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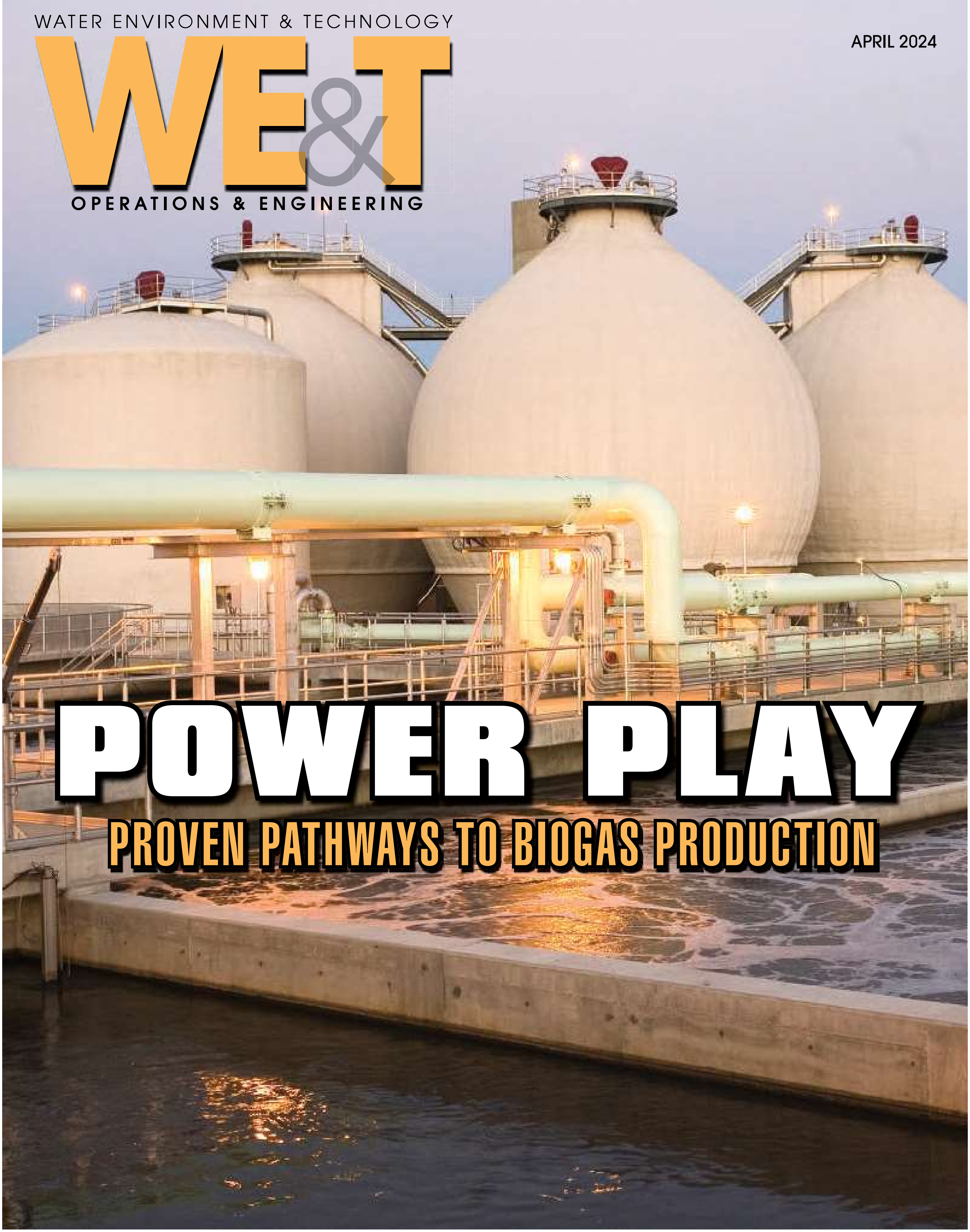


