A Project Report On

AI-BASED WATER LEAK DETECTION & QUALITY MONITORING SYSTEM

SDG ALIGNMENTS

SDG 6 – Clean Water and Sanitation

SDG 11 – Sustainable Cities and Communities

Abstract

Pure-Flow is an AI-powered water monitoring system designed to detect leaks and assess water quality in real time. The project addresses two major global challenges: water wastage caused by undetected pipeline leaks and health risks arising from unsafe water quality. By leveraging responsible artificial intelligence techniques such as prompt engineering, agentic AI workflows, and Retrieval-Augmented Generation (RAG), Pure-Flow provides explainable insights and actionable recommendations. The solution supports sustainable water management, enables early intervention, and aligns with the United Nations Sustainable Development Goal 6 (Clean Water and Sanitation).

Introduction

Water is one of the most critical natural resources required for human survival, economic development, and environmental sustainability. Despite its importance, water loss and contamination remain persistent problems worldwide. Rapid urbanization, population growth, and aging infrastructure have significantly increased stress on water distribution systems. Many regions experience large-scale water wastage and unsafe drinking water due to the absence of intelligent monitoring mechanisms. Pure-Flow aims to address these challenges by applying artificial intelligence to monitor water flow and quality proactively.

Background and Motivation

Traditional water monitoring systems rely heavily on manual inspections and periodic testing. These methods are reactive, time-consuming, and costly. Leaks often remain undetected for long periods, leading to significant water loss and infrastructure damage. Similarly, water quality issues may go unnoticed until they impact public health. The motivation behind Pure-Flow is to develop an affordable, scalable, and transparent AI-based solution that enables real-time monitoring, early detection, and informed decision-making.

Problem Statement

Water distribution systems lack continuous and intelligent monitoring capabilities. Undetected leaks cause substantial water wastage and increase maintenance costs. At the same time, water quality parameters such as pH level, turbidity, and chlorine concentration are not consistently monitored, resulting in unsafe water consumption. Existing solutions are either expensive, manual, or lack explainability. There is a strong need for an AI-driven system that can automatically detect leaks, assess water quality, and provide actionable insights.

SDG Alignment

Pure-Flow aligns with the United Nations Sustainable Development Goal 6: Clean Water and Sanitation. The project contributes to sustainable water management by reducing water wastage, improving water safety, and promoting efficient use of water resources. By enabling proactive monitoring and early intervention, Pure-Flow supports equitable access to clean and safe water.

Target Users

The primary users of Pure-Flow include:

- Municipal water authorities
- Water treatment plant operators
- Smart city administrators
- Residential and commercial building managers
- Environmental monitoring organizations

Why AI is Needed

AI enables:

- Early leak prediction using abnormal flow patterns
- Classification of water quality (Safe / Warning / Unsafe)
- Detection of recurring contamination or leakage trends
- Automated alerts and decision support at scale

Traditional systems lack predictive capability and real-time intelligence, making AI essential for proactive water management.

AI Solution Overview

Pure-Flow is an AI-based monitoring system that analyses water flow and quality data (real or simulated) to:

1. Detect potential leaks
2. Assess water safety
3. Explain the reasoning transparently
4. Recommend corrective actions

Key AI Functions

- Pattern detection
- Classification
- Predictive alerts
- Explainable decision support

System Architecture Overview

The Pure-Flow system consists of four main layers: data input, AI analysis, decision-making, and visualization. Water flow and quality data are processed using structured AI workflows. The AI engine analyses patterns, detects anomalies, and generates explanations and recommendations. Results are presented through a dashboard interface for easy interpretation.\

AI Technologies Used

Pure-Flow integrates multiple AI techniques:

- **Prompt Engineering** to structure AI reasoning
- **IBM Granite Models (conceptual)** for enterprise-grade AI reasoning
- **Retrieval-Augmented Generation (RAG)** to reference trusted water quality standards
- **Agentic AI Workflows** for autonomous decision-making
- **Entity Extraction and Summarization** to present concise insights

Leak Detection Methodology

Leak detection is achieved by comparing real-time flow rates against predefined normal baseline values. Significant deviations trigger alerts indicating potential leaks. The AI system explains the reasoning behind each alert, ensuring transparency and trust.

