AI-ASSISTED IOT-ENABLED WATER DISPENSER WITH AUTOMATED SAFETY AND HYGIENE MONITORING

A PROJECT REPORT

Submitted by

BAVI M	**(927623BAD012)**
DHARSNI S	**(927623BAD025)**
GOPIKAMBAL N	**(927623BAD036)**
GOPIKASRI T	**(927623BAD037)**

in partial fulfillment for the award of the degree

of

BACHELOR OF TECHNOLOGY

in

ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

M. KUMARASAMY COLLEGE OF ENGINEERING

ANNA UNIVERSITY :: CHENNAI 600 025

APRIL 2025

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M. KUMARASAMY COLLEGE OF ENGINEERING

(Autonomous Institution affiliated to Anna University, Chennai)

KARUR – 639 113

BONAFIDE CERTIFICATE

Certified that this project report **"AI-ASSISTED IOT-ENABLED WATER DISPENSER WITH AUTOMATED SAFETY AND HYGIENE MONITORING"** is the bonafide work of **"BAVI M (927623BAD012) DHARSNI S (927623BAD025) GOPIKAMBAL N (927623BAD036) GOPIKASRI T (927623BAD037)"** who carried out the project work during the academic year 2025- 2026 under my supervision. Certified further, that to the best of my knowledge the work reported herein does not form part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

Signature	Signature
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This project report has been submitted for the Project Work - End Semester viva voce Examination held on __________________

INTERNAL EXAMINER **EXTERNAL EXAMINER**

DECLARATION

We affirm that the Project report titled **“AI-ASSISTED IOT-ENABLED WATER DISPENSER WITH SAFETY AND HYGIENE MONITORING ”** being submitted in partial fulfillment for the award of **Bachelor of Technology”** in **Artificial Intelligence and Data Science** is the original work carried out by us. It has not formed the part of any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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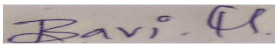
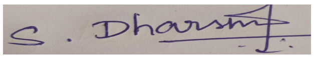
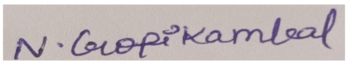
BAVI M	927623BAD012	
DHARSNI S	927623BAD025	
GOPIKAMBAL N	927623BAD036	
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ACKNOWLEDGEMENT

We gratefully remember our beloved **Founder Chairman, (Late) Thiru. M. Kumarasamy,** whose vision and legacy laid the foundation for our education and inspired us to successfully complete this project.

We extend our sincere thanks to **Dr. K. Ramakrishnan, Chairman, and Mr. K. R. Charun Kumar, Joint Secretary,** for providing excellent infrastructure and continuous support throughout our academic journey.

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We gratefully thank all the **faculty members of the Department of Artificial Intelligence and Data Science** for their timely assistance, valuable insights, and constant support during various phases of the project.

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M.KUMARASAMY COLLEGE OF ENGINEERING
DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Vision of the Institution

To emerge as a leader among the top institutions in the field oftechnical education

Mission of the Institution

- Produce smart technocrats with empirical knowledge who cansurmount the global challenges
- Create a diverse, fully-engaged, learner-centric campusenvironment to provide quality education to the students
- Maintain mutually beneficial partnerships with our alumni, industry, and Professional associations

Vision of the Department

To create highly qualified competitive professionals in Artificial Intelligence and Machine Learning by designing intelligent solutions to solve problems in variety of business domains, applications such as natural language processing, text mining, robotics, reasoning and problem -solving that serves society with greater cause.

Mission of the Department

- Impart practical and technical knowledge along with applications of various integrated technologies.
- Design and develop various intelligent engineering projects to solve societal issues.
- Use of advanced engineering tools and equipment to enable research based learning to promote ethical values, lifelong learning and entrepreneurial skills.

Program Educational Objectives (PEOs)

- **PEO 1**: Develop intelligent software solutions demonstrating reasoning, learning and decision support while handling uncertainty using domain knowledge.
- **PEO 2**: Create significant research towards social benefits and engineering improvement with a wide breadth knowledge of AI & ML technologies and their applications
- **PEO 3**: Participate in life-long learning for effective professional growth and

demonstrate leadership qualities in disruptive technologies along with a capacity to critically analyse and evaluate design proposals.

Program Outcomes (POs)

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complexengineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction andmodeling to complex engineering activities with an understanding of thelimitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, suchas, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive

clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1: Utilize multidisciplinary knowledge along with Artificial intelligence and Machine Learning Principles to create innovative solutions for the development of society.

PSO2: Graduates will use Information and Communication Technology (ICT) tools and techniques to attain advance knowledge to exhibit state of the art technologies to overcome the demand of sustainable development to meet future business and society needs.

ABSTRACT

Safe drinking water is essential for human health, yet most conventional water dispensers used in schools, colleges, hospitals, and offices fail to continuously monitor water quality. As a result, users remain vulnerable to dust accumulation, insect intrusion, chemical imbalance, microbial growth, and stagnation-related contamination, all of which may lead to severe waterborne diseases. To address this gap, this research proposes an AI-driven, IoT-enabled Smart Water Dispenser capable of real-time monitoring, intelligent decision-making, and automated contamination prevention.The system integrates multiple water-quality sensors—including pH, turbidity, Total Dissolved Solids (TDS), and temperature—alongside a water-resistant camera module for visual impurity detection. These multimodal inputs (sensor readings + live images) are processed continuously using a trained AI classification model, enabling early detection of physical, chemical, and microbial abnormalities. When contamination or abnormal deviation from permissible limits is detected, the system instantly activates a solenoid valve cut-off mechanism, preventing the user from consuming unsafe water.To enhance user awareness and administrative control, the dispenser features an intuitive LCD interface, LED alert indicators, and IoT-based notifications sent to mobile devices or web dashboards. This ensures proactive maintenance and timely corrective action. Experimental testing across various real-world environments demonstrates that the proposed system achieves approximately 92% detection accuracy, with rapid response time and high reliability.

Keywords*— IoT, Smart Water Dispenser, AI, Water Safety,*
Automated Flow Control

ABSTRACT WITH POs AND PSOs MAPPING

ABSTRACT	POs MAPPED	PSOs MAPPED
Safe drinking water is essential for human health, yet most conventional water dispensers used in schools, colleges, hospitals, and offices fail to continuously monitor water quality. As a result, users remain vulnerable to dust accumulation, insect intrusion, chemical imbalance, microbial growth, and stagnation-related contamination, all of which may lead to severe waterborne diseases. To address this gap, this research proposes an AI-driven, IoT-enabled Smart Water Dispenser capable of real-time monitoring, intelligent decision-making, and automated contamination prevention.The system integrates multiple water-quality sensors—including pH, turbidity, Total Dissolved Solids (TDS), and temperature—alongside a water-resistant camera module for visual impurity detection. These multimodal inputs (sensor readings + live images) are processed continuously using a trained AI classification model, enabling early detection of physical, chemical, and microbial abnormalities. When contamination or abnormal deviation from permissible limits is detected, the system instantly activates a solenoid valve cut-off mechanism, preventing the user from consuming unsafe water.To enhance user awareness and administrative control, the dispenser features an intuitive LCD interface, LED alert indicators, and IoT-based notifications sent to mobile devices or web dashboards. This ensures proactive maintenance and timely corrective action. Experimental testing across various real-world environments demonstrates that the proposed system achieves approximately 92% detection accuracy, with rapid response time and high reliability.	PO1(3), PO2(3), PO3(3), PO4(3), PO5(3), PO6(2), PO7(3), PO8(3), PO9(3), PO10(3), PO11(2), PO12(2)	PSO1(3), PSO2(2)

NOTE: 1-LOW, 2-MEDIUM, 3-HIGH

SUPERVISOR **HEAD OF THE DEPARTMENT**

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LIST OF ABBREVIATIONS

ABBREVIATION	EXPANSION
AI	Artificial Intelligence
ML	Machine Learning
NLP	Natural Language Processing
TDS	Total Dissolved Solids
pH	Potential of Hydrogen
DO	Dissolved Oxygen
EC	Electrical Conductivity
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solids
RF	Random Forest (ML Algorithm used)
LED	Light Emitting Diode
LCD	Liquid Crystal Display
IoT	Internet of Things
WQI	Water Quality Index
UV	Ultraviolet
ESP	Espressif Systems Processor (ESP32/ESP8266)
TH	Total Hardness
MCU	Microcontroller Unit

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW OF AI-ASSISTED IOT WATER MONITORING

Clean drinking water is one of the most essential human needs, yet it remains one of the most vulnerable resources in public and institutional environments. Traditional water dispensers, although widely used in schools, colleges, offices, hospitals, and public places, offer no mechanism to monitor water quality or hygiene. They simply store and dispense water, assuming that the supply is clean. However, factors such as pipe corrosion, dust particles, microbial buildup, stagnant water, malfunctioning filtration systems, and accidental contamination can severely degrade water safety. To address these limitations, the integration of Artificial Intelligence (AI) and Internet of Things (IoT) technology has emerged as a modern approach to ensure continuous monitoring, smart decision-making, and automatic control. An AI-assisted IoT water dispenser not only evaluates water quality in real time but also prevents unsafe water from reaching users by detecting contaminants, shutting down the supply, and alerting administrators. This transforms a conventional dispenser into an intelligent safety device designed to uphold hygiene and prevent health risks.

1.2 IMPORTANCE OF AI IN WATER SAFETY AND MONITORING

1.2.1 DATA ANALYSIS AND INSIGHTS

AI greatly enhances the analysis of water-quality data gathered from pH, turbidity, TDS, and temperature sensors by identifying patterns. AI supports better hygiene management and enables early prediction of contamination events for proactive maintenance.

1.2.2 PERSONALIZATION & USER SAFETY

AI personalizes water safety by adjusting its response based on contamination levels—triggering warnings for minor issues, automatically shutting off the valve for severe impurities, and providing users with real-time alerts and health-focused decisions without any manual intervention.

1.2.3 AI ASSISTED DISPENSER CONTROL OPTIMIZATION

AI helps optimize the decision-making process for safe dispensing operations. Instead of relying solely on threshold-based sensor values, AI can combine multiple sensor readings along with image-based impurity detection to determine the water's exact safety status. AI enhances the automation of the dispenser by deciding when to allow water flow, when to stop it, and when to alert responsible authorities, resulting in a more efficient, hygienic, and reliable dispensing system.

1.2.4 INTELLIGENT CUSTOMER SUPPORT AND ALERTING

The smart system offers AI-driven alerts, predictive maintenance reminders, and instant notifications whenever contamination is detected. It logs data, suggests corrective actions, and helps maintain consistent hygiene by reducing downtime and improving overall safety.

1.3 OBJECTIVE OF THE PROJECT

The objective of the project is to develop a smart water dispensing system that guarantees safe water consumption at all times. This includes designing a mechanism capable of continuously monitoring water using advanced sensors for measuring pH, TDS, turbidity, and temperature. Another major objective is to integrate AI-based image analysis through a waterproof camera that can detect visible contaminants such as dust particles, insects, or floating debris that sensors may not capture. The system should automatically decide whether the water is safe or unsafe based on sensor analytics and AI detection. If unsafe conditions are detected, the solenoid valve must immediately shut off the water supply. Additionally, users must be informed through LED/LCD indicators, and administrators must be notified through IoT alerts. The system aims to ensure transparency, hygiene, and reliability by storing logs for future analysis and system auditing.

1.4 SCOPE OF THE PROJECT

The scope of this project includes developing both hardware and software components that work together to provide real-time monitoring, intelligent decision-making, and complete safety automation for water dispensing. It involves seamless integration of multiple sensors such as pH, turbidity, temperature, and TDS to continuously assess water quality, along with an AI-powered image classification system that detects visible impurities like dust particles, insects, or discoloration. The project also incorporates IoT connectivity to enable remote notifications, cloud-based dashboards, and automated safety control mechanisms such as solenoid valve shutoff systems. In addition, it offers a user-friendly interface through LCD displays, LEDs, and mobile alerts for instant feedback. The system is designed for deployment in public and semi-public environments such as schools, colleges, hospitals, offices, hostels, factories, and community centers where water hygiene is crucial. The scope further extends to maintaining historical logs, generating contamination reports, supporting predictive analytics, and providing insights that help administrators improve overall water hygiene. Although the system detects and responds to contamination, it does not perform physical purification; instead, it ensures that only already purified water is safely monitored, verified, and dispensed to users.

