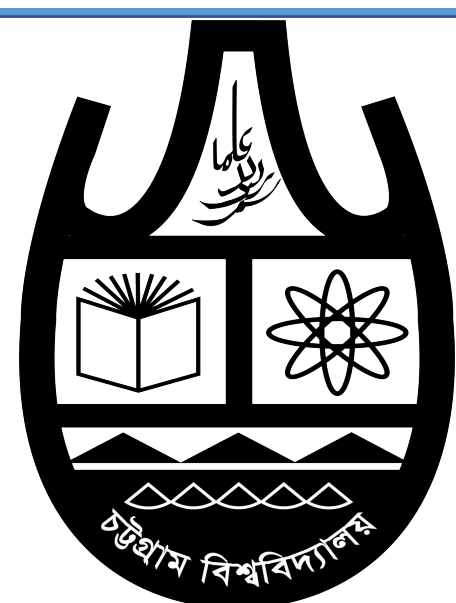




University of Chittagong

Comparative Analysis of Green and Conventional Chemical Approaches for Microplastic Remediation in Aquatic Systems

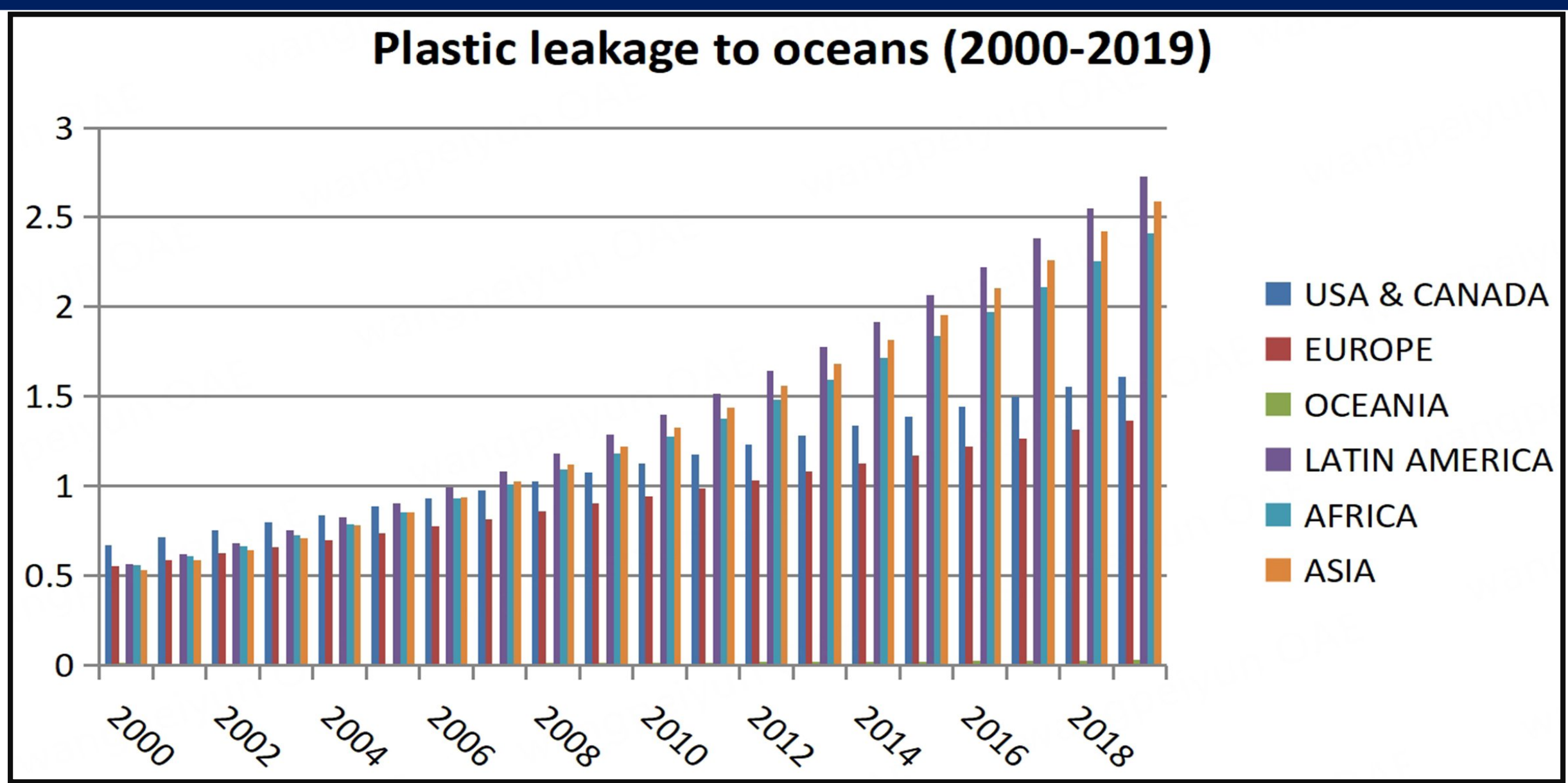
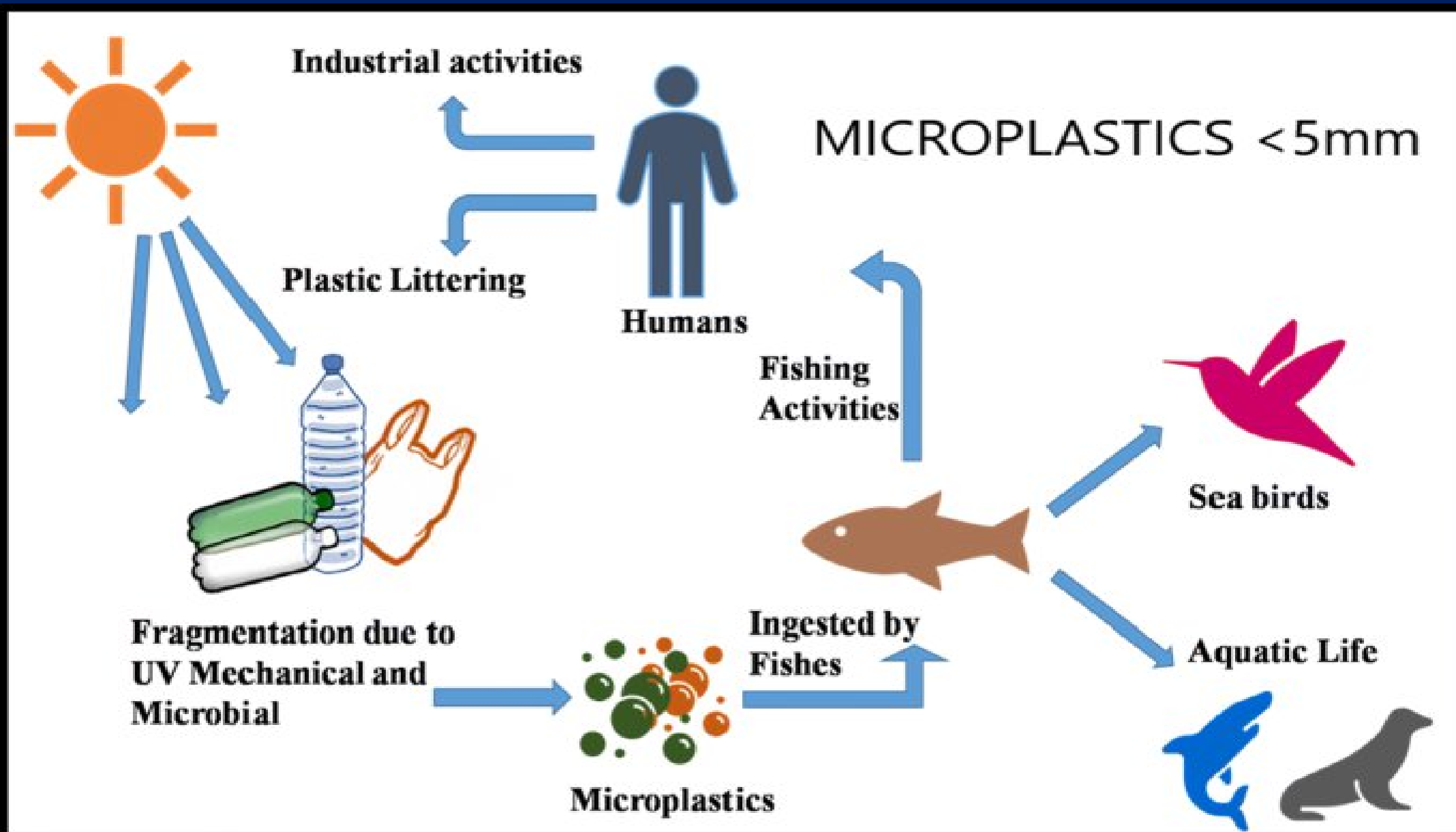
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Introduction