Water Quality Assessment

Water quality is assessed using parameters such as pH level, turbidity, and chlorine concentration. The AI classifies water as safe, warning, or unsafe. Based on the classification, corrective actions such as filtration, pH correction, or disinfection are recommended.

Prototype Description

The project prototype includes dashboard mock ups, workflow diagrams, and sample AI outputs. The dashboard visualizes leak alerts, water quality status, AI explanations, and recommended actions. This enables users to make informed decisions quickly.

FLOWCHART

Start

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Collect Water Data

(Flow rate, pH, Turbidity, Chlorine)

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Data Validation & Preprocessing

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AI Leak Detection Module

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Water Quality Classification

(Safe / Warning / Unsafe)

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Risk Assessment

↓

Explainable AI Reasoning

↓

Recommendations & Alerts

↓

End

WORKFLOW FLOWCHART

Water Data Input

(Flow rate, pH, Turbidity, Chlorine)

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Data Validation & Preprocessing

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AI Analysis Engine

├─ Leak Detection (Flow anomaly check)

└─ Water Quality Classification

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Risk Level Assessment

(Normal / Warning / Critical)

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Explainable AI Reasoning

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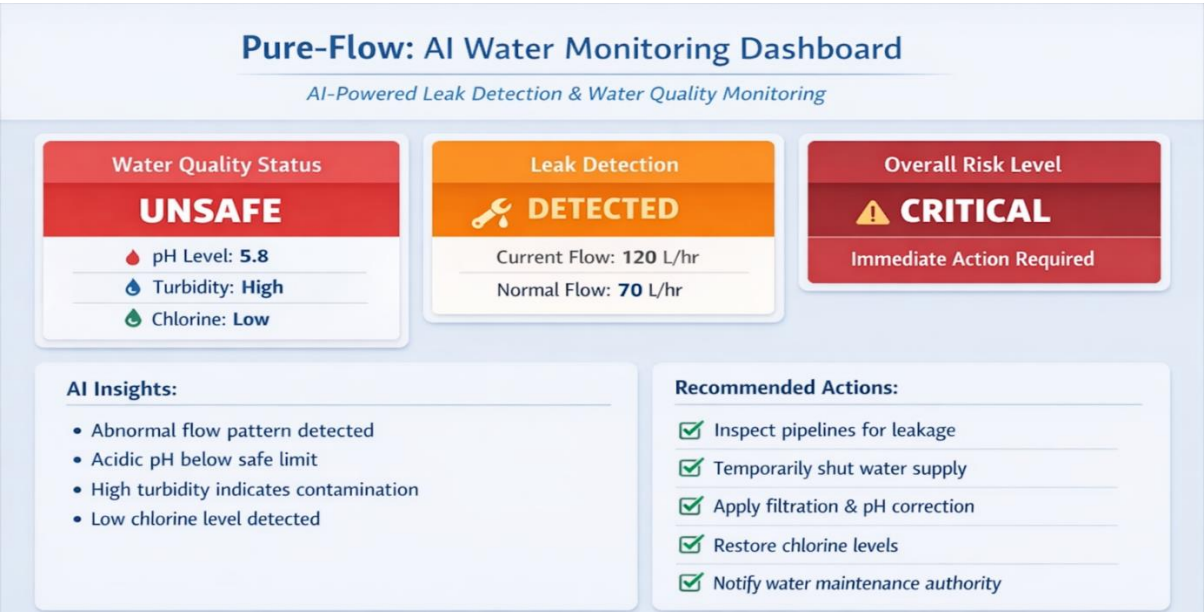
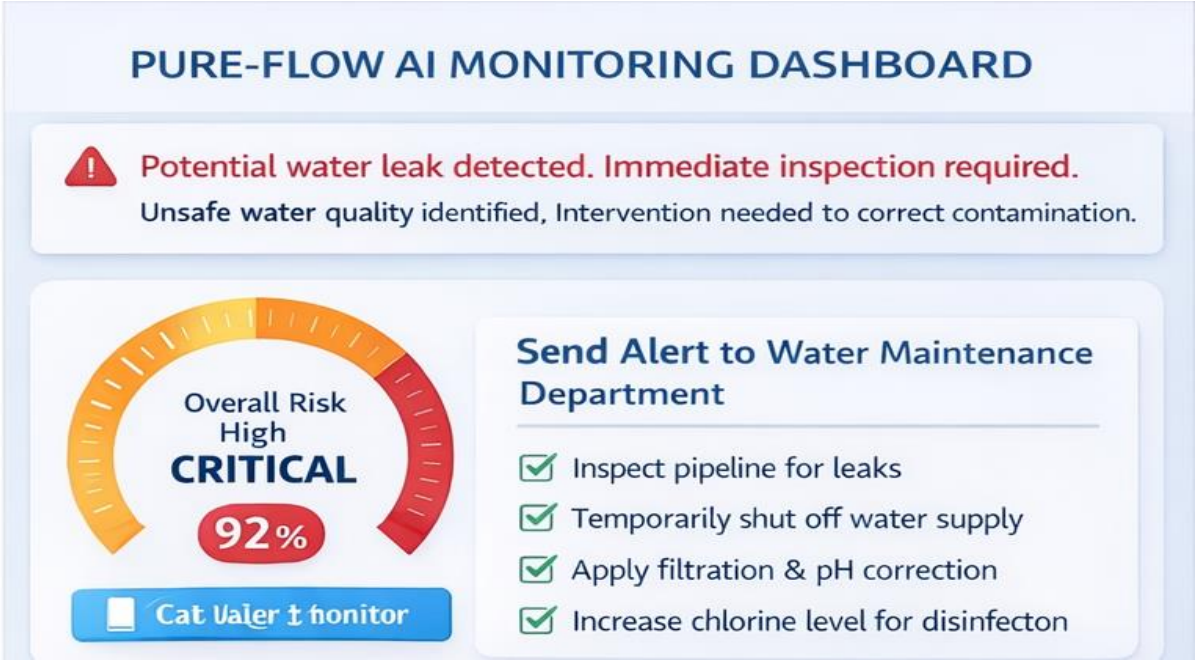
Recommendations & Alerts