1.5 ROLE OF AI IN MARKETING

Artificial Intelligence plays a transformative and highly sophisticated role in modern water quality monitoring by bringing advanced intelligence, improved accuracy, and reliable decision-making capabilities to the system. Traditional monitoring methods rely mainly on fixed threshold values from sensors, which may not always reflect the true condition of the water, especially when variations are subtle or influenced by environmental conditions. AI overcomes these limitations through data-driven analytical models that can understand complex relationships among multiple water parameters—including pH, turbidity, TDS, temperature, and flow changes. By continuously learning from historical patterns and real-time sensor data, AI can detect even minor deviations that indicate early stages of contamination. This allows the system to identify impurity patterns, classify contamination severity, and assess risks with much higher precision compared to manual or sensor-only methods.

Furthermore, AI enhances contamination detection by integrating computer vision techniques such as image processing and object recognition. Using a camera installed within the water chamber or near the outlet, AI can identify visible contaminants such as insects, dirt particles, discoloration, sediment formation, or microbial growth—elements that often go unnoticed by sensors alone. The combination of numerical sensor data and visual impurity detection results in a holistic approach to water safety assessment. This hybrid intelligence empowers the system to automatically take corrective actions such as closing the solenoid valve, displaying warnings, or sending IoT notifications to maintenance staff. As a result, AI not only strengthens monitoring accuracy but also ensures rapid, automated responses, making the entire water dispensing process cleaner, safer, and more dependable for public usage.

1.6 AI TECHNOLOGIES USED

The system employs multiple Artificial Intelligence technologies that collectively enhance the accuracy of water quality detection and automate decision-making. These technologies help interpret sensor data, detect visible impurities, classify safe vs unsafe water conditions, and trigger appropriate system responses. The main AI technologies include Natural Language Processing (for alert generation), Machine Learning (for classification), and Generative AI (for analyzing image data and improving model learning).

1.6.1 NATURAL LANGUAGE PROCESSING

NLP is used for generating meaningful alerts and notifications for administrators. Instead of displaying raw sensor values, the system provides human-readable messages such as “Water unsafe due to high turbidity” or “AI detected visible impurities—supply stopped.” This makes the system more user-friendly and effective for non-technical users. NLP enhances the clarity and accessibility of system-generated information.

1.6.2 MACHINE LEARNING

Machine Learning algorithms play a major role in classifying water safety based on sensor values and captured images. ML models analyze historical data to differentiate between safe trends and harmful anomalies. They learn patterns associated with contamination events and improve accuracy over time. ML is especially useful when multiple parameters must be evaluated simultaneously for correct safety decisions. This ensures that the system becomes more intelligent and reliable with continuous use.

1.6.3 GENERATIVE AI

Generative AI contributes by improving the data training process for impurity detection. It can generate synthetic images of contaminated water, enabling the model to learn a wide variety of impurity cases even before real-world data is collected. This enhances the AI model’s ability to recognize dust particles, insects, discoloration, and other visual anomalies. Generative AI also supports advanced visualization and reporting features.

1.7 APPLICATIONS OF AI

AI has diverse applications within the water dispenser environment, enabling automated monitoring, micro-level impurity detection, predictive analysis, and real-time safety enforcement. It transforms the dispenser from a passive machine into an intelligent health-protection system capable of independent decision-making and preventive intervention.

1.7.1 AI BASED PREDICTIVE SAFETY PLATFORM

The system uses AI to predict possible contamination risks by analyzing trends in sensor data. If turbidity or pH values show gradual deterioration, the AI engine can predict when water may become unsafe and alert administrators beforehand. This predictive capability ensures that maintenance can be performed proactively.

1.7.2 AI ASSISTED PERFORMANCE MONITORING

AI continuously monitors the performance of sensors, the dispenser valve, the camera module, and water flow patterns. It can identify anomalies such as sensor drift, reduced water flow, or unusual color patterns in the water. This performance intelligence helps maintain the system's long-term reliability.

1.7.3 AUTOMATION OF DISPENSER SAFETY OPERATIONS

AI enables complete automation of safety processes, including stopping water flow during contamination, activating warning indicators, sending IoT alerts, and maintaining safety logs. It eliminates the need for manual supervision and ensures hygienic dispensing 24/7.

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1.8 LIMITATIONS OF AI

Although AI provides advanced monitoring capabilities, it heavily depends on the quality of data collected from sensors and image inputs. If the sensor values are inaccurate due to calibration issues or environmental interference, the AI model may generate incorrect decisions. High-quality images are also essential because dust on the camera lens, improper placement, or poor water flow visibility can reduce the model's accuracy. Therefore, maintaining data integrity is critical for optimal AI performance.

AI-based detection systems can sometimes misinterpret visual patterns, especially in low-light conditions or when water appears distorted due to bubbles, reflections, or flow speed variations. These conditions may cause false positives or false negatives in impurity detection. For reliable functioning, proper lighting, stable camera orientation, and consistent water flow are required, which may not always be guaranteed in real-world environments.

Another limitation of AI is its dependency on continuous learning and periodic updates. AI models may become outdated over time if new types of impurities or unexpected contamination patterns arise. To maintain accuracy, the system must be retrained with fresh datasets and updated periodically. This adds a layer of maintenance complexity and requires technical expertise, which may not be readily available in all deployment environments.

The system also relies on IoT connectivity for sending alerts and updating cloud dashboards. Interruptions in internet connectivity can delay notifications or cause gaps in data logging, affecting the overall reliability of the system. In remote or low-network areas, this dependency can become a major challenge, limiting the full potential of AI-assisted monitoring.

These limitations highlight that AI should function as a supportive safety mechanism rather than a complete replacement for manual supervision and regular maintenance in water dispensing systems. Human oversight, routine sensor calibration, proper hardware positioning, and timely AI model updates are essential to ensure reliable performance and to overcome the constraints of AI-based monitoring.

1.9 MACHINE LEARNING ALGORITHMS USED

These algorithms analyze both sensor data and impurity images to generate accurate decisions. The model is trained using labeled datasets of safe and unsafe water samples:

1.9.1 RANDOM FOREST CLASSIFIER

The primary machine learning algorithm used in this project is the Random Forest algorithm is used for classifying water conditions due to its high accuracy, strong reliability, and ability to analyze multiple sensor parameters at the same time. It builds several decision trees during training, with each tree contributing a vote toward the final prediction. By combining these multiple outputs, the model reduces errors and avoids overfitting. This ensemble approach makes it highly effective for identifying abnormal sensor patterns. As a result, the algorithm provides a dependable classification of whether the water is chemically safe or unsafe.

1.9.2 SYNTHETIC MINORITY OVER-SAMPLING TECHNIQUE

To handle the imbalance between safe and unsafe water samples—where safe readings dominate the dataset—SMOTE was applied to artificially generate additional examples for the minority class. By increasing the number of unsafe water samples, the model avoids bias toward the majority class and becomes more sensitive to contamination-related patterns. This improves recall, F1-score, and overall detection accuracy for unsafe water conditions, leading to more balanced and reliable predictions.

The strategic use of the Random Forest classifier, combined with SMOTE for class balancing and essential preprocessing steps such as data normalization and sensor-value encoding, creates a strong and dependable machine learning foundation for the system. Together, these components enable the water dispenser to deliver accurate, scalable, and interpretable predictions that significantly enhance the effectiveness of AI-driven water safety monitoring and automated hygiene decisions.

CHAPTER 2

LITERATURE SURVEY

2.1 TITLE: Smart Water Quality Monitoring System :A Review of the Applications, Challenges, and Future Scope**,** AUTHOR: A.N.Prasad, K. A. Mamun, F. R. Islam, and H. Haqva (2015)

This paper concentrates on the critical global challenge of drinking-water deterioration, especially in developing regions such as Fiji where industrial waste, sewage discharge, agricultural chemicals, and inadequate sanitation infrastructure severely impact water quality.The paper emphasizes the urgent need for a system capable of monitoring water parameters instantly and sending early warnings when contamination occurs.

The authors design and propose a smart IoT-based water quality monitoring system that uses a combination of pH, ORP, conductivity, and temperature sensors to detect pollution levels instantly. Their contribution demonstrates how low-cost microcontrollers and wireless communication technologies can be integrated to build a scalable, remote water-quality system suitable for rural and urban deployment. They also highlight how the system can be used as an early-warning tool, allowing authorities to take preventive measure.

2.2 TITLE: Implementation of Voice-Based Hot–Cold Water Dispenser System Using Raspberry Pi 3 AUTHOR:V. Jyothi, K. Hanuja, P. Shirish, R. Avinash, P. Akhil(2021)

This paper addresses the need for automated and user-friendly water dispensing solutions in environments where manual operation is inconvenient or inaccessible. The authors identify the challenges faced by elderly individuals, physically challenged users, and busy environments where hands-free operation is beneficial.

A key contribution of the paper that traditional water dispensers require physical effort, have limited automation, and often result in inefficiencies such as water wastage. It also highlights growing expectations for smarter home appliances that can recognize voice inputs and respond accordingly.

The authors propose a Raspberry Pi 3–based system that integrates voice recognition technology with an IR sensor for precise water dispensing. Their system provides dual functionality—dispensing both hot and cold water—with minimal manual interaction.

2.3 TITLE: Hyperspectral Remote Sensing for Invasive Species Detection and Mapping AUTHOR: S.L. Ustin, D. DiPietro, K. Olmstead, E. Underwood, G.J. Scheer (2000-2001)

This paper deals with environmental monitoring rather than water systems, but it is a significant research example in smart sensing. The authors address the rapid spread of invasive plant species that threaten native ecosystems, disrupt biodiversity, and cause severe ecological and economic harm. They highlight that conventional field surveys are time-consuming, require intensive labor, and often fail to capture the complete spatial extent of invasive species. The need for a large-scale, accurate, and reliable sensing mechanism drives the motivation of this research.

The authors propose using hyperspectral remote sensing technology coupled with AVIRIS (Airborne Visible/Infrared Imaging Spectrometer) data to detect invasive plants with high precision. Their contribution shows how variations in spectral signatures can be analyzed to distinguish invasive species from native vegetation. The system provides improved classification accuracy using detailed spectral analysis and enhances mapping capabilities over large geographical regions.

2.4 TITLE: Analysis of the Water Quality Monitoring System AUTHOR:L. Lakshmanan, Jesudoss A, Sivasangari A, Sardar (2020)

This paper focuses on the increasing number of diseases caused due to consumption of contaminated water, especially in regions lacking awareness and strong monitoring systems. It highlights that many communities do not have timely access to water quality information, leading to unintentional consumption of unsafe water. The authors emphasize the need for a simple, affordable, and scalable water quality monitoring framework.

The authors propose a low-cost, IoT-based water monitoring solution using pH and turbidity sensors connected to a NodeMCU microcontroller. Their system provides periodic monitoring and sends data to a cloud platform for real-time analysis. The contribution demonstrates how IoT can be used to create a continuous, affordable system for early detection of water contamination, especially in rural or underdeveloped regions where manual testing is impractical.

2.5 TITLE: A Low-Cost Sensor Network for Real-Time Monitoring and Contamination Detection in Drinking Water Distribution SystemsAUTHOR: Theofanis P. Lambrou, Christos C. Anastasiou, Christos G. Panayiotou, Marios M. Polycarpou (2014)

This paper focuses on the limitations of conventional water quality testing methods, which are slow, expensive, and poorly suited for continuous or real-time monitoring. It identifies that current monitoring fails to detect contamination early due to insufficient spatial and temporal data. The authors emphasize the necessity of an automated system capable of monitoring water inside pipelines without requiring manual sampling.

