Chapter 11
An Optimal Method of Assessing the Quality of Water Using Integrated AI and Blockchain Methodology

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ABSTRACT

Water quality deterioration has become increasingly severe recently due to various factors. Pollution, climate change, and population growth all contribute to this issue. Contaminants such as microorganisms, heavy metals, and excessive nitrogen and phosphorous disrupt water pH levels, posing significant health risks. Despite advancements in IoT for maintaining pH balance through chlorine and fluoride addition after disinfection, security threats like distributed denial of service attacks, data manipulation, and session hijacking affect water treatment plant operations. This compromises water safety, leading to health problems and reduced life expectancy. To address these challenges, we propose integrating AI and blockchain technology into water treatment plant management. Our method utilizes a standard dataset on water quality parameters such as pH and total hardness to classify water as potable or non-potable.

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INTRODUCTION

Water quality degradation has become increasingly critical due to multiple factors in recent years. Pollution, climate change, and population growth all contribute to this issue. Contaminants like microorganisms, heavy metals, and excessive nitrogen and phosphorous disrupt water pH levels, posing significant health risks. Despite advancements in the Internet of Things (IoT) enabling pH balance through chlorine and fluoride addition after disinfection, various security concerns such as distributed denial of service attacks, data manipulation, and session hijacking affect water treatment plant operations. This compromises water safety, leading to health issues and reduced life expectancy. To tackle these challenges, we propose integrating artificial intelligence (AI) and blockchain technology into water treatment plant management. Our approach uses a standard water quality dataset featuring parameters like pH and total hardness for binary classification of water as potable or non-potable. AI classifiers such as stochastic gradient descent (SGDC), decision tree (DT), Naive Bayes (NB), K-nearest neighbors (KNN), and logistic regression (LR) are employed. Additionally, an InterPlanetary File System (IPFS)-based public blockchain is implemented to safeguard against data manipulation attacks, securely storing potable water samples in an immutable ledger. Evaluations include metrics like confusion matrix analysis, learning curve assessment, training accuracy, and blockchain scalability. Notably, the DT model performs best, achieving 99.41% accuracy and supporting 120 data transactions for scalability.

The motivation for our proposed approach is driven by several key factors:

1. **Streamlining Water Profiling:** Accurately profiling water is crucial for ensuring operational efficiency and delivering clean water. To simplify and enhance this process while maintaining safety, various approaches such as numerical modeling, IoT-based solutions, and AI-driven automation have been explored and implemented.
2. **Limitations of Numerical Modeling:** Previous studies have predominantly focused on numerical modeling for water treatment applications. However, these approaches often lack automation, which can lead to human errors and biases. Moreover, applying numerical optimization on resource-constrained smart sensors can degrade the performance of smart grid environments. This limitation motivated us to seek more accurate and automated methodologies, particularly leveraging AI.
3. **Machine Learning for Water Quality Forecasting:** Recent research has successfully applied machine learning techniques to forecast water quality with improved accuracy and reduced human biases. However, a significant drawback is the vulnerability of predicted data to tampering attacks. This gap prompted