**and **1 KB of EEPROM** for data storage. The microcontroller can be powered via a **USB connection.**

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IX. ADVANTAGES

Convenient Access to Clean Drinking Water

Coin-operated water dispensers in public spaces provide an easy and efficient way to access clean drinking water. By simply inserting a coin, users can obtain water without the need to carry personal bottles or rely on traditional water fountains. This system enhances hydration accessibility, particularly in areas with limited water availability.

Hygiene and Safety

these dispensers incorporate advanced water treatment and purification systems, such as filtration, UV sterilization, and other purification technologies, to remove contaminants, pathogens, and impurities. This ensures the water is safe for consumption, promoting better hygiene and public health.

Cost-Effectiveness and Revenue Generation

Coin-operated dispensers offer a **cost-effective** alternative to bottled water, allowing users to refill their containers at a lower cost. Additionally, from a commercial perspective, these dispensers can serve as a revenue-generating solution, helping building owners offset maintenance and operational expenses.

Environmental Sustainability

Coin-operated water dispensers contribute to environmental conservation by reducing plastic waste. By providing easy access to clean water, these systems encourage users to refill reusable bottles, minimizing dependence on single-use plastic containers. This reduces the environmental footprint associated with plastic production, disposal, and recycling.

Customization and Efficient Water Management

These dispensers can be programmed to dispense a predetermined volume of water per coin, allowing users to access only the required amount, thereby promoting efficient water usage and minimizing waste. Additionally, the system can be easily adapted to accept multiple currency denominations oralternative payment methods, enhancing user convenience and accessibility.

X. DISADVANTAGES

Inequitable Access and Affordability: People who lack the necessary coins or have financial limitations may have trouble using coin-based systems. Relying only on coinoperated systems may restrict access for individuals who cannot afford or do not have the requisite coins in instances when access to clean drinking water is essential, such as in public areas or during crises.

Needs: Coin-operated water dispensers need regular maintenance, which includes filter changes, cleaning, and system inspections. Inadequate or ignored maintenance might result in poor water quality, faults with the dispenser, and disgruntled customers. Operational difficulties may also arise from making sure there is a sufficient supply of coins for change and from fixing technical problems like coin jams.

Coin Recognition and Dispensing Mechanism Reliability: These systems' coin recognition and dispensing mechanisms are susceptible to faults due to technological problems. Users may experience trouble as a result of coin clogs or the dispenser's inability to recognize specific coin kinds. To reduce such problems, regular system inspections and maintenance are required.

Dispenser Systems: Coin-based water dispenser systems might be targeted for theft or attempted manipulation, raising security concerns. The coin collecting within the machine may draw unwanted attention, necessitating the use of suitable security measures to guard against theft or damage. Its continued functioning depends on ensuring the security and integrity of the system and the coins that have been gathered.

Dependency on Coin Currency: Systems based on coins depend on actual coins as their form of money. There is a chance that these systems may lose value or popularity in settings where cashless transactions are favored as a result of the rising digitalization of payment methods. This problem may be solved by integrating alternate payment methods, including contactless payment systems.

Limited Water Dispensing choices: The versatility in water dispensing choices is often restricted by coin-based systems, which usually supply a predetermined amount of water per coin. If users need different quantities of water or if the normal dispensing quantity is insufficient for their requirements, then problems may arise.

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Environmental Considerations: Although coin-operated water dispensers encourage the purchase of refillable bottles, which helps reduce plastic waste, they still need electricity to run their purification and dispensing processes. In the overall assessment of these systems, the energy consumption and related environmental effect should be taken into account

XI. APPLICATION

Dispenser can be installed on roads (highways), railway stations and other public places to provide water to people at low cost.

Public Parks and Recreational Areas: To provide people easy access to drinking water, coin-based water dispenser systems are often placed in public parks and recreational places.

These devices enable people to relieve their thirst while participating in outdoor activities and encourage hydration while exercising.

Shopping malls and Retail Centers: In shopping malls and retail establishments, water dispenser systems equipped with coin-based mechanisms are often seen. They provide customers with a choice of cool drinks and may provide building owners a chance to make money.

By lowering the usage of single-use plastic bottles, these systems also help to promote sustainable practices.

Public Transportation Hubs: The installation of coin-operated water dispensers at bus and railway stations, airports and other public transportation hubs is on the rise. During their trip, travelers may find clean drinking water, offering a practical and economical choice to remain hydrated

XII. RESULT

1. Mechanical Performance

✓ No structural damage or leakage after stress testing.

✓ Coin mechanism functions correctly, accepting valid coins and rejecting fake ones.

2. Electrical & Control System

✓ Stable power supply operation with no overheating or voltage fluctuations.

✓Accurate sensor readings for water level, temperature, and quality.

✓ Solenoid valve opens/closes correctly upon payment validation.

3. Water Quality

✓ TDS and pH levels are within safe drinking water standards.

✓ No microbial contamination detected after filtration.

4. Operational Performance

✓ Water dispenses at the correct flow rate and quantity.

✓ Coin and digital payment systems function smoothly.

✓the machine operates continuously without major failures.

5. User Experience

✓ Easy-to-use interface with clear instructions.

✓ Quick response time between payment and water dispensing.

✓ Proper error handling for out-of-service situations (low water, power failure, etc.).

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XIII. FUTURE SCOPE

Multiple coin detection can be enabled and utilized. Since the coin acceptor is a 6-type coin detection system, multiple coin mode can be easily achieved.

Can be used for other beverages and drinks also.

RFID tag identify action reading can be developed to accept the money cards.

Increase in diameter of the water and pipes would increase the flow rate. Hence, taking lesser time to fill in the tumbler.

Various Indian as well as multinational companies such as Sarvajal, DJB-Tata Power, Amrutdhara Water Services Pvt. Ltd etc. are involved in this business. They currently provide drinking water to people in the range 1 rupee per liter on a pilot basis. We will replace the wired network installed in the machine by a wireless network to remove the complex indoor wiring and provide the easy installation of sensor. We will install more sensors such as humidity, temperature, dust, and smell.

XIV. CONCLUSION

This project introduces a water dispensing machine which operates on coin. Various devices like a regulated power supply, IR sensor, coin sensor water pump etc., are embodied to design an efficient dispensing system.

Coin-based water dispenser systems offer numerous advantages in terms of accessibility, hygiene, cost-effectiveness, and environmental sustainability. However, addressing challenges related to equitable access, maintenance, security, and evolving payment preferences is crucial for their effective implementation. Future research and advancements should focus on enhancing user experience, incorporating smart monitoring systems, and further improving the efficiency and usability of coin-based water dispenser systems. By understanding the strengths, limitations, and potential improvements of coin-based water dispenser systems, stakeholders can make informed decisions regarding their adoption, ensuring the availability of clean drinking water and promoting sustainable practices in public spaces

The dispenser can be installed on roads (highways), railway stations and other public places to provide pure water to people at low cost.

Management of water also involves the effective and optimal use of available water and preservation.

The proposed of model can be used optimally because only limited amount of water will be supplied. Wastage of water will be reduced and water borne diseases without manual work.

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