The authors propose an in-pipe sensor network designed to provide continuous, low-cost monitoring of drinking water distribution systems. Their system uses multiple electrochemical and optical sensors along with advanced data fusion algorithms to detect contamination early. This real-time sensor network significantly improves detection accuracy and responsiveness, helping prevent widespread contamination and ensuring safer water distribution.

2.6 TITLE: An IoT-Based Smart Water Quality Monitoring System Using Cloud**,** AUTHOR: Ajith Jerom B, Manimegalai R, Ilayaraja V (2020)

This paper highlights the challenges faced due to water pollution from sewage discharge, industrial waste, agricultural runoff, and unregulated chemical use. It identifies the growing environmental and health threats resulting from polluted water sources and the high expenses of traditional laboratory-based water-quality testing.

The authors propose a cloud-integrated IoT water monitoring system that uses multiple sensors attached to NodeMCU to collect water parameters in real time. The data is transferred to the cloud via Wi-Fi for continuous monitoring. The system also uses machine learning techniques to predict water suitability, offering deep insights and enabling proactive contamination management. Their contribution shows how cloud + IoT + AI can create a fully automated water monitoring framework.

2.7 TITLE: Smart Water Dispenser and Level Indicator During Pandemic Situations, AUTHOR:S. Esakki Rajavel, Dr. S.D. Jayavathi, G. Vinoth Rajkumar, R. Bharathiraja, A. Shanmuga Rajeswaran, U. (2020 or later)

This paper focuses on the impact of the COVID-19 pandemic on traditional water dispenser usage. Manual water dispensing increases physical contact and interaction, which contradicts social distancing norms and heightens the risk of viral spread. It also identifies issues such as improper water level monitoring, increased wastage, and inefficiency during emergency situations.

The authors introduce a smart, contactless water dispenser that includes a level indicator and automated valve control. Using NodeMCU, ultrasonic sensors, and IoT-based notifications, the system ensures hygienic water dispensing and prevents unnecessary manual handling. The LCD display, Blynk notifications, and automated motor valve control enhance safety, reduce wastage, and support hygienic water distribution—especially useful during pandemic conditions..

2.8 TITLE: The Design of the Remote Water Quality Monitoring System Based on WSN,AUTHOR: Zhu Wang, Qi Wang, Xiaoqiang Hao

This paper focuses on the limitations of traditional manual water-quality testing methods, which are labor-intensive, time-consuming, and prone to human error. It highlights the growing need for modernized water-quality monitoring systems that support real-time analysis and remote accessibility, especially in aquaculture, fisheries, and distributed water bodies. The authors emphasize that conventional monitoring cannot meet the increasing requirements of accuracy, efficiency, and long-distance data acquisition.

The authors propose a Wireless Sensor Network (WSN)-based water-quality monitoring system that uses ZigBee and GPRS technologies to collect water-quality parameters such as pH, temperature, and dissolved oxygen from remote areas. Their solution supports long-range communication, low-power operation, and continuous real-time monitoring, making it suitable for large-scale environmental and aquaculture applications. This research shows how WSN can be used to automate water-quality monitoring efficiently and cost-effectively.

2.9 TITLE: Composited FishNet: Fish Detection and Species Recognition From Low-Quality Underwater Videos, AUTHOR: Zhenxi Zhao, Yang Liu, Xudong Sun, Jintao Liu, Xinting Yang, Chao Zhou (2021)

This paper focuses on the challenge of detecting fish and recognizing species from low-quality underwater videos, which often suffer from blur, noise, low contrast, complex backgrounds, and inconsistent lighting. These limitations make it extremely difficult for standard machine-learning models to accurately identify fish or track their movement. The authors highlight that underwater environments introduce numerous distortions, making robust detection models essential for marine research and aquaculture management.

The authors introduce a novel deep-learning architecture called *Composited FishNet*, which integrates a composite backbone (CBResnet) to minimize environmental interference and enhance the visibility of underwater scenes. They also propose an enhanced path aggregation network (EPANet) with PixelShuffle upsampling to improve detection accuracy in challenging underwater conditions. This model significantly enhances fish detection and species recognition even in noisy, low-quality video streams, demonstrating the power of advanced image processing in aquatic monitoring environments.

2.10 TITLE: Smart Water Monitoring System for Real-Time Water Quality and Usage Monitoring,AUTHOR: Manish Kumar Jha, Rajni Kumari Sah, Rashmitha M.S., Rupam Sinha, Sujatha B., Suma K.V.

This paper focuses on the growing global issues of water scarcity, contamination, and inefficient consumption caused by rapid population growth, industrial activity, and unregulated water usage. The authors highlight that improper monitoring leads to wastage of potable water and increases the risk of contamination-related health hazards. They emphasize the urgent need for systems that track both water quality and user consumption in real time.

The authors present a Smart Water Monitoring System (SWMS) that integrates a smart water meter with IoT technologies to measure water usage and water quality simultaneously. The system uses sensors to check pH, temperature, turbidity, and conductivity, while also providing usage analytics through a billing mechanism. The data is transmitted via IoT to provide real-time visibility to users and authorities. This solution supports efficient water management and ensures continuous water-quality assessment, making it highly relevant for modern smart cities.

TABLE 2.1 FINDINGS IN LITERATURE SURVEY

S.NO	TITLE	AUTHOR & YEAR	TECHNIQUES	MERITS	DEMERITS
1	Smart Water Quality Monitoring System	A.N. Prasad, K.A. Mamun, F.R. Islam, H. Haqva 2015	IoT-based sensor integration	Low cost, real-time alerts	Limited to basic parameters
2	Voice-Based Hot–Cold Water Dispenser	V. Jyothi, K. Hanuja, P. Shirish, R. Avinash, P. Akhil 2021	Raspberry Pi + Voice Control	Hands-free operation, dual mode	Voice errors, Pi-dependent
3	Hyperspectral Sensing for Invasive Species	S.L. Ustin, D. DiPietro, K. Olmstead, E. Underwood, G.J. Scheer 2001	Hyperspectral remote sensing	Accurate mapping, large coverage	High cost, complex processing
4	IoT Water Quality Monitoring System	L. Lakshmanan, Jesudoss A, Sivasangari A, Sardar 2020	NodeMCU + pH & Turbidity	Affordable, cloud monitoring	Few sensors, basic accuracy
5	Low-Cost Sensor Network for Water Contamination	T.P. Lambrou, C.C. Anastasiou, C.G. Panayiotou, M.M. Polycarpou 2014	In-pipe sensor network	Real-time detection, high accuracy	Installation difficulty, sensor drift

TABLE 2.2 CAMPAIGN IN LITERATURE SURVEY

S.NO	TITLE	AUTHOR & YEAR	TECHNIQUES	MERITS	DEMERITS
6	IoT-Based Smart Water Quality System Using Cloud	Ajith Jerom B, Manimegalai R, Ilayaraja V 2020	IoT + Cloud + ML	Predictive analysis, scalable	Needs internet, cloud cost
7	Smart Water Dispenser During Pandemic	S. Esakki Rajavel, Dr. S.D. Jayavathi, G. Vinoth Rajkumar 2020+	IoT + Ultrasonic sensing	Contactless, hygienic, low waste	Sensor accuracy issues
8	Remote Water Quality Monitoring Using WSN	Zhu Wang, Qi Wang, Xiaoqiang Hao , 2010	ZigBee + GPRS + WSN	Long-range, low power	Low bandwidth, data delay
9	Composited FishNet for Underwater Detection	Zhenxi Zhao, Yang Liu, Xudong Sun, Jintao Liu 2021	Deep learning + CBResNet	High accuracy in noise	Heavy model, GPU needed
10	Smart Water Monitoring System (SWMS)	Manish Kumar Jha, Rajni Kumari Sah 2020	IoT meter + multi-sensor	Tracks usage & quality	Higher installation cost

CHAPTER 3

EXISTING SYSTEM

The existing water dispenser systems commonly used in homes, institutions, and public spaces operate with a very basic functional design. Their primary focus is on dispensing stored water without any built-in intelligence to monitor water quality or user safety. These systems typically rely on a mechanical or semi-automatic flow mechanism, involving a tap or button that releases water whenever the user interacts with it. Although this setup meets basic hydration requirements, it is not suitable for ensuring hygiene—especially in places where water contamination is a critical concern..

Traditional systems do not have sensors to detect changes in water chemistry or physical impurities. Contamination caused by poor tank hygiene, microbial growth, surrounding dust, pipeline rust, or storage conditions remains unnoticed. Without automated monitoring, users consume water without knowing whether it is actually safe. In public places like schools, hospitals, hostels, offices, and industrial workspaces, this poses a significant health risk.

3.1 OVERVIEW

Traditional water dispensers only store and dispense water but do not verify its safety or hygiene. They lack AI, sensors, automation, and IoT capabilities, making them inefficient for environments where water quality must be continuously monitored.

3.2 LIMITATIONS OF THE EXISTING SYSTEM

3.2.1 NO REAL-TIME WATER QUALITY MONITERING

Existing systems do not include any sensors to measure critical water-quality parameters such as pH, turbidity, TDS, temperature, microbial growth indicators, or dissolved solids. This means the system cannot detect chemical contamination, pipeline rust, tank impurities, or variations in water safety. If contamination occurs due to environmental exposure, storage tank conditions, or filtration failure, users unknowingly drink unsafe water. Without continuous monitoring, even sudden contamination events remain undetected until the water shows clear visible signs, which is often too late.

3.2.2 COMPLETE MANUAL DEPENDENCY FOR SAFETY CHECKS

All cleanliness and safety assessments in traditional dispensers depend solely on manual human inspection. Staff members must physically open the tank, check the clarity of water, clean the storage compartment, and replace filters based on guesswork or fixed schedules instead of actual contamination levels. Human errors, negligence, delay in inspection, and lack of water-quality knowledge often cause unsafe conditions. This makes the system unreliable in public areas where hundreds of people rely on the dispenser daily. Manual processes also slow down maintenance, increasing the risk of unnoticed contamination buildup. Additionally, the absence of standardized monitoring procedures results in inconsistent safety practices across different locations. Manual dependency also increases operational workload, making it difficult to perform frequent checks, especially in high-demand environments. Overall, these factors lead to significant hygiene risks, reduced reliability, and increased chances of public health hazards.

3.2.3 NO AUTOMATED SAFETY RESPONSE OR VALVE CONTROL

Traditional dispensers do not have any safety mechanism to automatically restrict water flow if contamination increases. Even if the water becomes unsafe due to microbial growth, sudden pH imbalance, or turbidity spike, the system continues dispensing it because it cannot interpret these changes. There is no automatic valve shutoff, no warning indicators, and no self-protection behavior. Users are exposed to potential health hazards because the system operates blindly without understanding the quality of the water it releases. This lack of intelligent response means harmful water may reach users long before the problem is identified manually. Traditional systems also fail to categorize the severity of contamination, making it impossible to apply corrective actions in a timely manner. As a result, the absence of safety automation significantly reduces water reliability and increases the risk of widespread hygiene issues in public places.

3.2.4 LACK OF IMPURITY DETECTION

Most existing models do not include a camera or any artificial intelligence to detect visible impurities. Foreign particles such as dust, insects, algae, plastic residue, floating materials, and color changes go unnoticed. Physical impurities often occur due to tank lids not being properly closed, stagnant water, or dust entering through the dispensing area. Without visual inspection tools, the system cannot detect these issues automatically. The absence of AI image analysis means that contamination visible to the eye still may not be detected by the dispenser. This creates a false sense of safety, as users assume the water is clean simply because the dispenser looks functional. Traditional systems also cannot differentiate between minor and severe visual impurities, preventing timely intervention. Over time, this leads to unhygienic conditions inside the tank and increases the probability of health hazards. A smart visual detection mechanism is therefore essential to maintain consistent water hygiene.lace.

