

IOT – BASED INTEGRATED WATER TREATMENT SOLUTION FOR KC VALLEY

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Abstract: This project introduces an IoT-based water treatment system for the KC Valley, designed to ensure safe and sustainable water management. The system uses smart sensors to monitor water quality in real time, detecting contaminants such as heavy metals and pathogens. By integrating advanced technology, it offers a practical solution to the region's water challenges. Heavy metals such as lead, arsenic, mercury, and cadmium often enter the KC Valley water sources through industrial and agricultural activities. These pollutants can cause serious health issues and environmental harm. The water treatment system employs electrochemical sensors and filters to identify and remove these metals, ensuring water meets safety standards before use.

For microbial contamination, the system uses UV (ultraviolet) disinfection. UV rays destroy the DNA and RNA of bacteria and viruses, making them harmless. This method is chemical-free and highly effective against a wide range of pathogens, including E. coli and coliforms, providing safe drinking water for the community. All subsystems are connected via IoT, enabling remote monitoring, predictive maintenance, and automated adjustments.

This minimises manual intervention and operational costs while maximising efficiency. The system continuously analyses data to optimise filtration and disinfection processes, ensuring reliable performance. Overall, this IoT-based water treatment solution enhances water security, supports public health, and

promotes environmental sustainability in the KC and other pathogens, making them non-infectious and effectively removing them from the water. Water purification: Electrochemical and machine-learning-based systems automatically detect and remove heavy metals and other contaminants, ensuring safe water for communities. Waste-to-electricity: IOT automates sorting, processing, and conversion of organic and plastic waste into electricity, enhancing energy recovery and reducing landfill needs. A central IOT dashboard links these systems, using real-time data to optimise performance, schedule maintenance, and minimise manual work. The integration of IoT devices supports predictive management and resource efficiency. KC Valley release hazardous wastewater containing nitrates and heavy metals. Valley. It aligns with clean energy and climate action goals, making it a model for sustainable water management in similar regions.

Keywords: IoT, water treatment, smart sensors, heavy metals, electrochemical filters, UV disinfection, remote monitoring, predictive maintenance, water quality, environmental sustainability.

I. INTRODUCTION

The KC Valley faces serious environmental challenges due to increased odour, unsafe water, and inefficient waste management. IOT integrated solutions offer a practical and scalable way to simultaneously address these issues, improve local conditions, and support sustainable development.

This approach combines IoT-powered sensors and algorithms for monitoring, control, and data analysis across three main domains: UV light removes bacteria from water by penetrating the cell walls of microorganisms and disrupting their DNA or RNA, which prevents them from reproducing and causing infections.

When water flows through a UV reactor, the UV-C rays (at a wavelength of 254 nm) damage the genetic material of bacteria, viruses, The wastewater from Bengaluru is released into dry lakes such as Lakshmi Sagar and Nar Sapura. Waste Water is sent through pipelines to Kolar and Chikkaballapur districts. Around 440 million litres per day (MLD) from the KC Valley. It helps increase groundwater recharge and support farmers in dry areas. By applying these solutions, the KC Valley can reduce pollution, achieve sustainable water and energy outcomes, and set a model for other regions to follow. This practical and unified strategy directly supports climate action, water safety, and renewable energy goals.

II. COMPARATIVE INSIGHTS

Conventional plants in the KC Valley use manual sampling and lab tests, so they respond slowly to water contamination. The IoT-based system monitors pH, turbidity, TDS, and heavy-metal levels in real time using sensors, giving faster and more accurate alerts. Old plants run UV, filtration, and aeration on fixed schedules, which wastes energy and chemicals. The IoT solution adjusts UV dose, aeration, and filtration automatically based on real-time data, saving energy and cost.

Most KC Valley systems treat water, wastewater, and waste-to-energy separately with little coordination.

The proposed system integrates soil-aquifer treatment (SAT), GAC filtration, UV disinfection, and waste-to-electricity into one IoT platform with a central dashboard.

Traditional plants are rigid and hard to upgrade with smart monitoring. The IoT architecture is modular, so new sensors or control features can be added easily without big changes. The IoT-based solution adapts more effectively to new regulations, climate change, and growing water demand.

The proposed IoT-based integrated water treatment solution provides a significant performance upgrade over traditional, non-digital treatment methods used in the KC Valley. As summarised in the table below, our solution enhances responsiveness, resource efficiency, and automation compared to conventional manual systems and other reported literature.

