water

MDPI

Article

Unlocking the Secrets of River Pollution: Analyzing Organic Pollutants in Sediments—Experimental Study

Sadeq Abdullah Abdo Alkhadher [1,*], Suhaimi Suratman [1], Hussein E. Al-Hazmi [2,*], Mohamad Pauzi Zakaria [3], Bartosz Szeląg [4], Joanna Majtacz [2] and Jakub Drewnowski [2]

1 Institute of Oceanography and Environment, Universiti Malaysia Terengganu, Kuala Nerus 21030, Malaysia; suratman@umt.edu.my
2 Faculty of Civil and Environmental Engineering, Gdansk University of Technology, Narutowicza 11/12, 80-233 Gdansk, Poland; joamajta@pg.edu.pl (J.M.); jdrewnow@gmail.com (J.D.)
3 Institute of Ocean and Earth Sciences (IOES), University of Malaya, Kuala Lumpur 50603, Malaysia; mpauzi57@um.edu.my
4 Faculty of Environmental, Geomatics and Renewable Energy, Kielce University of Technology, 25-314 Kielce, Poland; bszelag@tu.kielce.pl
* Correspondence: sadeq.abdo@umt.edu.my (S.A.A.A.); hussein.hazmi1@pg.edu.pl (H.E.A.-H.)

Abstract: Untreated wastewater released into rivers can result in water pollution, the spread of waterborne diseases, harm to ecosystems, contamination of soil and groundwater, as well as air pollution and respiratory problems for nearby humans and animals due to the release of greenhouse gases. The current study aims to investigate the recent input of anthropogenic loads into the rivers using linear alkylbenzene (LAB), which is one of the molecular chemical markers with application of sophisticated model statistical analyses. In order to determine the compositions of LABs, which act as wastewater pollution molecular indicators, surface sediment samples from the Muar and Kim Kim rivers were collected. Gas chromatography-mass spectrometry (GC-MS) was utilized to identify LABs and investigate their sources and degradation. ANOVA and the Pearson correlation coefficient were employed to determine the significance of differences between sampling locations, with a threshold of $p < 0.05$. To assess the degradation degree and efficacy of wastewater treatment plants (WWTPs), LABs were identified based on chains ranging from long to short (L/S), C_{13}/C_{12} homolog, and internal to external (I/E) congeners. The results indicated that LAB concentrations in the studied areas of the Muar River ranged from 87.4 to 188.1 ng g^{-1}dw. There were significant differences in LAB homology at $p < 0.05$, and a significant percentage of sampling stations contained C_{13}-LAB homology. Based on the LAB ratios (I/E) determined, which ranged from 1.7 to 2.2 in the studied areas, it was concluded that effluents from primary and secondary sources are being discharged into the marine ecosystem in those areas. The degradation of LABs was up to 43% in the interrogated locations. It can be inferred that there is a requirement for enhancing the WWTPs, while also acknowledging the efficacy of LAB molecular markers in identifying anthropogenic wastewater contamination.

Keywords: linear alkylbenzene; river sediment; wastewater; degradation; molecular marker

Citation: Alkhadher, S.A.A.; Suratman, S.; Al-Hazmi, H.E.; Zakaria, M.P.; Szeląg, B.; Majtacz, J.; Drewnowski, J. Unlocking the Secrets of River Pollution: Analyzing Organic Pollutants in Sediments—Experimental Study. *Water* **2023**, *15*, 2216. https://doi.org/10.3390/w15122216

Academic Editors: Antonio Albuquerque and Eleonora Santos

Received: 13 April 2023
Revised: 24 May 2023
Accepted: 9 June 2023
Published: 13 June 2023

1. Introduction

Wastewater can be classified into various types based on origin and characteristics, including mainstream (domestic), side-stream (industrial), agricultural, stormwater, hospital, and commercial wastewater [1–6]). Each type requires different treatment processes to make it safe for reuse or discharge into the environment [7–15]. However, treated wastewater released into rivers can contain organic chemical substances, such as linear alkylbenzenes (LABs), commonly used in the production of detergents. When LAB-containing wastewater is released into a river, significant degradation occurs in the LABs, and some of them can be transferred downstream and accumulate in the sediments and aquatic species [16]. LABs are hydrophobic, meaning they do not readily dissolve in water, but instead tend to