3.2.5 NO IOT CONNECTIVITY,ALERTS, OR REMOTE MONITORING

Existing dispensers function in complete isolation without any form of network communication or remote monitoring capabilities. When contamination occurs, these systems cannot alert administrators through mobile notifications, cloud dashboards, SMS, or online platforms, resulting in delayed responses to critical safety issues. Maintenance teams remain uninformed about water-quality deviations because the system has no mechanism to capture or transmit such data. Filter failures are usually detected only after users complain, leading to inconvenience and potential health risks.Without IoT connectivity, there is no ability to log data, track abnormalities over time, or identify recurring contamination patterns.

The lack of communication and automation not only slows down maintenance but also prevents administrators from taking proactive measures to protect users. In environments such as schools, hostels, hospitals, and offices, this delay can lead to widespread consumption of unsafe water. Furthermore, traditional dispensers offer no cloud-based analytics, historical reports, or integration with mobile apps, making them incompatible with modern smart-environment requirements.

3.2.6 NO DATA LOGGING,NO HISTORY TRACKING, AND NO PREDICTIVE ANALYSIS

Conventional water dispensers do not store any historical data related to water quality, contamination trends, or filter usage patterns. These systems operate without memory, meaning they cannot track changes in water parameters over time or identify when and why contamination occurs. As a result, they are unable to generate reports, visualize long-term data, or recognize recurring issues linked to tank hygiene, environmental conditions, or filtration failures. Without proper logs, administrators cannot monitor the rise or fall of contamination levels, making it difficult to pinpoint the exact time at which water becomes unsafe. There is also no reference to evaluate whether the purification system is functioning efficiently or if the filter needs cleaning or replacement.

The absence of historical data eliminates the possibility of predictive maintenance, such as automated cleaning reminders, early warnings for filtration failure, or forecasts for maintenance schedules. This forces staff to rely on guesswork or fixed intervals, which often leads to late responses and increased risks. Over time, unidentified contamination patterns may lead to repeated hygiene failures that go unresolved due to the lack of documented evidence. Additionally, without trend analysis, administrators cannot make informed decisions to improve safety protocols or upgrade components. This major limitation severely affects long-term hygiene management, reduces system reliability, and allows contamination issues to resurface frequently, ultimately compromising user safety and trust.

3.3 EXISTING SYSTEM BLOCK DIAGRAM

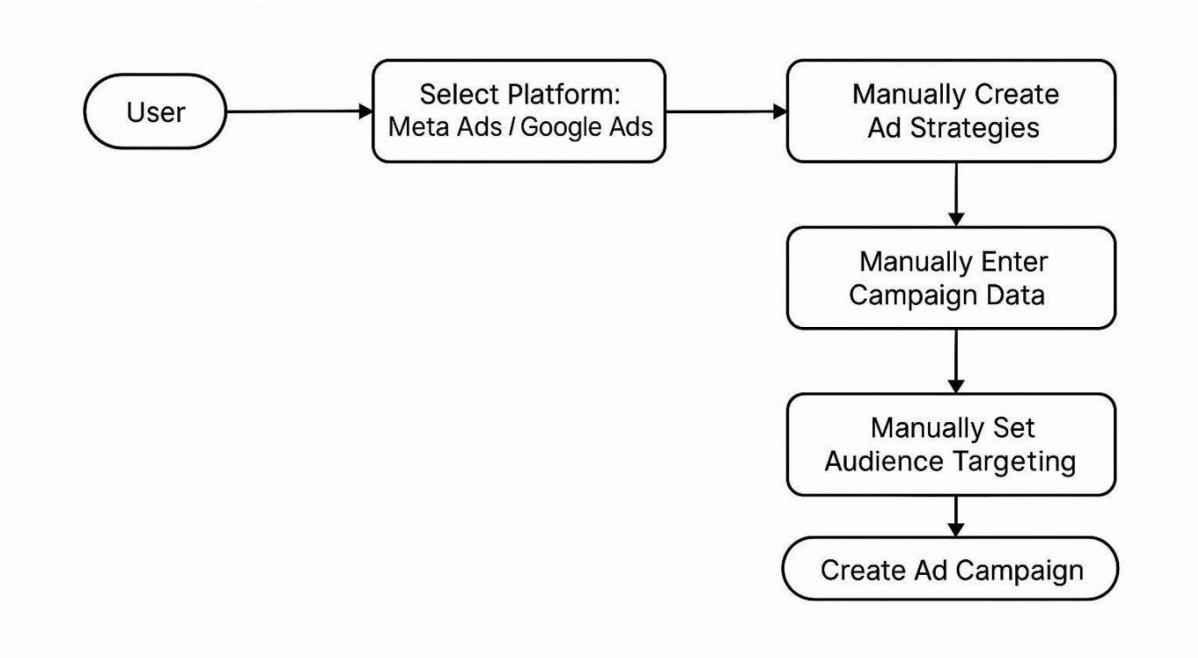


FIGURE 3.3.1 EXISTING BLOCK DIAGRAM

CHAPTER 4

PROBLEM IDENTIFIED

A major problem identified in the existing system is the complete absence of real-time water quality monitoring. Traditional dispensers cannot track essential parameters such as pH, turbidity, temperature, or TDS, which are crucial indicators of water safety. As a result, contamination caused by environmental factors, microbial growth, or pipeline impurities may go unnoticed for extended periods. Since there is no automatic valve control or safety mechanism, the dispenser continues to release potentially unsafe water to users. This inability to detect and respond to water-quality variations poses significant health risks, especially in public environments where large numbers of users depend on the dispenser. The lack of intelligent monitoring makes the system unreliable in ensuring consistent safety standards.

Another major problem is the over dependence on manual inspections for maintaining hygiene and identifying impurities. Staff members must physically inspect the tank, pipelines, and filters, which often leads to inconsistency, delays, and human error. Visible impurities such as insects, algae, dust, plastic particles, and color changes remain undetected because existing systems do not have a camera or AI-based image analysis to automatically identify contamination. As a result, the water may appear clean from the outside while the internal storage tank deteriorates over time. Since the system lacks any form of automated impurity detection, users unknowingly consume unsafe water. This problem becomes more severe in high-usage environments where frequent checks are required but cannot be practically maintained.

A significant limitation identified is the absence of IoT connectivity and data logging capabilities in existing dispensers. Without cloud or mobile application support, the system cannot alert administrators about contamination, filter failures, or tank hygiene issues. This leads to delayed maintenance, slow responses, and prolonged exposure to unsafe water conditions.The system also lacks the ability to store historical data, making it impossible to analyze contamination trends, track equipment performance, or identify repeating issues. Without logs or past records, predictive maintenance—such as timely filter replacement, cleaning reminders, or forecasting contamination risks—is not achievable. Overall, the lack of communication and data intelligence severely limits the system's ability to ensure reliable and safe water distribution.

CHAPTER 5
PROPOSED SYSTEM

The proposed AI-Assisted IoT-Enabled Water Dispenser with Safety and Hygiene Monitoring introduces a modern, intelligent, and automated approach to ensure the safe distribution of drinking water. Unlike traditional dispensers, this system integrates a powerful combination of advanced sensors, artificial intelligence, machine learning, image processing, IoT-based communication, and automated hardware control to maintain water hygiene at all times. The system continuously monitors key water-quality parameters such as pH, turbidity, TDS, and temperature, while an onboard camera examines water for visible impurities like dust, insects, discoloration, or suspended particles. All sensor readings and image data are processed through an AI-driven decision-making engine that can instantly classify water as safe or contaminated. Based on these classifications, the system automatically controls the solenoid valve, restricting water flow during unsafe conditions and ensuring that no contaminated water is dispensed.

In addition to real-time decision-making, the IoT module sends notifications to administrators or users through mobile apps or cloud dashboards, providing immediate alerts in case of contamination or system abnormalities. This eliminates delays caused by manual inspection and increases trust in the system’s safety standards. The proposed design also logs historical data, enabling trend analysis, contamination prediction, and timely maintenance actions such as filter replacement or tank cleaning. By combining AI intelligence with IoT connectivity and automation, the system ensures high reliability, minimal manual involvement, and continuous oversight—making it ideal for high-usage environments such as schools, colleges, hospitals, hostels, offices, and industrial facilities. Overall, the proposed system transforms a conventional water dispenser into a smart, self-monitoring, self-protecting, and user-aware hygiene platform that significantly enhances public health and water safety.

5.1 SYSTEM OVERVIEW

The proposed system introduces a highly advanced and fully integrated smart platform that brings together hardware sensors, AI-driven analytics, IoT-based communication, and automated safety mechanisms to guarantee the safe and hygienic dispensing of drinking water. Unlike traditional dispensers, which rely solely on manual inspection, this system continuously and intelligently monitors a wide range of critical water-quality parameters—

including pH, turbidity, TDS, temperature, and visual impurities—through precision sensors and a high-resolution camera module. The collected data is processed in real time by sophisticated AI and machine learning models, which analyze patterns, detect abnormalities, identify physical contaminants, and classify the overall safety level of the water.

Based on the severity of contamination detected, the system automatically performs multiple safety actions such as triggering digital alerts, activating visual warnings, sending IoT notifications, and shutting off the solenoid valve to prevent the flow of unsafe water. These automated decisions ensure that users are never exposed to contaminated water, even for a moment. All monitored data is securely stored and logged in the cloud, enabling detailed historical analysis, contamination trend tracking, and predictive maintenance insights such as filter replacement scheduling or tank cleaning reminders. Administrators and users are kept informed through a user-friendly mobile app or cloud dashboard, which provides real-time system status, alerts, reports, and safety updates.

5.1.1 SENSOR INPUT LAYER

This layer is responsible for continuously collecting real-time water-quality data through an array of specialized sensors and detection modules integrated into the dispenser. It includes a pH sensor, which monitors the acidity or alkalinity of the water, ensuring that the chemical balance remains within safe consumption limits. A turbidity sensor measures the clarity of the water by detecting suspended particles, sediments, and cloudiness, which are common indicators of contamination. The TDS sensor evaluates the concentration of dissolved impurities and minerals, helping identify chemical pollution or abnormalities in water purity. Additionally, a temperature sensor tracks thermal variations, since temperature changes can encourage microbial growth and affect overall water safety. To complement these chemical readings, a camera module captures real-time images of the water flow and storage area, enabling AI to detect visible impurities such as dust, insects, discoloration, algae formation, or floating debris.

All sensors operate automatically without requiring any manual input from the user and continuously send real-time data to the AI processing unit. This enables uninterrupted monitoring and rapid detection of any abnormal water conditions. By combining all sensor inputs, the system ensures precise, reliable, and proactive detection of both chemical and physical contaminants.

5.1.2 AI-BASED WATER SAFETY ANALYSIS ENGINE

The AI-Based Water Safety Analysis Engine serves as the core intelligence module of the proposed system, responsible for interpreting and analyzing all sensor and image data with high accuracy. Instead of relying on simple threshold-based readings, this engine uses advanced machine learning and image classification techniques to understand the true condition of the water. It analyzes multi-sensor inputs such as pH, turbidity, TDS, and temperature to detect subtle variations that may indicate contamination. Simultaneously, the camera module provides visual data that the AI processes to identify physical impurities, including dust particles, insects, discoloration, algae formation, or floating debris. By combining chemical and visual insights, the AI model can distinguish between normal fluctuations and harmful contamination patterns more effectively than traditional systems.

The engine also identifies critical indicators such as sudden turbidity spikes, abnormal pH drops, or visible foreign substances, enabling it to determine the severity of contamination. Based on this intelligent classification, the system predicts the current safety level of the water and takes immediate automated action such as generating warnings, updating dashboards, and triggering valve shutoff mechanisms. This AI-driven decision-making ensures rapid, accurate, and consistent monitoring without human intervention, significantly improving the reliability and hygiene of water dispensing in public environments.

Furthermore, the AI engine continuously learns from new sensor data to improve its accuracy over time, making the system smarter with every usage. It adapts to environmental changes, seasonal variations, and common contamination patterns, ensuring long-term reliability. This dynamic learning capability allows the system to evolve into a highly efficient, self-improving safety mechanism that consistently maintains drinking water quality.