- Microplastics are < 5 millimeters.
- Made of polyethylene, polypropylene, polystyrene, PET, or PVC.
- Persist for decades — resist natural degradation.
- Ingested by plankton, fish, and shellfish → enter food chain.
- Trigger oxidative stress, inflammation, and DNA damage.
- A rising threat to aquatic ecosystems and human health.



Objectives

The objective of this study is to compare conventional chemical methods (e.g., coagulation, oxidation) with green approaches (e.g., biopolymer coagulants, enzymatic degradation) for microplastic remediation in aquatic systems. The study emphasizes removal efficiency, by-product toxicity, and ecological safety, while highlighting challenges and opportunities for adopting sustainable, SDG-aligned solutions.

Result and Discussion

Method	By-products
Coagulation–Flocculation	Sludge with MPs, residual Al ³⁺ /Fe ³⁺
Chlorination	Trihalomethanes, haloacetic acids, MP fragmentation
Ozonation	Aldehydes, ketones, oxidized MP fragments
Fenton’s Reagent	Organic acids, oxidized fragments, Fe sludge
Incineration	Dioxins, furans, PAHs, heavy metals

Table 1. By-products of Conventional Microplastic Removal Methods

Method Type	Toxic By-products	Sludge/Residue Hazard	Biodegradability of Agents (%)	Secondary Pollution Risk	Energy Intensity (kWh/m ³)
Coagulation–Flocculation (Alum/FeCl ₃)	Residual Al ³⁺ /Fe ³⁺ up to 2–5 mg/L	50–150 g sludge/m ³	<10	High (sludge leaching)	0.1–0.3
Chlorination / Oxidation	THMs up to 80 µg/L	Negligible	0	High (chlorinated by-products)	0.2–0.5
Membrane Filtration (UF/NF/RO)	Low	10–30 L brine/100 L treated water	—	Moderate	0.5–2.5
Biopolymer Coagulants (Chitosan, Starch)	None detected	5–20 g sludge/m ³	>90	Low	0.1–0.2
Enzymatic Degradation (PETase, Cutinase)	None detected	None	~100	Low	0.3–0.6
Microbial Consortia	None detected	None	~100	Possible ecological imbalance	0.05–0.2
Green Photocatalysis (TiO ₂ , ZnO)	Oxidized fragments (COOH, C=O)	Low	~50	Nanoparticle release risk	1.0–3.0
Biochar Adsorption	None detected	10–30 g spent biochar/kg water treated	>80	Desorption under pH shifts	0.1–0.3