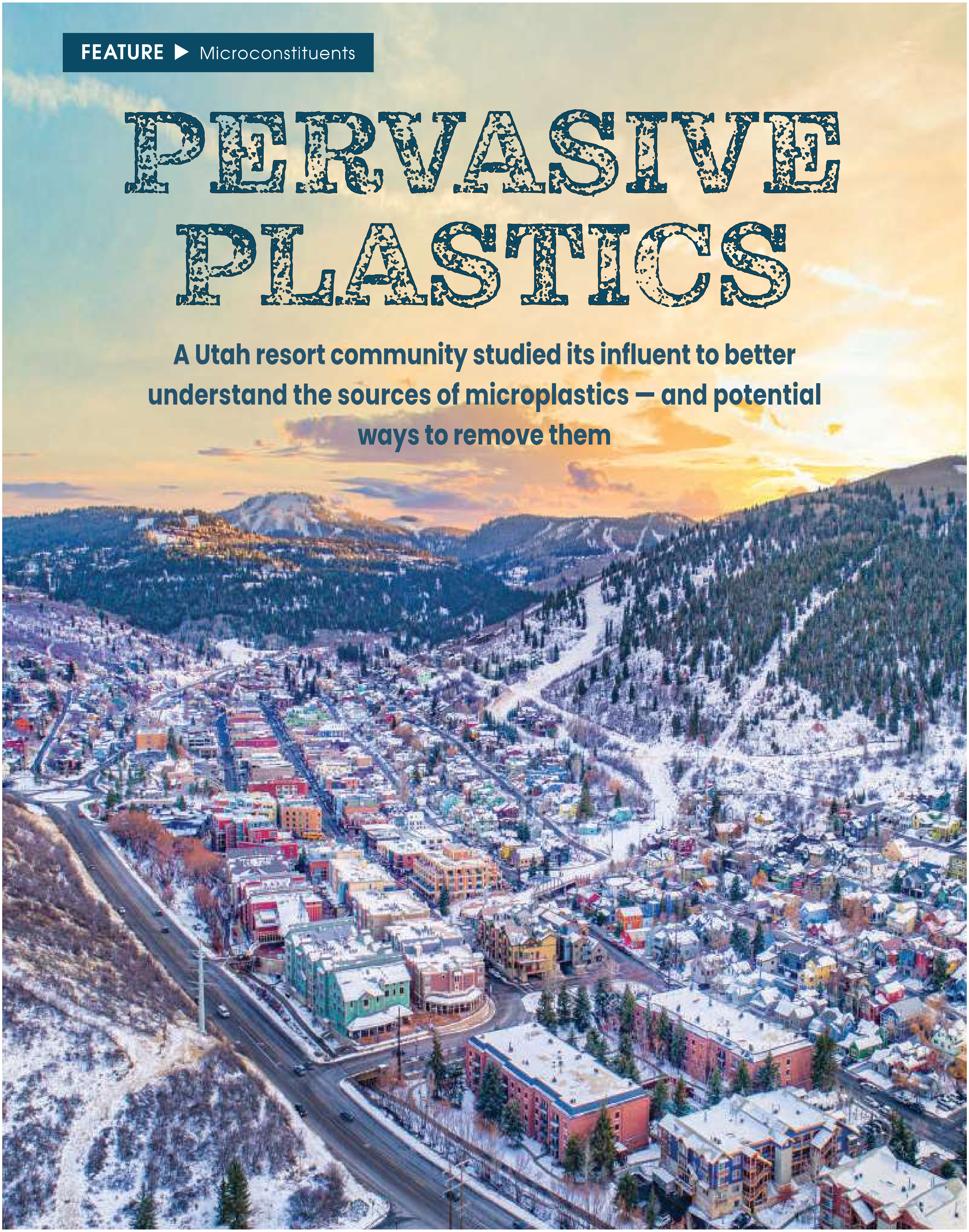
POWER PLAY

PROVEN PATHWAYS TO BIOGAS PRODUCTION

FEATURE ▶ Microconstituents

PERVASIVE PLASTICS

A Utah resort community studied its influent to better understand the sources of microplastics — and potential ways to remove them




Getty Images

Erin Andersen, Craig Ashcroft, Michael Luers, Tiffini Adams, and Chad Burrell

As every water professional knows, plastics are everywhere. Microplastics — defined as plastic particles ranging from 1 nm to 5 mm — have been detected widely in aquatic and marine ecosystems. Surveys show that water resource recovery facilities (WRRFs) receive high concentrations of microplastics from industrial and domestic users alike, making them potential point sources of microplastic contamination in receiving waters. But what influences the concentrations of microplastics in wastewater influent, and how well do current treatment processes manage them? The Snyderville Basin Water Reclamation District (Park City, Utah) decided to find out. The district's East Canyon Water Reclamation Facility (ECWRF), which treats wastewater from the bustling resort community, performed a comprehensive sampling campaign to quantify microplastics during high- and low-flow periods. This study led to two major findings: High microplastics concentrations correlated with tourist season, and the existing treatment process was extremely efficient at microplastics removal.