III. TECHNOLOGIES AND MODELS

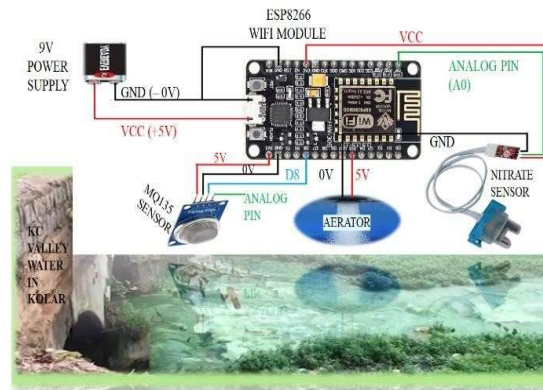


Figure 1 : BLOCK DIAGRAM OF PROJECT

1. IoT-enabled sensing layer

Uses advanced electrochemical and optical sensors for real-time measurement of pH, turbidity, TDS, dissolved oxygen, temperature, and heavy-metal indicators in water.

Employs low-power wireless protocols (e.g., Wi-Fi, LoRa, or ZigBee) to form a scalable sensor network across intake, treatment, and distribution points in KC Valley.

2. Real-time data acquisition and communication

Microcontroller-based gateways (e.g., ESP32, Raspberry Pi) collect sensor data and transmit it to a cloud server or edge server for immediate processing.

Table 2”: Comparison of Water Treatment Approaches

Aspect	Conventional Plants	Existing Literature	Proposed IoT-Based Solution
Monitoring	Periodic lab sampling; slow response	Real-time monitoring of limited parameters	Continuous monitoring of pH, turbidity, TDS, and heavy metals
Efficiency	Fixed UV/filtration schedules; energy/chemical waste	Some automation in smart grids	Dynamic adjustment of UV, aeration, and filtration; reduced energy and chemical use
Integration	Separate water, wastewater, and waste-to-energy systems	Single-function modules in smart water grids	Integrated SAT, GAC, UV, and waste-to-energy in one IoT dashboard
Upgradability	Rigid, costly retrofits	Limited modularity in reported systems	Modular IoT architecture; easy sensor/control upgradeS

Cloud-based dashboards enable remote monitoring, historical logging, and role-based access for plant operators and authorities in the KC Valley.

3. Smart water treatment modules

UV-based disinfection module: High-intensity UV-C units with IoT-driven intensity and exposure-time control to effectively kill pathogens and reduce chemical-based disinfection.

Soil Aquifer Treatment (SAT) module: Natural subsurface filtration using SAT beds, monitored by moisture and contaminant sensors to optimise recharge and recovery.

Granular Activated Carbon (GAC) filtration module: IoT-controlled flow-rate and backwashing cycles to remove organic pollutants and certain heavy metals, improving treated-water quality.

Aeration and mixing module: Smart blowers and mixers are adjusted in real time based on dissolved-oxygen and turbidity data to enhance biological and physical treatment efficiency.

4. Waste-to-energy and sludge management

Biogas or a small-scale waste-to-energy module integrated with IoT metering to convert treatment-plant sludge and organic waste into electricity or heat.

Level and pressure sensors on digesters and storage tanks enable predictive maintenance and avoid over-pressurisation or overflow.

5. Advanced control and automation

Programmable Logic Controller (PLC) or IoT-enabled controller for automated valve sequencing, pump scheduling, and fault-detection in water-flow paths.

6. Remote monitoring with LPWAN:

In far-off or weak-signal areas, LoRa WAN or satellite-IoT can send data from solar nodes, so the system covers more ground without heavy cellular infrastructure.

V. RESULTS

Challenges: High cost and setup complexity: Adding IoT sensors, gateways, and cloud systems to KC Valley plants requires high investment and is hard to manage over a large area.

Old plants are hard to upgrade: Most existing plants were not built for digital control, so connecting IoT automation with old pumps and valves is technically difficult. Sensors can fail in bad conditions: Humid, dirty, and chemical-rich environments can damage sensors, so they need strong protection and regular checks.

Risk of cyber-attacks: Real-time dashboards and data can be hacked if not protected by strong encryption, access control, and secure communication. Operators may lack skills: Local staff may not fully understand IoT and data tools, so training is needed to use the system correctly and respond to alerts.

Lightweight encryption and secure authentication protocols to protect data transmission between field devices, gateways, and cloud servers.

Open-API or MQTT-based integration allowing the system to connect with municipal water-management platforms or smart-city dashboards in the KC Valley. in the cloud to suggest maintenance schedules and optimise set-points.

Rule-based and simple AI/ML models (e.g., anomaly detection, predictive maintenance) embedded at the edge or

VI. CHALLENGES AND FUTURE SCOPE

Future Scope

AI for smart control: AI can predict water-quality changes and leaks, so the system can take early action instead of reacting after problems occur. Small solar IoT units: Small solar-powered IoT treatment units can clean water in upstream areas, reducing load on big plants and improving groundwater quality.