Table 2. Ecological Safety Parameters of Microplastic Remediation Methods

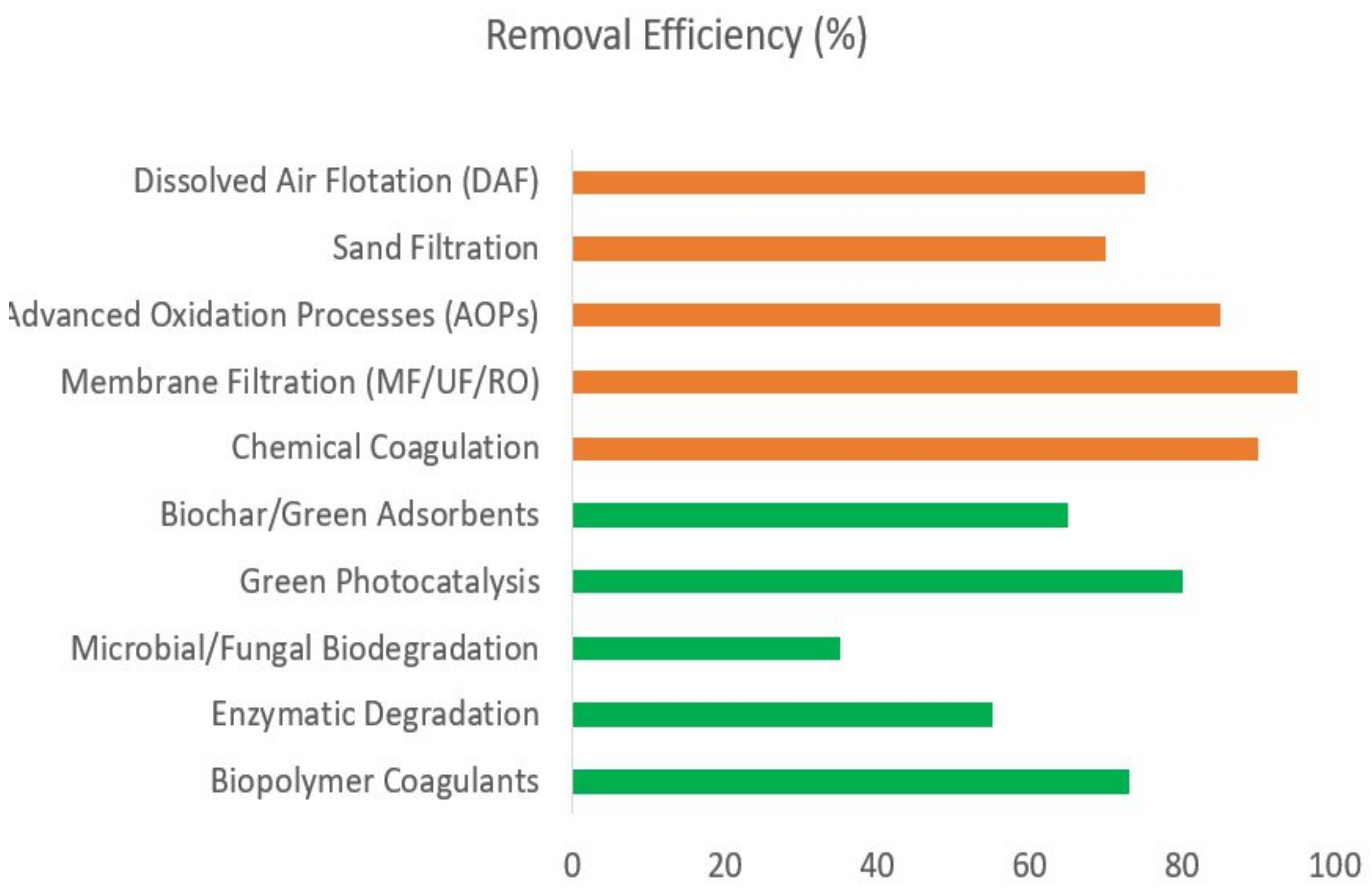


Table 3. Microplastic removal efficiencies of green and conventional methods.