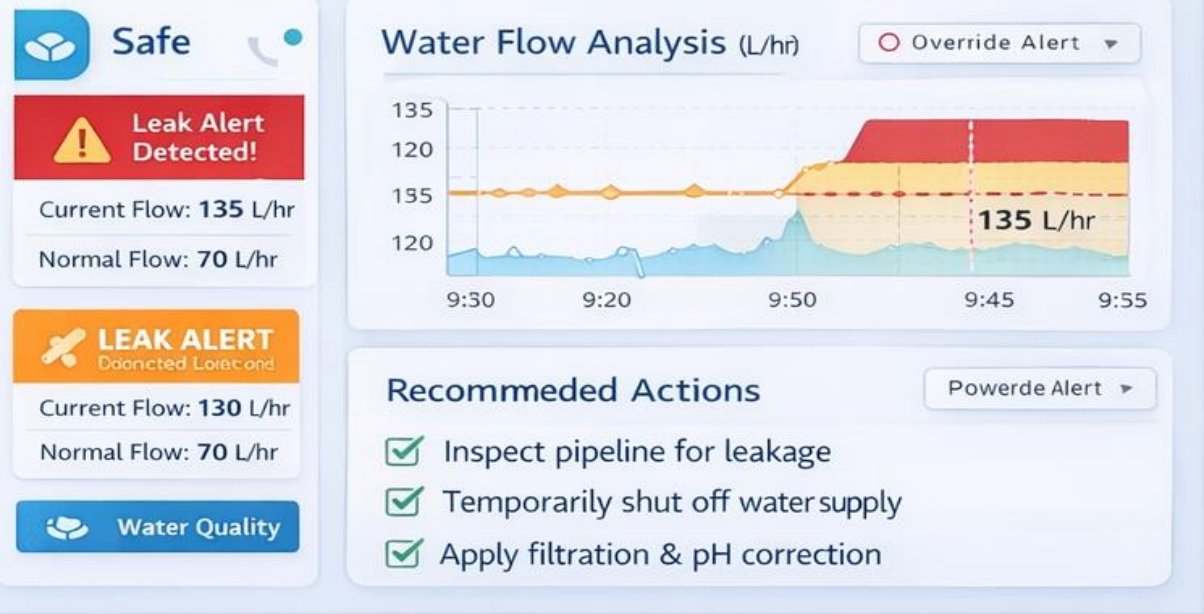
SCREENSHOTS:




Water Quality Status
SAFE
pH Level: 7.2
Turbidity: Low
Chlorine: Low
Leak Detection
DETECTED
Current Flow: 130 L/hr
Normal Flow: 70 L/hr
Overall Risk Level
WARNING
Immediate Action Required
Water Flow Analysis
L/hn
130
120
110
0
Leak Zone
Leak Zone
130 L/hr
9:00
9:10
9:30
9:40
9:55
9:30
9:45
9:55


AI Analysis & Recommendations
High water flow rate detected
Inspect pipelines for leaks
High turbidity indicates consimain
Monitor water quality closely
UNSAFE
pH Level: 5.8
Turbidity: High
Chlorine: Low
Water Quality Overview
SAFE
PH : 7.2
Turbidity: Low
Chlorine Level: Optimal


PURE-FLOW AI MONITORING DASHBOARD
Potential water leak detected. Immediate inspection required.
Unsafe water quality identified, Intervention needed to correct contamination.
Overall Risk
High
CRITICAL
92%
Send Alert to Water Maintenance Department
Inspect pipeline for leaks
Temporarily shut off water supply
Apply filtration & pH correction
Increase chlorine level for disinfecton



Prototype Logic Explanation

1. The system receives water-related data (real-time sensor data or simulated input).
2. AI compares current values with historical or safe thresholds.
3. Abnormal flow patterns indicate possible leakage.
4. Quality parameters are classified into Safe, Warning, or Unsafe.
5. AI generates human-readable explanations.
6. Corrective actions are suggested.

Sample AI Prompt (Prototype Demo)

Prompt: "You are an AI water sustainability assistant. Analyse the following data.

Flow rate: 120 L/hr (normal: 70 L/hr) pH: 5.8 Turbidity: High Chlorine: Low

Tasks:

1. Detect leakage
2. Classify water quality
3. Explain reasoning
4. Suggest actions"

Expected Output:

- Leak detected: YES (abnormal flow)
- Water quality: UNSAFE
- Reason: Acidic pH, high turbidity, low chlorine
- Actions: Shut valve, inspect pipeline, use filtration, notify authority

Responsible AI Considerations

- **Fairness:** Designed for both urban and rural use cases
- **Transparency:** AI explains every decision
- **Privacy:** No personal or sensitive user data collected
- **Ethics:** Advisory-only system, no automated enforcement

Impact Analysis

The implementation of Pure-Flow can significantly reduce water wastage, improve public health outcomes, lower operational costs, and enhance environmental sustainability. Communities, authorities, and ecosystems all benefit from improved water management.

Design Thinking Methodology

The project follows the design thinking approach:

- Empathize
- Define
- Ideate
- Prototype
- Test & Refine

Expected Impact

- Reduction in water wastage
- Early contamination detection
- Improved public health
- Cost savings for users and authorities

- Supports sustainable water management

Future Enhancements

- Integration with IoT sensors
- Mobile app dashboard
- GIS-based leak heatmaps
- Multilingual voice alerts
- Municipal-level analytics

Limitations and Future Scope

The current prototype is conceptual. Future enhancements may include IoT sensor integration, cloud deployment, predictive analytics, mobile alerts, and large-scale implementation.

Conclusion

Pure-Flow demonstrates the effective use of responsible AI to address sustainability challenges. By combining water leak detection and quality monitoring, the project offers a comprehensive solution for smarter and safer water management.