What ECWRF learned can help other WRRFs better understand the fate of microplastics and work toward advanced treatment to mitigate the continued release of microplastics to the environment.

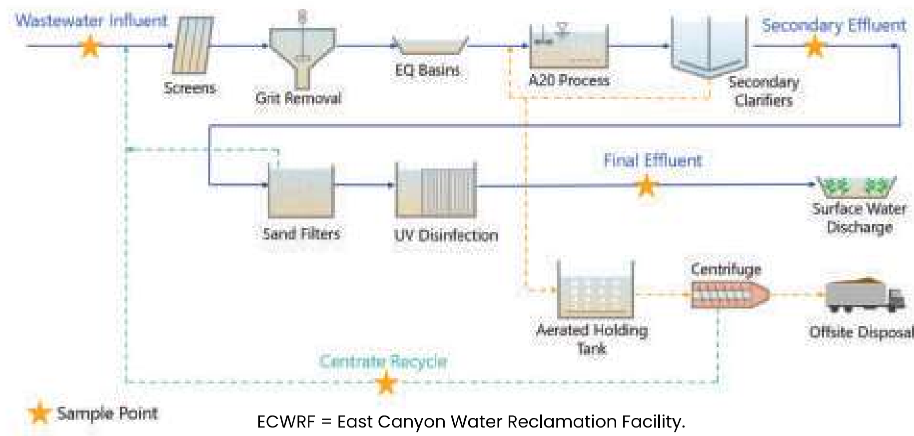
The Facility

ECWRF is a biological nutrient removal, activated sludge facility with a treatment capacity of 18,900 m^3/d (5 mgd). Each winter, tourists flock to Park City to experience its world-class snow skiing and the Sundance Film Festival. This annual influx of tourists can result in an increase in the influent flow to ECWRF by as much as 100% in a single day.

The ECWRF treatment process includes primary treatment with screening and grit removal, equalization, secondary treatment through an anaerobic-anoxic-aerobic activated sludge process, clarification, tertiary treatment through alum addition and filtration using continuous backwashing, deep-bed sand filtration, and finally ultraviolet disinfection. Filter-reject flow is returned to the head of the treatment process. Centrifuges dewater the nondigested waste activated sludge before it is disposed of at the local landfill, and the resulting centrate returns to the head of the treatment process (see Figure 1, p. 52).

The facility discharges into East Canyon Creek, which has a beneficial use designation as a cold-water fishery. The creek flows into East Canyon Reservoir, which is used as both a domestic and agricultural water supply for parts of the northern and central Wasatch Front. Furthermore, this creek is effluent-dominant in the summer months; as such, the facility has taken steps above and beyond to determine its effects on the steam. Most recently, ECWRF conducted two sampling campaigns to monitor the quantity and characteristics of microplastics in the influent during the peak tourist and dry summer seasons. The sampling also helped ECWRF evaluate the fate of these microplastics through its treatment process, so the facility could better define effects on the downstream ecosystem and inform future research and treatment efforts.

Figure 1. ECWRF Process Flow Diagram



ECWRF = East Canyon Water Reclamation Facility.
EQ = equalization.
A20 = anaerobic-anoxic-aerobic.
UV = ultraviolet.

Sampling and Analysis

To quantify microplastics removal through the treatment process, ECWRF collected composite samples every 15 minutes over a 24-hour period in four locations: at the influent Parshall flume, prior to the return of the recycle streams, downstream of the secondary treatment process at the filter inlet channel, and from the effluent channel downstream of UV disinfection.

They repeated this 24-hour sampling effort three times over the course of a week in March, when hotel occupancy and flows are high; and again on 2 additional days in early November, when influent flows typically are at their lowest. On the same days in March they collected the process water samples, they also collected grab samples of the centrate to learn more about microplastics recycling in the system and potential accumulation of microplastics in wasted solids. The facility collected all samples in nonpolymeric containers and sent them to two outside labs for analysis.