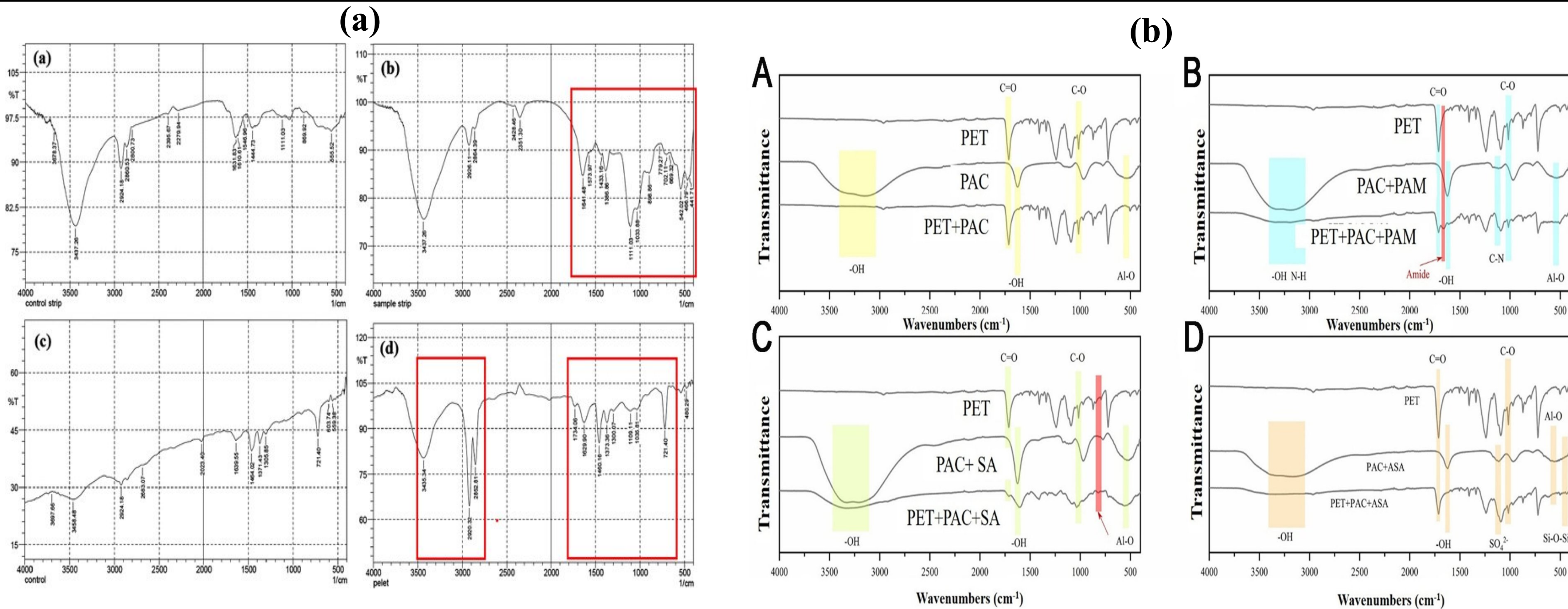


Figure 4. FTIR spectra of degraded low-density polyethylene (LDPE): (a) biodegradation by bacterial consortia showing the appearance of new functional groups (C=O, O-H) and reduction in CH₂ stretching peaks, and (b) chemical coagulation using alum/FeCl₃, indicating surface oxidation and minor structural modifications.

Methodology

A systematic literature review was conducted using databases such as Scopus, Web of Science, and PubMed to compare green and conventional chemical methods for microplastic remediation in aquatic systems. Studies from 2010–2024 were screened based on removal efficiency, by-product toxicity, and sustainability metrics. Inclusion focused on experimentally validated techniques with quantifiable performance data. Extracted data were analyzed and averaged for comparison.

Challenge and Future Perspective

- Current Limitations and Technical Challenges
- Critical Knowledge Gaps in Microplastic Remediation
- Advances in Technological Innovation and Hybrid Systems
- Future Perspectives for Scalable and Sustainable Applications
- Policy Frameworks and Regulatory Considerations

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