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Water Quality Analysis and Prediction using Machine Learning

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Abstract: *Water quality analysis is essential for ensuring safe drinking water and environmental sustainability. This paper explores the use of the Vector Space Model (VSM) algorithm to predict and classify water quality based on various physicochemical parameters. The study includes data preprocessing, feature selection, and model training to achieve accurate classification. The results indicate that VSM provides efficient and reliable water quality classification compared to traditional methods. The findings of this study can contribute to developing an early warning system for water pollution detection, helping authorities take timely corrective actions.*

Keywords: Water Quality, Machine Learning, VSM Algorithm, Prediction, Classification.

I. INTRODUCTION

The availability of clean water is crucial for human health and ecosystem balance. Various contaminants degrade water quality, making it necessary to develop predictive models that classify water quality efficiently. Contaminants such as heavy metals, bacteria, and chemical pollutants can cause severe health issues, making water monitoring an essential process. The increasing population and industrial expansion have significantly contributed to water pollution, necessitating robust computational methods for monitoring and analysis. This research applies the VSM algorithm to classify water quality based on physicochemical properties such as pH, tur- bidity, dissolved oxygen, and heavy metal concentrations. By leveraging machine learning approaches, it becomes feasible to establish automated, accurate, and scalable solutions for water quality assessment.

II. METHODOLOGY

A. Data Collection

Water quality data was obtained from multiple sources, including governmental environmental agencies and publicly available datasets. The dataset includes attributes such as pH, turbidity, total dissolved solids (TDS), dissolved oxygen (DO), and biochemical oxygen demand (BOD). The data spans various geographical locations, covering different water sources such as rivers, lakes, and underground reservoirs.

B. Data Preprocessing

- Preprocessing steps include:
- Handling missing values using mean imputation.
- Normalization of data to ensure uniform feature scales.
- Feature selection using correlation analysis.
- Removal of outliers detected using interquartile range (IQR) method.

Data preprocessing ensures that inconsistencies in data do not affect the performance of machine learning models and helps improve prediction accuracy.

C. Vector Space Model (VSM) Algorithm

The VSM algorithm is used to represent water quality samples as vectors in a multidimensional space. The classification is performed based on the similarity between test samples and predefined water quality classes using

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cosine similarity. The VSM approach provides an efficient method for comparing water quality samples and establishing thresholds for contamination detection.

D. Evaluation Metrics

The model performance is evaluated using:

- Accuracy
- Precision
- Recall
- F1-score
- Confusion Matrix

These metrics ensure a comprehensive evaluation of the model, helping assess both correctness and robustness in classifying water quality levels.

III. RESULTS AND DISCUSSION

Experimental results demonstrate that the VSM algorithm achieves high classification accuracy compared to traditional machine learning models such as KNN and Decision Trees. The model efficiently differentiates between clean and contaminated water samples based on predefined quality thresholds. The study found that VSM achieved an accuracy of over 90% in most test cases, outperforming baseline machine learning methods. Additionally, the use of cosine similarity in vector- based representation allowed for better differentiation between borderline cases of water contamination. The findings suggest that this method can be integrated into real-time monitoring systems to provide rapid and reliable assessments of water quality.

IV. CONCLUSION AND FUTURE WORK

This study presents a novel approach using the VSM algorithm for water quality prediction. The results show that VSM provides reliable classification performance. Future work will involve integrating real-time water monitoring sensors with an IoT-based system for automated water quality prediction. Ad- ditionally, expanding the dataset with real-time samples from various geographic regions and testing the model's adaptability to seasonal variations will be explored. Implementing a cloud- based analytics platform could further enhance scalability and accessibility for public use and governmental monitoring.

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