Connect with smart city: The system can link with traffic, energy, and waste systems to save water, recover energy, and reduce flood risk in the city.

Blockchain for trust: Sensor data and treatment logs can be stored on blockchain to create tamper-proof records for regulators and citizens.

Public dashboards and apps: People can see lake and tap- water quality on apps and websites and report issues, helping them actively protect water security.

1. UV Rays System: The UV system uses UV-C light to kill bacteria, viruses, and other harmful microorganisms in water. Key components include a reactor chamber, UV lamp, quartz sleeve, and a control unit for monitoring. Water flows through the chamber and is exposed to UV light, which damages the DNA of pathogens and makes them harmless. The system is eco-friendly, does not add chemicals, and keeps water's taste and odour unchanged. It can be integrated with IoT for remote monitoring, automation, and real-time alerts, ensuring safe and efficient water treatment.

2. Water Purification Using Tertiary Soil Aquifer Treatment (SAT): As shown in the figure 5.2 Heavy metals lead (Pb), cadmium (Cd), and zinc (Zn) concentrations in wastewater were reduced by ~60%, ~90%, and ~70% respectively through SAT filtration. Turbidity, organic load (BOD/COD) reduced by 45-60% enabling potable water reuse standards to be met. AI sensors monitored soil and water parameters (moisture, pH, electrical conductivity), optimizing infiltration rate and saturation for maximal heavy metal adsorption. Soil samples showed safe accumulation levels, confirming environmental.

3. Waste to Electricity Conversion: As shown in the figure 5.3 Organic waste collected from water treatment sludge was converted by anaerobic digestion to biogas. Biogas yield averaged 0.35 m³/kg of volatile solids, with methane content ~65%, sufficient for small scale onsite electricity generation via generator or CHP units. AI controlled digesters optimized temperature and feed rates, improving biogas yield by 20%. Electricity produced powers sensor networks and aerator pumps, demonstrating sustainable energy reuse within the system.

4. Aerator System: For Dissolved Oxygen Management Water aeration increased dissolved oxygen (DO) levels from 2 mg/L to above 6 mg/L within 2 hours in constructed wetlands and ponds. Dissolved oxygen is vital for aerobic microbial degradation in wastewater, improving purification

5. Integrated IOT Monitoring System: ESP8266based IoT nodes transmitted real-time sensor data for CO₂, water quality, soil moisture, and biogas parameters. IOT algorithms interpreted data streams to forecast maintenance needs, detect anomalies, and optimize system operations. Remote control and alerts enabled rapid response enhancing system robustness and reliability.

CONCLUSION

Our project integrates hazardous water treatment, IOT monitoring, and waste-to-electricity into one system. It converts waste into wealth, pollution into energy, and danger into opportunity. Practical, scalable, and globally applicable, it directly improves health, agriculture, industries, and the environment.

IoT facilitates holistic environmental management by integrating carbon capture with renewable energy systems and environmental monitoring networks.

This reduces the carbon footprint and optimises energy usage, thus supporting sustainability goals in the KC valley area. For water purification, IoT sensor networks can continuously monitor water quality parameters like pH, turbidity, and contaminant levels, enabling timely intervention and ensuring safe drinking water.

Development Authority in supplying field data and water quality information is gratefully acknowledged, as it was essential for the completion of this project.

Remote sensing and automated control improve resource management and reduce health risks.

In waste-to-electricity applications, IoT systems monitor waste composition, process parameters, and energy output, enabling efficient operation, real-time diagnostics, and performance optimisation.

This promotes sustainable waste management, generates clean energy locally, and reduces landfill dependence in the KC valley.

Altogether, IoT-based solutions offer dynamic, data-driven approaches for environmental conservation, climate change mitigation, and resource optimisation with cost- effectiveness, operational excellence, and regulatory compliance in the KC valley region's water purification and waste-to-energy domains.

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REFERENCES

- [1]. **Vikas V., Venkatesh (2020):** Study on KC Valley wastewater plant performance.
- [2]. **Kumar and S. Patel (2022):** IoT -Enabled Real-Time Water Quality Monitoring and Alert System.
- [3]. **Thama Shree B (2022):** Study on antibacterial effects of Tulsi and Neem extracts.
- [4]. **Chaitra Shree J (2023):** Survey of KC Valley farmers about treated water use.

- [5]. **A. Sharma and M. Verma (2023):** Cloud-Integrated Smart Water Management Framework Using IoT.
- [6]. **IISc Study (2023):** Research on groundwater recharge and water quality in KC Valley.
- [7]. **D. Patil and V. Kulkarni (2024):** Performance Analysis of Granular Activated Carbon in Water Containment Removal.
- [8]. **ResearchGate Study (2025):** Study on medicinal plants used for water purification.