

Review on the doctoral dissertation by Ruqayah Ali Naser Grmasha for final defense

Titled

“Polycyclic aromatic hydrocarbons (PAHs) in water and sediments of three major rivers: Spatial distribution, pollution source apportionment, ecological risks and human health impacts”

Submitted to obtain a Ph.D. degree in
Biochemical, Environmental and Chemical Engineering
University of Pannonia
Faculty of Engineering

Environmental Engineering field

Ruqayah Ali Naser Grmasha’s dissertation constitutes a pioneering and methodologically rigorous investigation into the occurrence of sixteen priority polycyclic aromatic hydrocarbons (PAHs) across three major river systems: the Danube in Hungary and the Tigris and Euphrates in Iraq. In the Danube River, PAH concentrations ranged from 224.8–365.8 ng/L in water and 316.7–422.9 ng/g in sediment, whereas the Tigris River showed significantly higher levels, with up to 3750.7 ng/L in water and 12795.0 ng/g in sediment (nearly 30 times greater) especially downstream from oil refineries. The Euphrates River exhibited PAH concentrations between 464–992 ng/L in water and 5940–9723.9 ng/g in sediment. The study's ecological risk assessment classified sediments in Iraqi rivers as highly to very highly polluted, and the calculated Incremental Lifetime Cancer Risk (ILCR) for adults and children in multiple sites exceeded the critical threshold of 1×10^{-4} , signifying notable carcinogenic threats. These results underscore the urgent need for regulatory intervention and pollution control, particularly in Iraq.

This dissertation is exceptionally timely and relevant, addressing urgent challenges within the field of environmental engineering, particularly those related to the monitoring, assessment, and management of organic pollutants in aquatic systems. Given the increasing global focus on PAHs due to their toxicity, environmental persistence, and bioaccumulative behavior, the research offers considerable contributions to both engineering practice and regulatory policy. The findings carry significant implications for public health policy, environmental management, and pollution mitigation strategies in both developed and developing contexts. The work responds directly to pressing global concerns regarding water pollution and its carcinogenic risks, thus contributing meaningfully to sustainable development and environmental protection efforts.

The dissertation employed an extensive and well-designed sampling campaign (covering an entire year for the Danube River and several months for the Euphrates and Tigris) allowing for robust spatial and temporal evaluation. Sampling protocols incorporated upstream and downstream sites around oil refineries, reflecting strong environmental engineering principles in source

identification and pollution pathway analysis. The integration of gas chromatography–mass spectrometry, solid-phase extraction, and sediment quality assessments highlights a high level of technical proficiency and innovation in environmental monitoring methodologies. Moreover, the dissertation includes a comprehensive risk characterization, utilizing eco-toxicological indices and the Incremental Lifetime Cancer Risk (ILCR) model to evaluate public health implications. Such health risk modeling is a crucial component of environmental engineering, enabling the translation of chemical data into actionable environmental health insights. The candidate’s work also introduces original findings on the spatial and temporal distribution of PAHs, identifies distinct pollution sources using advanced diagnostic ratios and PCA, and assesses ecological and human health risks, including calculation of ILCR for both adults and children in the studied regions.

The results revealed a clear contrast in pollution levels between European and Middle Eastern rivers. PAHs concentrations in the Danube River were moderate, whereas both the Tigris and Euphrates Rivers displayed significantly elevated levels, particularly the Tigris, which showed extreme sediment contamination directly linked to oil refinery discharges. The correlation analysis between total organic matter (TOM) and PAHs further reinforced these findings, offering evidence-based insights critical for environmental impact assessments and remediation planning.

This dissertation stands out for its scientific precision, engineering relevance, and practical applicability. Her recommendations urge Iraqi authorities to implement stringent pollution control measures and call on Hungarian regulators to adopt more robust guidelines to manage PAHs in the Danube River. Overall, this research represents a significant advancement in environmental engineering, particularly in the areas of pollutant fate analysis, water quality management, and ecological risk mitigation. I recognize these results as original contributions that advance understanding of PAHs contamination dynamics, source apportionment, and risk assessment in under-researched regions, and therefore consider the dissertation a valuable addition to scientific knowledge.

The dissertation exhibits an exemplary structural organization, adhering to the conventions of academic research with clear segmentation of chapters and sub-sections. The flow progresses logically from introduction to methodology, results, discussion, conclusions, and recommendations. Each section is appropriately detailed, with the table of contents reflecting a coherent hierarchy and well-defined subheadings. Additionally, the segmentation by river and analysis type (e.g., spatial distribution, PCA, ecological risk) demonstrates thoughtful thematic grouping, facilitating reader comprehension. Overall, the structure supports the dissertation's scope effectively while maintaining clarity and academic rigor.

The dissertation features advanced and professionally presented graphs and charts that significantly enhance the quality of the research. The visualizations are clear, well-structured, and effectively support the analysis throughout the study. Each figure is thoughtfully designed with appropriate labeling, consistent formatting, and informative captions, making complex data

accessible and easy to interpret. The use of comparative visuals, seasonal trends, and spatial distributions reflects a high level of analytical skill and scientific presentation. These elements contribute meaningfully to the reader's understanding and underscore the Ruqayah's strong command of environmental data visualization techniques.

The dissertation demonstrates a high standard in processing the literature. It offers a comprehensive, well-structured review of the sources of PAHs, their health and environmental impacts, and analytical methods for their detection. The candidate effectively integrates international standards, regulatory frameworks, and recent scientific findings to build a solid foundation for the research. The literature review is thorough, up-to-date, and critically analyzed, with clear links to the study's objectives. This reflects strong scholarly engagement and critical thinking.

