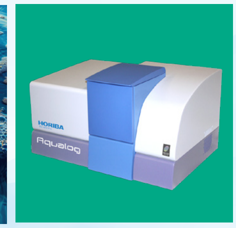
Fluorescence

Rapid Identification of Oil Contamination in Process Water Using Fluorescence Excitation Emission Matrix and Parallel Factor Analysis



Application Note
Environment
FL-2024-10-10

Introduction

The presence of oil contamination in process water can lead to significant operational and environmental challenges, especially in industries relying on large-scale fuel usage. For example, major coal-fired power generation companies consume up to 30,000 liters of fuel oil per hour during cold start-ups. Such high volumes increase the risk of oil leaks, contaminating water sources and leading to irreversible fouling of water treatment membranes. Traditional methods for detecting oil contamination, such as gas chromatography (GC) and mass spectrometry (MS), are effective but often time-consuming and complex. (Madhav and Gilmore 2024, Water Science and Technology, Vol 90 No 3, 908-919)

In this application note, the authors present a novel, rapid method for identifying low concentrations of oil contamination in process water using Fluorescence Excitation Emission Matrix (FEEM) combined with Parallel Factor Analysis (PARAFAC). This method allows for quick detection and analysis of oil contaminants in process water, offering a practical solution for industries where timely intervention is crucial.

Method Overview

The developed method utilizes FEEM, a technique that captures fluorescence spectra across multiple wavelengths, generating a three-dimensional matrix of excitation and emission data. The collected data is then processed using PARAFAC, a multivariate analysis technique that decomposes the complex fluorescence data into individual components, making it easier to identify specific contaminants.

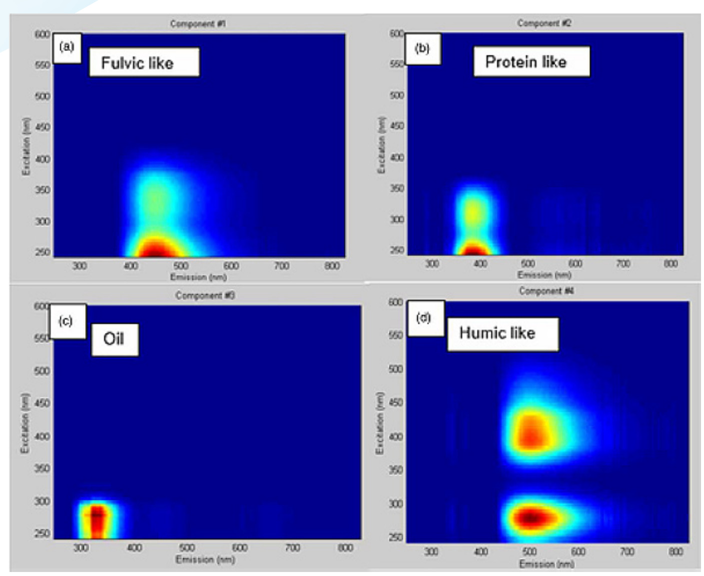
Sample Preparation

Samples were collected from two sources , including various types of process water such as bulk cooling water, mine water recovery, and clarified cooling water. These samples were spiked with known concentrations of the water-soluble fraction of crude fuel oil to simulate contamination. The spiked samples were analyzed using the FEEM technique, with a HORIBA Aqualog spectrometer (Gilmore and Tong, 2019, US Patent #10,168,310 B2) employed to collect the excitation-emission matrices.

Instrumentation and Data Analysis

FEEM data was collected using the patented Aqualog spectrometer, which corrects for fluorescence inner-filter effects, ensuring accurate results. The FEEM data was then processed using PARAFAC to decompose the fluorescence signals into individual components representing various substances within the water samples.

A four-component PARAFAC model was developed, consisting of an oil component and three natural organic matter components. The model was validated with a split-half method, achieving a 90% match, indicating the model's robustness in identifying oil contamination.



Results and Discussion

The PARAFAC model successfully identified oil contamination at low parts-per-billion (ppb) levels in the process water samples. The oil component was isolated with high accuracy, as demonstrated by a linear regression analysis of the PARAFAC component scores, yielding an R^2 value of 0.98. This high correlation confirms the model's capability to differentiate oil contamination from other organic matter present in the water.

A pass/fail test was developed based on the PARAFAC scores, allowing for a qualitative assessment of oil contamination in process water. Samples exceeding the threshold for the oil component were marked as "fail," indicating contamination, while samples below the threshold were marked as "pass."

Conclusion

The combination of FEEM and PARAFAC offers a rapid, reliable method for detecting low-level oil contamination in process water. This method is particularly valuable for industries comsuming high volumes of water, where quick identification of contaminants can prevent costly damage to water treatment systems and ensure compliance with environmental regulations.

By implementing this method, companies can enhance their monitoring capabilities, reduce the risk of undetected oil contamination, and improve their overall operational efficiency.

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