Quantifying Caffeine as an Anthropogenic Biomarker for Septic Tank Contamination in Queens Cove Using HPLC and GIS Integration

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Caffeine, a prevalent compound in human wastewater, has emerged as a reliable anthropogenic biomarker for detecting septic tank contamination in aquatic systems due to its minimal natural occurrence and chemical stability. While most existing studies rely on advanced techniques to detect caffeine, this study demonstrates the novel application of ultraviolet absorbance spectroscopy as a cost-effective and practical alternative for measuring septic tank leachate. The Indian River Lagoon, an ecologically critical estuary, faces increasing pollution from septic system leachate. This study investigated caffeine absorbances in Queens Cove to determine spatial contamination patterns and the effectiveness of caffeine as a tracer. Water samples were collected from sites categorized as septic tank, sewer, and natural environments. Samples were filtered and analyzed using High-Pressure Liquid Chromatography (HPLC) to measure caffeine absorbance at 274 nm and Geographic Information System (GIS) mapping to determine spatial patterns of contamination. Statistical analysis, including one-way ANOVA and Tukey-Kramer post hoc tests, evaluated differences in caffeine levels among site types. The highest caffeine absorbances (>0.029 AU) were detected in enclosed residential canals near dense septic system clusters. Moderate absorbances (0.0076–0.018 AU) were observed in semi-enclosed canals, while open-water areas exhibited negligible levels (<0.001 AU). Statistical analysis confirmed significant differences in caffeine levels between septic tank, sewer, and natural sites ($p < 0.05$). These findings demonstrate that septic tank effluent is a major contributor to anthropogenic contamination in the lagoon and highlights caffeine's utility as a tracer in environmental monitoring.

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