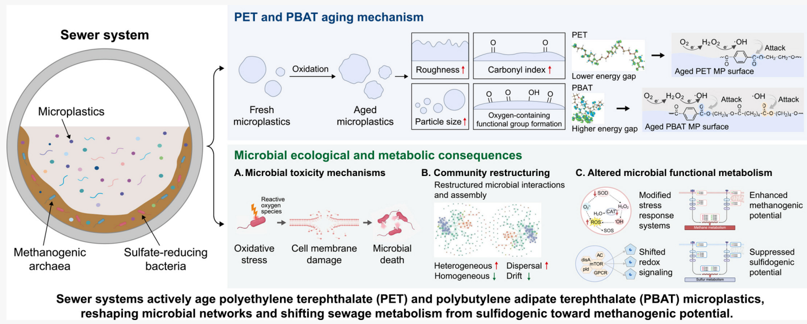
Microplastics in sewers: Hidden catalysts for methane emissions?

GA, UNITED STATES, July 10, 2026 /EINPresswire.com/ -- Microplastics, the persistent pollutants already known to threaten ecosystems and human health, have a previously unrecognized dark side inside the world's urban sewer networks. A new study reveals that these tiny plastic particles, particularly polyethylene terephthalate (PET) and polybutylene adipate terephthalate (PBAT), undergo aging in the low-oxygen, sulfide-rich environment of sewers, generating reactive oxygen species (ROS) that reshape the microbial communities within. This transformation shifts the metabolic balance of the sewer microbiome, suppressing hydrogen sulfide production but significantly enhancing methanogenic activity, potentially increasing greenhouse gas emissions and posing new safety risks in urban drainage systems.



Sewer-driven microplastic aging and its cascade effects on microbial ecology and metabolism.

Microplastics are abundant in municipal wastewater, with concentrations ranging from 10 to 470 particles per liter in sewage. Despite the vast scale of urban sewer systems—extensive underground networks where complex physical, chemical, and biological processes occur—research has largely focused on microplastics' transport and removal in wastewater treatment plants, while their ecological impacts within the sewer environment itself remain critically underexplored. Sewers are not passive conduits but dynamic bioreactors hosting diverse microbial communities that mediate key biogeochemical cycles, including sulfur and methane metabolism. Based on these challenges, there is a pressing need for in-depth investigation into how microplastics interact with and potentially disrupt these vital sewer ecosystems.

A team of researchers from Beijing University of Technology and Beijing Waterworks Group Co., Ltd. has now uncovered the bidirectional interactions between microplastics and sewer systems. Publishing (DOI: 10.1016/j.ese.2026.100726) their findings in June 2026 in the journal Environmental Science and Ecotechnology, the team conducted a 120-day experiment using concrete sewer reactors fed with real domestic sewage, exposing them to environmentally relevant concentrations of polyethylene terephthalate (PET) and polybutylene adipate terephthalate (PBAT) microplastics at 30, 100, and 500 particles per liter. Through a combination of physicochemical characterization, metagenomic sequencing, and ecological network analysis, they demonstrated that sewer conditions actively promote microplastic aging while the aged particles, in turn, restructure the microbial ecosystem.

The study revealed that hydroxyl radicals (·OH), generated through sulfide autoxidation and redox reactions in the low-oxygen sewer environment, are the primary drivers of microplastic aging. Using electron paramagnetic resonance (EPR) spectroscopy and spin-trapping with 5,5-dimethyl-1-pyrroline-N-oxide (DMPO), the researchers confirmed that ·OH signals were present only in sewage—not in deoxygenated water—and that microplastics amplified this radical generation. These radicals preferentially attack ester bonds in PET and PBAT polymers, triggering chain scission, increasing surface roughness, and introducing oxygen-containing functional groups. Notably, the biodegradable PBAT degraded substantially faster than PET, with its particle size shrinking by 11.3% and carbonyl index rising by 16.3%. The aging process itself created a self-reinforcing cycle—as the plastics fragmented, they further promoted radical generation, amplifying oxidative stress within the microbial community. Using Fukui function calculations based on density functional theory, the researchers identified the specific molecular sites most vulnerable to radical attack, confirming that ester bonds in the aliphatic segments were the primary degradation targets. Two-dimensional correlation spectroscopy (2D-COS) analysis further revealed distinct degradation sequences: PET underwent slow, stepwise oxidative degradation beginning with ester bond cleavage, while PBAT exhibited rapid and extensive oxidative cleavage across multiple C–O bands simultaneously.

"Microplastics are not inert. In the sewer environment, they undergo physicochemical changes while simultaneously reprogramming the metabolism of the resident microbial community," the authors said. "These particles trigger a cascade of effects—oxidative stress, membrane damage, and community restructuring—that shifts the balance toward methanogenesis. What's particularly concerning is that this process may create a legacy effect in sewer microbiomes, where communities become locked into a deterministic, stress-adapted state that may persist even if microplastic inputs are reduced."

The ecological consequences of microplastic exposure were substantial. The microplastics weakened microbial co-occurrence networks, reducing the number of interspecies interactions and shifting community assembly from stochastic to deterministic processes. Hydrolytic and fermentative bacteria declined by up to 63.4%, while hydrogen-producing acetogens and methanogenic archaea increased by 48.4–67.0%. Sulfate-reducing bacteria, responsible for hydrogen sulfide production, fell by up to 49.7%. At the gene level, exposure to 500 particles per liter reduced genes encoding adenosine-5'-phosphosulfate reductase (aprA/B) and dissimilatory sulfite reductase (dsrA/B) by 40.4–55.5%, while enhancing hydrogenotrophic methanogenesis genes including fdwG, ftr, mch, mtd, and mer. These shifts translated to a dramatic 89.5% reduction in sulfide concentration but potentially elevated methane production, challenging the notion that reducing sulfide automatically improves sewer safety.

These findings carry significant practical implications for urban wastewater management. First, they demonstrate that sewer systems are active reactors that can pre-age microplastics, potentially increasing their environmental reactivity and ecotoxicological effects before they reach treatment plants. Second, the observed metabolic shift from sulfidogenesis to methanogenesis suggests that microplastic pollution could inadvertently trade odor and corrosion problems for increased greenhouse gas emissions and combustible gas accumulation risks in poorly ventilated sewer segments. This complicates conventional strategies for simultaneous H_2S and CH_4 control. The researchers emphasize that effective microplastic management must extend beyond wastewater treatment plants to include upstream source reduction, such as limiting microfiber release from laundry and pretreating industrial effluents. Installing capture systems at key sewer nodes could restrict the downstream transport of "pre-aged" microplastics, providing a critical intervention point for mitigating both ecological and operational risks in urban drainage infrastructure.

References
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