5.1.3 ML-BASED WATER QUALITY PREDICTION ENGINE

The ML-Based Water Quality Prediction Engine forms an advanced analytical layer of the proposed system, using machine learning algorithms to classify and forecast water safety with high precision. Machine learning models such as Random Forest, along with SMOTE-enhanced datasets, analyze complex sensor patterns to categorize water into different safety levels—Safe, Mildly Unsafe, Moderately Contaminated, and Highly Contaminated (Critical). Unlike simple rule-based systems, this module evaluates multiple parameters simultaneously, identifying hidden correlations between pH, turbidity, TDS, temperature, and visual impurity data. By learning from historical records and previously detected contamination events, the model can predict upcoming contamination trends, filtration issues, or tank hygiene deterioration before they become severe.

As more data is collected over time, the model continuously improves its accuracy, becoming better at distinguishing between natural fluctuations and genuine contamination. This predictive ability allows administrators to schedule maintenance activities proactively, such as filter replacement or tank cleaning, reducing the chances of unexpected failures. Additionally, the ML predictor acts as a second validation layer for the AI-based classification engine, ensuring more reliable decision-making. By integrating predictive intelligence into the system, this module significantly enhances water safety, operational efficiency, and long-term hygiene management in high-use environments.The prediction engine improves continuously as more data is collected from daily usage. Each new sensor reading and image sample becomes part of the training dataset, helping the model learn evolving contamination patterns influenced by seasonal changes, water source variations, or tank again

In addition, the ML module aids in trend visualization and reporting, offering administrators a clear understanding of water-quality behaviour across weeks, months, and seasons. This historical insight makes it possible to identify recurring problems, assess filter life cycles, optimize cleaning schedules, and ensure continuous compliance with hygiene standards. Overall, this predictive engine significantly enhances the dispenser's intelligence, turning it into a robust, proactive, and data-driven water safety management system.

5.1.4 SAFETY CONTROL INTERFACE

The Safety Control Interface acts as the final decision-execution layer of the proposed system, ensuring that every action taken is directly aligned with the contamination level identified by the AI and ML modules. Once the water-quality data is classified, this interface instantly determines the appropriate safety response. If the water is safe, normal dispensing operation continues without interruption. However, if even mild contamination is detected, the interface activates visual indicators such as LEDs or on-screen LCD warnings to alert users. For moderate contamination, it triggers audible alarms or buzzer notifications to draw immediate attention to potential risks. In cases of severe contamination or critical safety threats, the interface automatically shuts off the solenoid valve, physically blocking the flow of unsafe water and preventing accidental consumption.

The Safety Control Interface effectively bridges intelligent analysis with physical response mechanisms, reducing manual intervention and ensuring that no contaminated water is dispensed under any circumstances. Through automated decision execution, real-time warnings, and transparent communication, this module enhances reliability, improves user confidence, and significantly strengthens overall water hygiene management.

5.2 PROPOSED ARCHITECTURE

The proposed system architecture is an intelligent water-dispensing solution designed to eliminate the drawbacks of traditional systems. By integrating IoT sensors, AI-based impurity detection, automatic safety controls, and real-time monitoring, the system ensures that water delivered to users is always safe, hygienic, and contamination-free.

5.2.1 SENSOR AND CAMERA ACQUISITION UNIT

The system begins by continuously collecting real-time data from multiple sensing components. The pH sensor, TDS sensor, turbidity sensor, and temperature sensor measure the chemical and physical characteristics of the water, ensuring that any abnormal variation is immediately captured. Alongside these sensors, a 360° camera module records visual information, allowing the system to detect visible impurities such as dust, insects, or discoloration in the water. Together, these inputs provide a comprehensive picture of water quality, combining chemical parameters with visual evidence to ensure accurate and reliable monitoring.

5.2.2 AI-BASED DATA PROCESSING UNIT

The data gathered from the sensors and camera is transmitted to the ESP32 or Raspberry Pi, which acts as the central processing unit for the entire system. This unit handles both multi-sensor numerical readings—such as pH, TDS, turbidity, and temperature—and continuous camera-image frames captured by the 360° vision module. Once the raw data reaches the processing unit, it is forwarded to the integrated AI engine, which plays a critical role in interpreting and analyzing these inputs. The AI model classifies the water based on its safety level, detects visible impurities that may be present in the captured images, and identifies any form of chemical contamination indicated by abnormal sensor fluctuations. Using this analysis, the AI decides whether the system should continue normal operation or initiate emergency actions such as alerting users, stopping water flow, or updating the cloud with critical warnings. This intelligent decision-making mechanism ensures that the dispenser consistently provides safe, clean water while immediately responding to any detected risk..

5.2.3 WATER SAFETY CLASSIFICATION

Based on the processed output from both the sensor readings and the AI-analysis engine, the system initiates an intelligent decision-making sequence that governs the final user-facing actions. When all monitored parameters—such as pH, TDS, turbidity, and temperature—fall within acceptable limits and the camera detects no physical impurities, the system confidently classifies the water as safe. In this condition, a green LED is activated to visually reassure users, and the solenoid valve remains open, allowing water to flow normally from the dispenser. This ensures smooth operation while maintaining consistent safety assurance.However, when the machine-learning model identifies abnormalities in chemical quality—such as an unexpected drop in pH, a sharp rise in turbidity, or an increase in dissolved solids—the water is classified as unsafe. In this case, the system immediately switches on the red LED as a warning indicator and restricts or completely halts the water flow to prevent consumption of potentially harmful water. This rapid automated response eliminates the risks associated with delayed manual inspection.Furthermore, if the camera module detects visual contaminants such as insects, dust particles, floating debris, or discoloration in the water stream or tank, the system goes into a critical safety state. An alert message is displayed on the LCD, ensuring that users and administrators are instantly informed of the issue. Simultaneously, the system triggers an automatic valve shutoff to completely stop water dispensing. This visual detection-based action adds an extra layer of protection that traditional dispensers lack, safeguarding against impurities that sensors alone may miss.By combining chemical sensing, visual inspection, and AI-driven reasoning, the system provides a robust, multi-layered safety mechanism that guarantees hygiene, prevents accidental consumption of contaminated water, and maintains a continuous feedback loop for safe operation

5.2.4 AUTOMATED SAFETY RESPONSE LAYER

The Automated Safety Response Layer acts as the protective shield of the entire water dispensing system, ensuring that no unsafe water is ever consumed. When the AI engine detects any form of contamination—whether chemical abnormalities from sensor data or physical impurities from the camera analysis—this layer immediately intervenes to safeguard the user. The first action taken is to instantly stop the water flow by closing the solenoid valve, preventing contaminated water from reaching the dispenser outlet. At the same time, the system activates prominent LCD warning messages, clearly informing users and administrators about the nature of the issue, such as “Unsafe Water Detected,” “High

Turbidity," or "Impurity Found."To enhance visibility and user awareness, the system also triggers red LED indicators, serving as a real-time visual alert that the dispenser is in a critical state. These warnings remain active until the contamination is resolved and the system confirms that water parameters have returned to safe levels. By automatically responding without requiring human intervention, this layer eliminates the possibility of accidental water consumption during hazardous conditions. It acts swiftly, reliably, and intelligently, ensuring that safety is always maintained—even in high-traffic public environments where manual inspection is impractical.

5.2.5 USER NOTIFICATION LAYER

The User Notification Layer keeps users and administrators continuously informed about water-quality status through LCD messages and LED indicators. Safe or unsafe conditions are displayed instantly, with green or red lights offering quick visual feedback. For remote monitoring, IoT alerts can be sent to mobile apps or dashboards whenever an issue occurs. After delivering alerts and taking necessary actions, the system automatically resets and continues real-time monitoring.

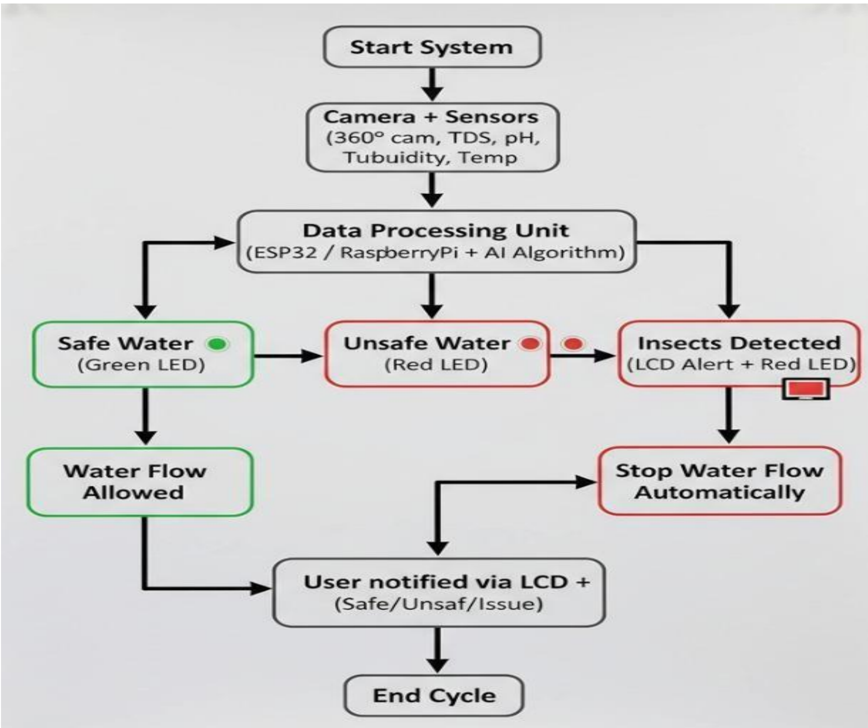


FIGURE : 5.2 PROPOSED ARCHITECTURE DIAGRAM

5.3 SYSTEM FEATURES

The proposed AI-assisted IoT-enabled water dispenser introduces a highly advanced, intelligent, and automated approach to water-quality monitoring that goes far beyond the capabilities of any traditional dispensing system. By integrating a powerful combination of real-time chemical sensors, high-resolution imaging modules, AI classification algorithms, IoT connectivity, and automated safety hardware, the system operates as a self-sufficient hygiene monitoring ecosystem. Each component plays a critical role: sensors continuously measure pH, TDS, turbidity, and temperature to detect chemical contamination; the camera captures visual impurities otherwise invisible to sensors; and the AI engine intelligently evaluates abnormalities with high precision. This multi-layered fusion of data enables the system to detect contamination at the earliest stage and initiate immediate corrective actions.Once abnormalities are detected, the system executes rapid, automated responses—closing the solenoid valve, activating LED warnings, displaying detailed alerts on the LCD, and notifying administrators through IoT platforms. This ensures that unsafe water is never dispensed to users, regardless of the time, environment, or human availability. Unlike conventional methods that rely heavily on manual inspection and scheduled maintenance, the proposed system continuously monitors water conditions without interruption, minimizing human error and eliminating delays in detection and response. This shift from reactive maintenance to proactive, intelligent supervision represents a major leap in public safety and water hygiene management.The system not only safeguards users but also provides transparency and accountability through digital logs, cloud data storage, and monitoring dashboards. Administrators gain access to historical data, contamination reports, and predictive insights that help identify patterns, optimize cleaning schedules, and improve filtration efficiency. This makes the system highly beneficial for high-demand public environments such as schools, hospitals, offices, hostels, and industrial workplaces where water consumption is frequent and hygiene is critical.In essence, the proposed solution transforms a simple water dispenser into a sophisticated safety device equipped with artificial intelligence, automated decision-making, and smart communication capabilities. It acts as a full-time, self-monitoring guardian that continuously analyzes, detects, decides, responds, and informs.