The literature review integrates global and regional data, supported by tables and figures, aligning with international research standards. The methodologies and analytical techniques (GC-MS, SPE, QA/QC) are well-grounded in scientific principles, demonstrating a solid foundation for the research.

Ruqayah integrates a broad range of scientific studies, clearly identifies knowledge gaps, and offers a comparative evaluation of analytical methods for detecting PAHs. The literature review not only summarizes previous findings but also critiques limitations of conventional detection techniques. Ruqayah contextualizes findings within global and regional studies, showing critical reflection on the applicability and reliability of various analytical approaches in different environmental settings.

The experimental methods described in the dissertation are comprehensive, well-structured, and highly appropriate for the stated objectives. The use of solid-phase extraction (SPE) for water samples and solvent extraction methods for sediments aligns with established protocols for PAHs analysis in environmental matrices. The integration of gas chromatography-mass spectrometry provides high sensitivity and specificity, making it an optimal choice for quantifying 16 priority PAHs. Additionally, the sampling design (including temporal and spatial coverage across different seasons and river locations) supports robust statistical analysis and source apportionment. The inclusion of quality control and assurance measures further strengthens the reliability of the data. Overall, the chosen methods are scientifically sound, validated by literature, and well-matched to address the objectives of assessing PAHs distribution, sources, ecological risks, and human health impacts.

Analytical measurements were performed in triplicates, with relative standard deviations maintained below 10%, ensuring precision and repeatability. The study applied the Kolmogorov-Smirnov test for normality at a 0.05 significance level across all datasets, reflecting a solid approach to statistical validation. Additionally, the use of principal component analysis (PCA) exemplifies robust multivariate analysis. The incorporation of recovery corrections, standard

deviation reporting, and external standard calibration further enhance the reliability and credibility of the findings

The dissertation demonstrates a commendable effort in comparing the Ruqayah's own findings with existing literature. For example, it states that ILCR values for the Euphrates River were "3-6 times higher than reported in the literature," thus situating the results within a broader scientific context. Additionally, the study benchmarks measured PAHs concentrations against international standards, such as the USEPA surface water quality guidelines, highlighting exceedances and aligning the discussion with global research

The dissertation cited references that are highly relevant to the research topic. Ruqayah also cited peer-reviewed articles, authoritative regulatory documents (e.g., USEPA, WHO, EU directives), and high-impact journals that reflect the current state of research in environmental pollution and PAHs analysis. Importantly, the references are well-distributed across the thesis sections, supporting key points in the introduction, methodology, discussion, and regulatory context. Overall, the referencing is systematic, comprehensive, and enhances the academic rigor of the thesis.

The structure is organized, guiding the reader seamlessly through complex technical content with exceptional clarity and coherence. Each chapter transitions with elegance and purpose, while the language remains precise, formal, and scientifically rigorous throughout. Ruqayah's ability to articulate intricate environmental and biochemical concepts in an accessible yet authoritative tone is truly commendable. Furthermore, the use of visuals, tables, and figures is expertly integrated, enhancing the impact of the narrative and supporting the evidence-based approach. The clarity of expression, combined with the thoroughness of documentation and the seamless integration of international literature, demonstrates not only a command of the subject matter but also a rare level of academic finesse. This dissertation is a model of excellence in scientific writing, clear, compelling, and profoundly professional, worthy of high distinction and international recognition.

The conclusions presented in this dissertation are well-formulated, reflecting a high level of scientific rigor and intellectual maturity. Ruqayah has demonstrated remarkable analytical depth by seamlessly integrating extensive empirical data with sophisticated statistical tools, such as Principal Component Analysis and diagnostic ratio assessments, to trace pollution sources and delineate their ecological and human health implications. Ruqayah contribution stands as a benchmark in environmental pollution research and provides a robust, evidence-based foundation for future studies and regulatory reforms.

At the end, Ruqayah has successfully disseminated her research findings in prestigious, high-impact international journals (D1) underscoring the academic rigor, innovation, and significance of her contributions. Moreover, her research productivity is highly commendable, with several publications and an H-index of 12, reflecting the substantial influence and scholarly recognition of her work within the scientific community.

Questions:

- 1- Polycyclic aromatic hydrocarbons (PAHs) are hazardous organic pollutants that originate from sources such as fossil fuel combustion, industrial discharges, and urban runoff. Due to their persistence in soil and water and their carcinogenic nature, addressing PAH contamination is a major focus in environmental protection efforts. What remediation techniques are utilized in Environmental Engineering to manage PAHs contamination in the environment?
- 2- Iraq is currently facing severe environmental issues, including air and water pollution, poor waste management, and land degradation. These challenges demand effective and sustainable interventions to restore environmental quality and protect public health. As an Environmental Engineer, how can you reduce the pollution in Iraq?

Final Conclusion

The PhD dissertation titled “*Polycyclic Aromatic Hydrocarbons (PAHs) in Water and Sediments of Three Major Rivers: Spatial Distribution, Pollution Source Apportionment, Ecological Risks, and Human Health Impacts*”, authored by Ruqayah Ali Naser Grmasha, submitted to the Doctoral School of Chemical Engineering and Material Science at the University of Pannonia within the field of Environmental Engineering, meets all academic and scientific requirements for the award of a PhD degree.

The dissertation has achieved a commendable level of scientific merit and methodological rigor, meeting the requisite standards for the doctoral degree, and is therefore strongly **recommended for acceptance**.

May 12, 2025.



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