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Editorial: Wastewater treatment: removal of recalcitrant compounds

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Editorial on the Research Topic
Wastewater treatment: removal of recalcitrant compounds

The United Nations reported in 2017 that over 80% of wastewater was released into the environment without adequate treatment, and for this reason, goal 6.3 of the UN Sustainable Development Goals (SDGs) states as follows: "By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally".

Currently, traces of organic contaminants have been found in water bodies and wastewater treatment plant effluents. These contaminants—known as emerging contaminants—are of great concern because these pollutants cause adverse ecological and human health effects. Most of these contaminants such as pharmaceuticals, hydrocarbons, pesticides, or personal care products are recalcitrant and can be found in high concentrations in industrial wastewater.

Wastewater treatment needs to be improved to address the problems that arise from the accumulation of recalcitrant and emerging contaminants in natural water bodies.

Biological treatment is usually employed for wastewater recovery, mainly for economic reasons; however, it must frequently be supplemented with other techniques to efficiently degrade non-biodegradable or recalcitrant pollutants. Among these other techniques, we find coagulation, electrocoagulation, membrane processes, adsorption, and advanced oxidation processes, such as photocatalysis, Fenton, UV/hydrogen peroxide, and ozonation. The application of these techniques depends on the characteristics of the wastewater to be treated.

This Research Topic is intended to study in depth the characterization and treatment of wastewater containing recalcitrant contaminants, optimize the mineralization and detoxification of the effluents, and maximize the reuse of water.

This Research Topic is composed of six articles. In two of them, the researchers investigated biological processes for the removal of nitrogen from wastewater.

Wang et al. studied the removal of nitrogen from pharmaceutical wastewater with high organic matter (3,750 ± 50 mg/L COD) and nitrogen content (210 ± 10 mg/L NH_4^+-N). For this purpose, they used an anaerobic sequencing batch reactor (ASBR) combined with a modified sequencing batch biofilm reactor (SBBR) that yielded above 93.5% removal for all parameters. In the effluent, COD was 230 ± 10 mg/L, while only 5 ± 3 mg/L TN was detected, of which 1 ± 0.5 mg/L was attributable to NH_4^+-N. The authors found that a C/N ratio of five in the influent enhanced the simultaneous nitrification and denitrification (SND) in the aerobic section. At the genus level, the main bacteria found in the system were *Thauera* and *unidentified_Sphingobacteriales,* responsible for the denitrification functions, and *Denitratisoma, Paracoccus, and Pseudomonas*.

Moloantoa et al. developed a bioremediation strategy to remove nitrate from mine wastewater, which contained over 120 mg/L of NO_3^-. A metagenomic analysis applied to study microbial diversities revealed that the samples were dominated by the phyla Proteobacteria and Bacteroidetes. The authors supplemented the cultures with metal enzyme co-factors (iron and copper) and observed that copper supplemented at 50 mg/L promoted complete denitrification of over 500 mg/L of NO_3^-.

Another study dealt with the removal of malachite green (MG) and leucomalachite green (LMG) from freshwater and seawater using different adsorbents. Lin et al. found that the removal of MG and LMG was complete in freshwater when zeolite or humic acid (HA) was used although the removal efficiency was lower when the contaminants were in seawater. ClO_2 was able to remove the contaminants completely in both water matrices. However, adsorption on oyster shell powder (OSP) exhibited lower MG and LMG removals than the other alternatives, especially in seawater.

Wu et al. studied the removal of organophosphorous pesticides, such as glyphosate, with a Cu/Fe bimetallic system. They found that acidic pH (2.0), 250 g/L Cu/Fe dosage, 0.25% Cu/Fe, and 60 mg/L initial glyphosate concentration were the appropriate conditions for glyphosate removal. The removal efficiencies of total phosphorus and total organic carbon reached 99% and 65%, respectively, and detoxification, studied against luminescent bacteria Q67, was achieved.

Liu et al. developed a new visible light-driven reduced graphene oxide (rGO) and nanoscale zero-valent iron (nZVI) co-modified g-C_3N_4-based photocatalyst synthesized via ultrasonication-assisted chemisorption. They studied the removal of fluoroquinolone antibiotics with this material and found an enhanced photoactivity of their material compared to that of carbon-doped g-C_3N_4 and rGO-supported g- C_3N_4. They ascribed their findings to the synergistic effect of nZVI and rGO to improve the separation of charge carriers and boost the harvest of visible light.

Lastly, Zhang et al. prepared a PVDF/DA-modified membrane and studied the removal and degradation of sulfamethoxazole (SMX) in a membrane bioreactor (MBR). The system operated for 60 days, and they found that the removal rate of the contaminant was above 85%. They also studied membrane fouling and found that the PVDF/DA membrane could alleviate membrane fouling compared to PVDF membranes, thereby improving the service life of the membrane and reducing its operating cost.

The findings published in this Research Topic demonstrate that the denitrification of wastewater containing recalcitrant contaminants can be accomplished using biological techniques. Additionally, zeolites have shown to be good adsorbents for the removal of organic compounds from wastewater with different salinities. Regarding photocatalysis under visible light, the combination of nZVI, rGO, and g - C_3N_4 enhances photoactivity due to a better separation of charge carriers. Lastly, the removal of contaminants can be also achieved using low-fouling PVDF/DA membranes. In brief, the treatment of wastewater contaminated with recalcitrant organics can be managed using diverse techniques appropriately.

Author contributions

DS: Writing–original draft. JM: Writing–review and editing. EP-M: Writing–review and editing. VV: Writing–review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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