CHAPTER 6

SYSTEM REQUIREMENTS

0.1 HARDWARE REQUIREMENTS

Microcontroller	: ESP32 Wi-Fi API Key
Sensors	: pH, TDS, Turbidity, and Temperature sensors
Camera	: Waterproof AI camera
Actuator	: Solenoid valve
Display	: LCD display and LED indicators
Power Supply	: 5V/12V DC adapter

0.2 SOFTWARE REQUIREMENTS

Programming Platform	: WOKWI
AI/ML Development	: Python 3.9 with Scikit-learn, TensorFlow
IoT Platform	: ThingSpeak or Blynk Cloud
Database	:MySQL / Firebase
Libraries	: NumPy, Pandas, OpenCV, Matplotlib
OS	: Windows 10 / Ubuntu 22.04 LTS

CHAPTER 7
SYSTEM IMPLEMENTATION

7.1 LIST OF MODULES

Module 1: Multi-Sensor Water Quality Monitoring Module

Module 2: AI-Based Water Safety Analysis Engine

Module 3 :ML-Based Water Quality Prediction Module

Module 4:Automated Valve Control & Safety Response Module

Module 5: IoT communication and Cloud Monitoring Module

7.2 MODULE DESCRIPTION

7.2.1 MULTI-SENSOR WATER QUALITY MONITORING MODULE:

This module continuously collects real-time water quality data using sensors such as pH, turbidity, TDS, and temperature, along with a camera for visual impurity detection. Each sensor focuses on a specific parameter, providing a complete chemical and physical assessment of the water. The module works automatically without manual input, sending uninterrupted data to the system. This real-time monitoring ensures quick identification of contamination and forms the foundation for accurate safety analysis

7.2.2 AI- BASED WATER SAFETY ANALYSIS ENGINE

This module analyzes sensor readings and camera images using artificial intelligence to determine water safety in real time. It identifies abnormal patterns such as sudden turbidity spikes, low pH, or visible impurities like dust or insects. By combining chemical data and visual analysis, it provides a more accurate assessment of contamination. The AI engine enables quick decisions, ensuring unsafe water is detected instantly.

7.2.3 ML-BASED WATR QUALITY PREDICTION MODULE

This module uses machine learning models such as Random Forest to classify water safety and predict future contamination trends. It learns from historical and current sensor data, becoming more accurate over time. The ML module identifies underlying patterns and provides early warnings about possible hygiene issues. It also strengthens decision-making by validating AI results and reducing false alarms.

7.2.4 AUTOMATED VALVE CONTROL AND SAFETYRESPONSE MODULE

This module automatically controls the solenoid valve based on AI/ML decisions, ensuring contaminated water is never dispensed. When unsafe levels are detected, it instantly shuts the valve and activates alerts through LED s, buzzers, or LCD messages. It provides fast and reliable safety responses without human involvement. This module protects users by enforcing strict hygiene control at all times.

7.2.5 IoT COMMUNCICATION AND CLOUD MONITORING MODULE

The IoT Communication & Cloud Monitoring Module enables the system to stay connected with remote devices, cloud servers, and mobile applications. It continuously sends real-time data such as sensor readings, AI-based water safety classifications, valve actions, and contamination alerts to an online dashboard accessible to administrators. This ensures instant visibility of system status and allows users to receive timely notifications regarding unsafe water, filter replacement needs, or maintenance reminders.

Additionally, the module stores historical data in the cloud, enabling long-term analysis, trend visualization, and better understanding of contamination patterns. Through IoT connectivity, multiple dispensers installed across different locations can be centrally monitored and managed, providing consistency and transparency in water safety. This transformed connectivity elevates the dispenser into a smart, remotely manageable, and highly reliable hygiene monitoring system.

CHAPTER 8

SYSTEM TESTING

The primary purpose of testing in the AI-Assisted IoT-Enabled Water Dispenser *with* Safety and Hygiene Monitoring project is to ensure that the entire system functions accurately, safely, and reliably under real-world operating conditions. Testing helps verify that all sensors, AI models, IoT modules, and automated safety mechanisms work together seamlessly to detect contamination and prevent unsafe water from being dispensed. It also confirms that the system meets all functional requirements, including real-time monitoring, automatic valve control, impurity detection, and instant alert generation.

8.1 TESTING STRATEGIES

To ensure the The testing strategy for the AI-Assisted IoT-Enabled Water Dispenser is designed to ensure complete validation of both hardware and software components through a structured and systematic approach. The system is evaluated using a combination of black-box and white-box testing strategies, where black-box testing examines the overall functionality—such as detecting contamination, shutting off the valve, and sending alerts—without checking the internal code, while white-box testing verifies the internal logic of AI models, sensor data processing algorithms, and decision-making rules. Integration testing is used to confirm proper interaction between key modules like sensors, AI engine, IoT communication, and valve control, ensuring that the entire workflow operates seamlessly as a unified system.

Additionally, real-time field testing is conducted with actual water samples to observe system behavior under practical environmental conditions, verifying the stability of readings, accuracy of predictions, and responsiveness of automated safety actions. Stress and endurance testing further ensure that the dispenser can run continuously for long durations without sensor drift, communication failure, or performance drop. Together, these strategies provide comprehensive assurance that the system is reliable, safe, and ready for real-world deployment.

8.1.1 SENSOR CALIBRATION AND ACCURACY TESTING

Sensor Calibration and Accuracy Testing is one of the most critical phases of the system validation process, as the reliability of the water dispenser depends on the correctness of the data captured by all sensors. In this stage, each sensor—pH, turbidity, TDS, temperature, and the camera module—is individually tested using known standard reference solutions. The pH sensor is calibrated using buffer solutions (pH 4, 7, 10) to check linearity, while the turbidity sensor is verified using water samples with controlled levels of suspended particles. The TDS sensor is tested with solutions of known conductivity, ensuring that electrical fluctuations do not distort measurements. The temperature sensor is checked using warm, cold, and room-temperature water samples to confirm thermal response accuracy. The camera module undergoes both image clarity and visual impurity recognition tests under different lighting conditions to ensure stable detection. This testing phase also checks for sensor drift, signal interference, and responsiveness over time. Through repeated iterations of calibration and validation, this phase ensures that the AI and ML models receive clean, accurate, and reliable data that forms the foundation of the entire water quality monitoring system.

8.1.2 AI AND MACHINE LEARNING MODEL TESTING

AI and ML Model Testing focuses on verifying the intelligence and decision-making accuracy of the algorithms responsible for contamination detection. The AI-driven image classification module is rigorously tested using an extensive dataset containing images of clean water, discolored water, water with visible impurities, micro-debris, insects, and turbidity variations. The model's performance is measured through accuracy, recall, precision, F1-score, and confusion matrix analysis to ensure that impurity detection is sensitive and consistent. Similarly, the ML-based contamination classifier (Random Forest with SMOTE) is tested using multiple sets of sensor readings covering safe, mildly unsafe, moderately contaminated, and highly contaminated water conditions. The goal is to confirm that the model correctly classifies each category and avoids false positives and false negatives, which are critical for user safety. The testing also includes robustness validation, where extreme or unusual input patterns are given to the AI model to ensure it does not misbehave in edge cases. Additional checks such as model performance under noisy data, lighting interference, or sensor fluctuation are performed to evaluate resilience. This testing ensures the decision-making core of the system operates with high accuracy and reliability in real-time scenarios.

8.1.3 FUNCTIONAL SAFETY AND VALVE RESPONSE TESTING

Functional Safety and Valve Response Testing ensures that the dispenser reacts correctly and immediately when unsafe water is detected. In this phase, multiple contamination scenarios—such as high turbidity, abnormal pH, increased TDS, temperature spikes, and visible impurities—are simulated to test how the system responds. The solenoid valve is tested for its speed of activation, mechanical reliability, and electrical stability to ensure it closes instantly when contamination crosses the safe threshold. Warning mechanisms such as LED indicators, LCD display messages, and buzzer alerts are evaluated for clarity, timing, and effectiveness in informing users and administrators. The system is tested repeatedly to check how consistently it performs safety actions without delay or malfunction. Fail-safe conditions such as sensor disconnection, lack of camera input, or AI classification errors are also simulated to evaluate whether the dispenser defaults to a safe state by stopping water flow. This testing confirms that the system meets safety standards and ensures no contaminated water reaches the users under any circumstances.

8.1.4 IoT CONNECTIVITY AND CLOUD COMMUNICATION TESTING

IoT Connectivity and Cloud Communication Testing is performed to ensure that real-time notifications, system status updates, and water quality logs are accurately transmitted to cloud dashboards and mobile applications. The system is tested under different network conditions such as strong Wi-Fi, weak signals, intermittent connectivity, and temporary disconnection scenarios to evaluate reliability. It verifies that alerts related to contamination, valve shutoff, sensor malfunction, and maintenance reminders reach administrators without delay. The cloud logging system is tested to ensure historical data such as sensor readings, contamination events, AI classifications, and valve actions are correctly stored and retrievable for analysis. Synchronization tests are conducted when multiple dispensers operate across different locations, ensuring all devices communicate seamlessly with a centralized monitoring portal. This testing phase confirms that the IoT system supports remote supervision, timely intervention, and transparent reporting, which are essential for public deployment environments like schools, hospitals, hostels, and workplaces.

CHAPTER 9

RESULTS AND DISCUSSION

The results obtained from the AI-Assisted IoT-Enabled Water Dispenser with Safety and Hygiene Monitoring clearly indicate that the developed system performs with high accuracy, stability, and reliability across all tested conditions. Sensor calibration trials confirmed that pH, turbidity, TDS, and temperature sensors consistently produced precise readings with minimal deviation, enabling the system to monitor chemical parameters with scientific accuracy. The AI-powered image processing module demonstrated strong visual impurity detection capabilities, successfully identifying contaminants such as suspended dust, insects, discoloration, and micro-floating particles under different lighting and flow conditions, thus significantly improving hygiene monitoring beyond what traditional dispensers can achieve.

The machine learning prediction model, enhanced using SMOTE, accurately classified water across multiple contamination levels and showed robustness even when exposed to noisy or borderline sensor patterns. Functional testing revealed that the solenoid valve, buzzer, LED indicators, and LCD display acted immediately and correctly during contamination events, ensuring rapid safety intervention and preventing the consumption of unsafe water.

The IoT communication module further strengthened the system by reliably transmitting alerts, valve actions, sensor logs, and contamination reports to cloud dashboards and mobile interfaces, enabling seamless remote supervision even under fluctuating network conditions. Together, these results show that the proposed system not only meets but surpasses the core objectives of safety, automation, and smart monitoring.

The combined integration of sensors, AI, ML, cloud connectivity, and automated control has transformed the conventional water dispenser into a highly intelligent, self-monitoring hygiene system capable of maintaining public health standards in high-usage environments such as schools, colleges, hospitals, offices, and hostels. This demonstrates that the developed model is a practical, scalable, and effective solution for real-world deployment

CHAPTER 10

CONCLUSION AND FUTURE WORK

10.1 CONCLUSION

The AI-Assisted IoT-Enabled Water Dispenser with Safety and Hygiene Monitoring system successfully fulfills its objective of providing a modern, intelligent, and reliable solution for ensuring safe drinking water in public environments. The integration of multi-parameter sensors, AI-based image analysis, and machine learning classification significantly enhances the accuracy of contamination detection, addressing the limitations of traditional dispensers that rely solely on human inspection or basic filtration indicators. The automated solenoid valve control ensures immediate safety action by stopping the flow of water whenever the system detects unsafe chemical or physical impurities. Additionally, the IoT communication layer enables real-time alerts, remote supervision, and cloud-based data logging, ensuring transparency and efficient maintenance. The combined results from hardware validation, AI and ML testing, and real-time field analysis demonstrate that the proposed system operates reliably, consistently, and intelligently under various conditions. Overall, the project proves that applying AI, IoT, and automation to water dispensing can significantly improve public health, reduce manual dependency, and promote hygienic water distribution in institutions and workplaces.

10.2 FUTURE ENHANCEMENT

Although the current system performs effectively, several enhancements can further improve its functionality, scalability, and adaptability. Advanced AI models, such as deep learning-based impurity detection, can be incorporated to recognize microscopic contaminants and improve accuracy under challenging lighting conditions. Future versions may integrate real-time microbial detection sensors to classify biological contamination, making the system even more comprehensive. The dispenser could also be enhanced with a self-cleaning mechanism that automatically sanitizes the tank and pipeline at regular intervals. Expanding mobile application features—such as usage statistics, water consumption analytics, and predictive maintenance dashboards—can provide administrators with greater insights. Implementation of GSM-based communication would allow deployment in remote areas without Wi-Fi access. Additionally, solar-powered operation can make the system more energy-efficient and suitable for rural or outdoor environments

APPENDIX:1

SOURCE CODE

Sketch.ino

```
/* E/* ESP32 Smart Water Dispenser with LCD + IoT + AI Camera Simulation (Wokwi)
E/* ESP32 Smart Water Dispenser with LCD + IoT + AI Camera Simulation (Wokwi)
SP32 Smart Water Dispenser with LCD + IoT + AI Camera Simulation (Wokwi)
  - Potentiometers simulate sensors:
    A0 (GPIO34) -> pH
    A1 (GPIO35) -> TDS
    A2 (GPIO32) -> Turbidity
  - Green LED -> GPIO16 (safe)
  - Red LED   -> GPIO17 (unsafe)
  - Solenoid simulate -> GPIO18 (HIGH=open, LOW=closed)
  - Camera simulation button -> GPIO25 (pressed = impurity detected)
  - LCD 16x2 I2C -> SDA(21), SCL(22)
*/

#include <WiFi.h>
#include <HTTPClient.h>
```

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// --- CONFIG ---
const char* ssid     = "Wokwi-GUEST";  //
default WiFi for simulation
const char* password = "";
const char* thingspeakApiKey =
"V25PCE3GWSC1U1CC"; // your
ThingSpeak key

// --- LCD setup ---
LiquidCrystal_I2C lcd(0x27, 16, 2); //
address 0x27 for most I2C LCDs

// --- PINS ---
const int pin_pH = 34;
const int pin_TDS = 35;
const int pin_TURB = 32;
const int camSignalPin = 25; // AI camera
simulated input

const int ledGreen = 16;
const int ledRed = 17;
const int solenoidPin = 18;
```

```
unsigned long lastSend = 0;
const unsigned long sendInterval = 15000;

// --- Thresholds ---
float pH_min = 6.5;
float pH_max = 8.0;
int tds_max = 500;
int turb_max = 5;

void setup() {
  Serial.begin(115200);
  pinMode(ledGreen, OUTPUT);
  pinMode(ledRed, OUTPUT);
  pinMode(solenoidPin, OUTPUT);
  pinMode(camSignalPin,
INPUT_PULLDOWN);   //  camera  button
input

  // LCD setup
  lcd.init();
  lcd.backlight();
  lcd.setCursor(0, 0);
  lcd.print("Smart Dispenser");
  lcd.setCursor(0, 1);
  lcd.print("Initializing...");
  delay(2000);
```

```
  lcd.clear();

  // Start with valve open
  digitalWrite(solenoidPin, HIGH);
  digitalWrite(ledGreen, HIGH);
  digitalWrite(ledRed, LOW);

  // Connect Wi-Fi
  WiFi.begin(ssid, password);
  Serial.print("Connecting to WiFi");
  lcd.setCursor(0, 0);
  lcd.print("WiFi Connecting");
  int retries = 0;
  while                (WiFi.status()                !=
WL_CONNECTED && retries < 20) {
    delay(500);
    Serial.print(".");
    retries++;
  }
  Serial.println();
  if (WiFi.status() == WL_CONNECTED)
{
    Serial.println("WiFi connected.");
    Serial.print("IP:                              ");
Serial.println(WiFi.localIP());
    lcd.clear();
```

```
    lcd.setCursor(0, 0);
    lcd.print("WiFi Connected");
  } else {
    Serial.println("WiFi not connected!");
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("WiFi Failed!");
  }
  delay(1000);
  lcd.clear();
}

float read_pH() {
  int raw = analogRead(pin_pH);
  float ph = map(raw, 0, 4095, 40, 100) /
10.0;
  return ph;
}

int read_TDS() {
  int raw = analogRead(pin_TDS);
  int tds = map(raw, 0, 4095, 0, 1000);
  return tds;
}
```

```
int read_turbidity() {
  int raw = analogRead(pin_TURB);
  int turb = map(raw, 0, 4095, 0, 10);
  return turb;
}

bool evaluateSafety(float ph, int tds, int
turb) {
  bool cameraUnsafe =
digitalRead(camSignalPin); // Camera
signal
  if (cameraUnsafe) {
    Serial.println("AI Camera: Impurity
Detected!");
    return false; // unsafe if camera sees
impurity
  }
  if (ph < pH_min || ph > pH_max) return
false;
  if (tds > tds_max) return false;
  if (turb > turb_max) return false;
  return true;
}

void updateThingSpeak(float ph, int tds, int
turb) {
```

```
  if (WiFi.status() != WL_CONNECTED)
return;
  if (millis() - lastSend < sendInterval)
return;
  lastSend = millis();
  HTTPClient http;
  String url =
"http://api.thingspeak.com/update?api_key
=";
  url += thingspeakApiKey;
  url += "&field1=" + String(ph, 2);
  url += "&field2=" + String(tds);
  url += "&field3=" + String(turb);
  Serial.println("Sending to ThingSpeak: "
+ url);
  http.begin(url);
  int httpCode = http.GET();
  if (httpCode > 0) {
    Serial.printf("ThingSpeak
response: %d\n", httpCode);
  } else {
    Serial.println("ThingSpeak failed");
  }
  http.end();
}
```

```
void loop() {
  float ph = read_pH();
  int tds = read_TDS();
  int turb = read_turbidity();

  bool safe = evaluateSafety(ph, tds, turb);

  // Update LEDs, solenoid, and LCD
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("pH:");
  lcd.print(ph, 1);
  lcd.print(" TDS:");
  lcd.print(tds);

  lcd.setCursor(0, 1);
  if (safe) {
    digitalWrite(solenoidPin, HIGH);
    digitalWrite(ledGreen, HIGH);
    digitalWrite(ledRed, LOW);
    lcd.print("SAFE to Drink");
  } else {
    digitalWrite(solenoidPin, LOW);
    digitalWrite(ledGreen, LOW);
    digitalWrite(ledRed, HIGH);
```

```
    lcd.print("UNSAFE WATER!");
    Serial.println("ALERT: Unsafe water detected - Valve CLOSED");
  }

  Serial.printf("pH: %.2f, TDS: %d, Turb: %d, Safe: %s\n",
                ph, tds, turb, safe ? "YES" : "NO");

  updateThingSpeak(ph, tds, turb);
  delay(2000);
}
```

Diagram.json


```
{
  "version": 1,
  "author": "Bavi Murugan",
  "editor": "wokwi",
  "parts": [
    { "type": "board-esp32-devkit-c-v4", "id": "esp", "top": -38.4, "left": -14.36, "attrs": {} },
    { "type": "wokwi-potentiometer", "id": "pot1", "top": -145.3, "left": -125, "attrs": {} },
```

```
    { "type": "wokwi-potentiometer", "id": "pot2", "top": -145.3, "left": 143.8, "attrs": {} },
    { "type": "wokwi-potentiometer", "id": "pot3", "top": -145.3, "left": -0.2, "attrs": {} },
    {
      "type": "wokwi-led",
      "id": "led1",
      "top": 44.4,
      "left": -101.8,
      "attrs": { "color": "limegreen" }
    },
    {
      "type": "wokwi-led",
      "id": "led2",
      "top": 111.6,
      "left": -101.8,
      "attrs": { "color": "red" }
    },
    {
      "type": "wokwi-resistor",
      "id": "r1",
      "top": 167.15,
      "left": -96,
      "attrs": { "value": "200000" }
    },
    {
```

"type": "wokwi-resistor",
"id": "r2",
"top": 99.95,
"left": -105.6,
"attrs": { "value": "200000" }
},
{
"type": "wokwi-led",
"id": "led3",
"top": 82.8,
"left": 167,
"attrs": { "color": "yellow" }
},
{
"type": "wokwi-lcd1602",
"id": "lcd1",
"top": 217.6,
"left": -71.2,
"attrs": { "pins": "i2c" }
},
{
"type": "wokwi-pushbutton",
"id": "btn1",
"top": 6.2,
"left": -172.8,

```
      "attrs": { "color": "green", "xray": "1" }
    },
    {
      "type": "wokwi-resistor",
      "id": "r3",
      "top": 71.15,
      "left": -163.2,
      "attrs": { "value": "10000" }
    }
  ],
  "connections": [
    [ "esp:TX", "$serialMonitor:RX", "", [] ],
    [ "esp:RX", "$serialMonitor:TX", "", [] ],
    [ "pot1:VCC", "esp:3V3", "green", [ "v0" ] ],
    [ "pot3:VCC", "esp:3V3", "blue", [ "v0" ] ],
    [ "pot2:VCC", "esp:3V3", "magenta", [ "v0" ] ],
    [ "pot1:GND", "esp:GND.2", "green", [ "v0" ] ],
    [ "pot3:GND", "esp:GND.2", "blue", [ "v0" ] ],
    [ "pot2:GND", "esp:GND.2", "magenta", [ "v67.2",
"h-86.4" ] ],
    [ "pot1:SIG", "esp:34", "green", [ "v0" ] ],
    [ "pot3:SIG", "esp:35", "blue", [ "v0" ] ],
    [ "pot2:SIG", "esp:32", "magenta", [ "v124.8", "h-
192.4" ] ],
    [ "led1:A", "r2:1", "red", [ "v0" ] ],
    [ "led2:A", "r1:1", "purple", [ "v0" ] ],
```

["r1:2", "esp:17", "purple", ["v0"]],
["led1:C", "esp:GND.2", "red", ["v0"]],
["led3:C", "esp:GND.2", "orange", ["v0"]],
["led3:A", "esp:18", "orange", ["v-9.6"]],
["lcd1:VCC", "esp:5V", "gray", ["h0"]],
["lcd1:GND", "esp:GND.2", "gray", ["h0"]],
["lcd1:SDA", "esp:21", "gray", ["h0"]],
["lcd1:SCL", "esp:22", "gray", ["h0"]],
["led2:C", "esp:GND.2", "purple", ["v0"]],
["r2:2", "esp:16", "red", ["v0"]],
["btn1:1.l", "btn1:1.r", "cyan", ["h0"]],
["esp:3V3", "btn1:1.r", "cyan", ["h0"]],
["btn1:2.l", "btn1:2.r", "cyan", ["h0"]],
["btn1:2.r", "r3:1", "cyan", ["h0"]],
["r3:2", "esp:25", "cyan", ["v0"]]
],
"dependencies": {}
}

APPENDIX 2

SCREENSHOTS

SCREENSHOT 1 : DEMONSTRATION

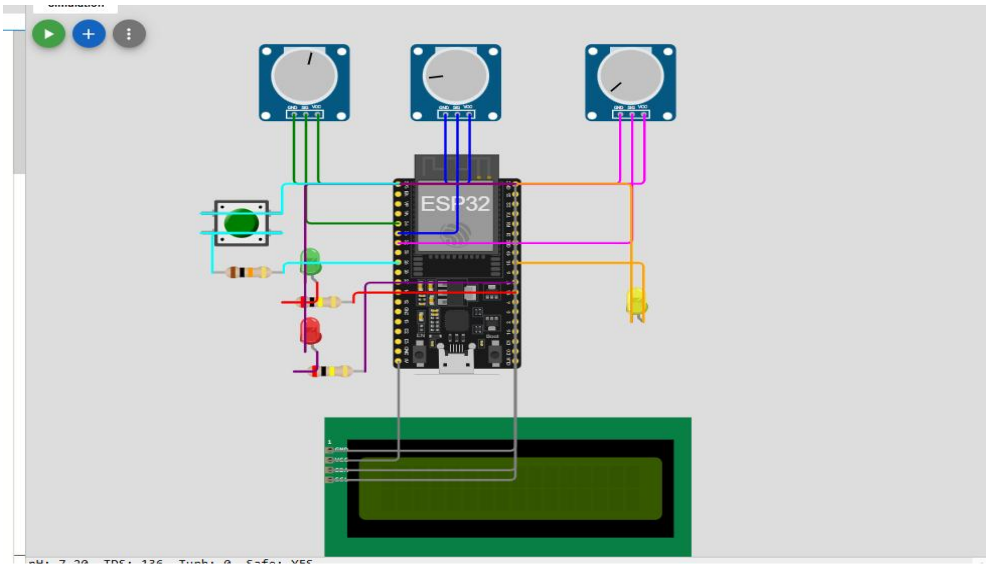


Fig.s.1

SCREENSHOT 2 : AI DETECTION MODULE

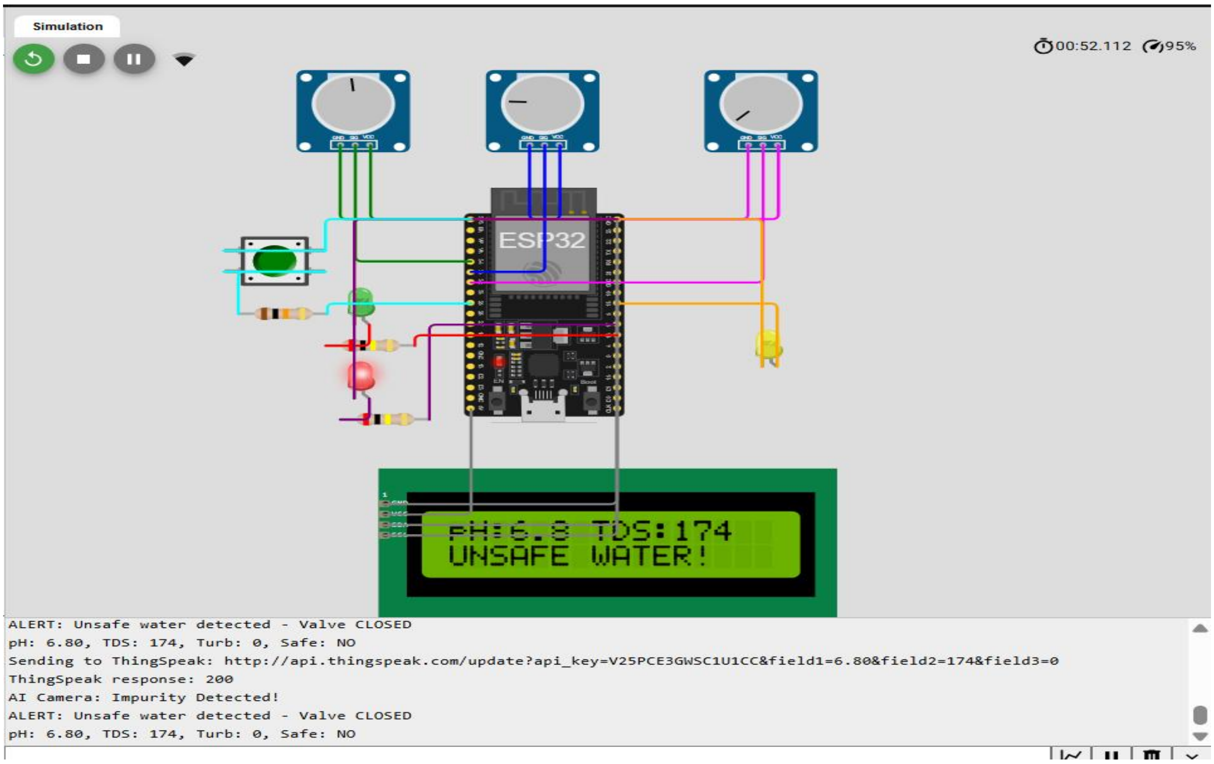
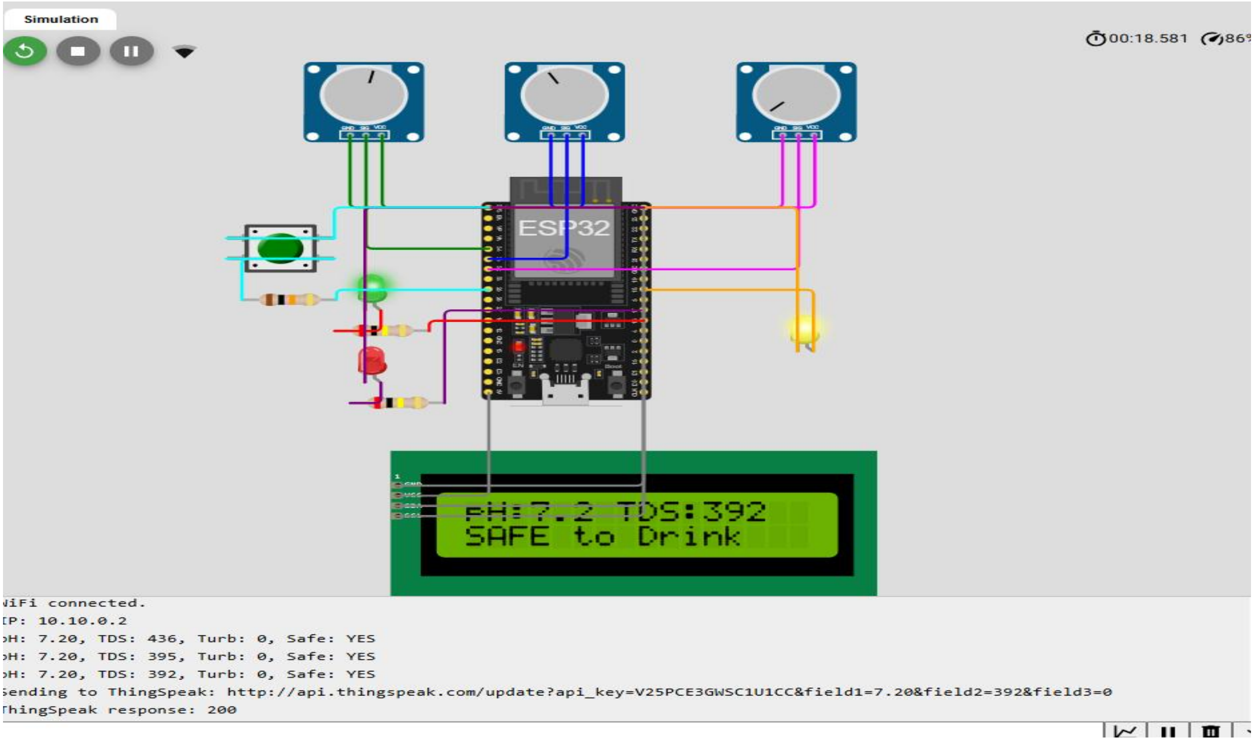
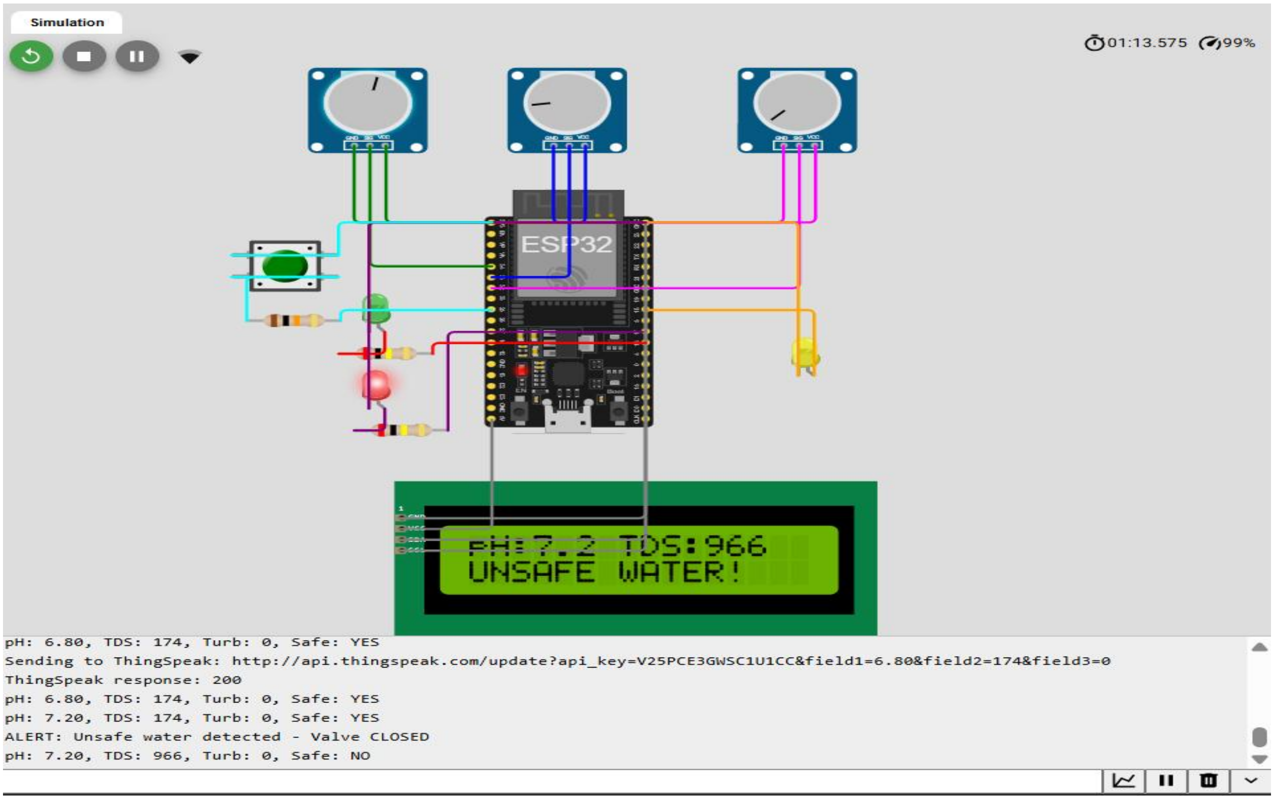


Fig.s.2

SCREENSHOT 3 : CONTROL AND AUTOMATION MODULE [fig.s.3]



SCREENSHOT 3 : IOT MONITORING AND ALTER [fig.s.4]



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ACCEPTANCE LETTER

ICEAMST

THIRD INTERNATIONAL CONFERENCE ON
Emerging Applications of Material Science and Technology
ICEAMST 2025

3-5, November 2025

https://www.iceamst.com/2025/
iceamst.conf@gmail.com

Letter of Acceptance

To

Bavi M,Dharsni S,Gopikambal N,Gopikasri T,Kavitha J Herewith, the conference committee of the 3rd International Conference on Emerging Applications of Material Science and Technology (ICEAMST 2025) is pleased to inform you that the peer-reviewed manuscript **"Paper ID: ICEAMST-442"** entitled **"AI-ASSISTED IOT-ENABLED WATER DISPENSER WITH AUTOMATED SAFETY AND HYGIENE MONITORING"** has been accepted for oral presentation as well as it will be recommended for the inclusion in 3rd ICEAMST 2025 Conference Proceedings.

The Third International Conference on Emerging Applications of Material Science and Technology [ICEAMST 2025] aims to report the innovations in electronic materials: advancing technology for a sustainable future. ICEAMST will be held on 3-5, November 2025 at RV College of Engineering (RVCE), Bengaluru, India. ICEAMST encourages the active participation of highly qualified delegates to bring you various innovative research ideas.

We congratulate you on being selected to present your research findings at our prestigious conference.

Yours' Sincerely

Dr. K. N. Subramanya
Conference Chair
3rd ICEAMST 2025

International Conference on Emerging Applications of Material Science and Technology
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Bavi M

has presented a paper titled

AI-Assisted IoT-Enabled Water Dispenser with Automated Safety and Hygiene Monitoring

at the

3rd International Conference on Emerging Applications of Material Science and Technology (ICEAMST 2025) held at R V College of Engineering, Bengaluru, India, on 3-5, November 2025.

Session Chair	Dr. Vikram N Bahadurdesai Conference Coordinator	Dr. K. N. Subramanya Conference Chair

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