ECWRF sent the March bulk liquid samples to the University of Arizona's WEST Center (Tucson), and the November samples to Eurofins Environmental Testing Australia (Eurofins AU; Victoria). Prior to shipping the November samples, the facility prepared them at the certified ECWRF lab, using a nonpolymeric vacuum apparatus to filter them through 15-μm polycarbonate filter paper. Eurofins AU provided the polycarbonate filter paper and tested it to ensure that no polymer particles were shed during filtration. It also provided plastic-free water for rinsing the filter apparatus between samples. Following filtration, the ECWRF lab placed each filter paper with the retained solids in a nonpolymeric container and shipped it to Eurofins AU for analysis.

Both labs processed all samples with hydrogen peroxide and Fenton's reagent for removal of organic matter. Where necessary to remove sediment from the remaining solids, they applied a density-separation procedure using low- and high-density sodium chloride solutions. Remaining solids were passed through a sieve to remove particles smaller than the minimum detection limit of the analytical equipment. The labs then analyzed retained material by laser direct infrared spectroscopy for size, morphology, and polymer type.

Results

Quantity and characteristics. The labs identified 29 different types of polymers in the ECWRF influent across both sampling events (see Figure 2, p. 53).

In a majority of the influent samples taken in March, during high flows, the three most common polymers detected were polyvinyl chloride (27.2%) — which is commonly used in biomedical applications, apparel, and packaging — and polyamide (18.4%) and polyester (15.4%), both of which are common in textiles used in carpet and apparel.

For samples taken in early November, prior to the start of the ski season, the predominant polymer types were polyurethane (21.3%), which commonly is used in protective coatings and high-efficiency insulating materials; silicone (15.1%), which is common in lubricants, water repellants, and seals such as O-rings and gaskets; and polyethylene terephthalate (12.9%), which is used in the production of packaging and textiles for carpet and apparel.

Analysis showed an increase in the detected particles per liter in samples taken on Monday and Tuesday compared to samples taken in the middle and at the end of the week (see Figure 3, p. 54). This difference was especially stark for samples collected in March, when there was an increased number of weekend visitors at local hotels and resorts and a subsequent increase in laundry upon their departure. Overall, samples taken in March contained a higher number of polymer particles per liter than those taken in November, during low flows.

Fate of microplastics. The samples showed that ECWRF achieved removal efficiencies ranging from 73% to 99% across the entire treatment process, with the majority of removal — 55% to 99% — occurring within the primary and secondary treatment processes.

The overall removal efficiency calculated for November 5 was significantly lower than those on other sampled days. On this day, the influent sample was observed to have a higher content of fats, oils, and grease (FOG), which clung to the sides of the sample container and filter apparatus despite multiple rinses with plastic-free water. The facility suspects that polymeric particles were retained within the FOG material and therefore lost from the influent sample, resulting in a lower-than-expected removal efficiency through the primary and secondary treatment processes (-28%), thus reducing the overall removal efficiency on that day (-13%). High FOG was not observed in the secondary or final effluent samples taken on this day.

Generally, little to no removal of microplastics was seen across the tertiary filters. Two exceptions were March 16 and November 1, when the tertiary filters removed 35% and 33% of the total influent particles, respectively. It is unclear what might have caused the increased removal on these days. One possibility is that alum dosing upstream of the tertiary sand filters might have improved microplastics removal. Because this happened only on March 16, further investigation would be required to confirm a connection.

Using ECWRF operation data on the days centrate grab samples were collected, the facility conducted a mass balance of microplastics in the system. This showed that the vast majority of the microplastics in the influent — about 98% — were captured in the dewatered solids and not returned to the head of the plant via the centrate and filter reject recycle streams or discharged to the environment in the effluent.

Takeaways

Although ECWRF is not optimized specifically for microplastics removal, the facility achieved impressive removal efficiencies ranging through their entire process. The majority of the removal occurred through the primary and secondary treatment processes, where primary treatment consists of only screening and grit removal. Given that approximately 98% of these removed microplastics were captured in the dewatered solids, the environmental concern associated with microplastics shifts from the receiving waters to the biosolids disposal site.

Figure 2. Detected Polymers as % of Total Detected Particles

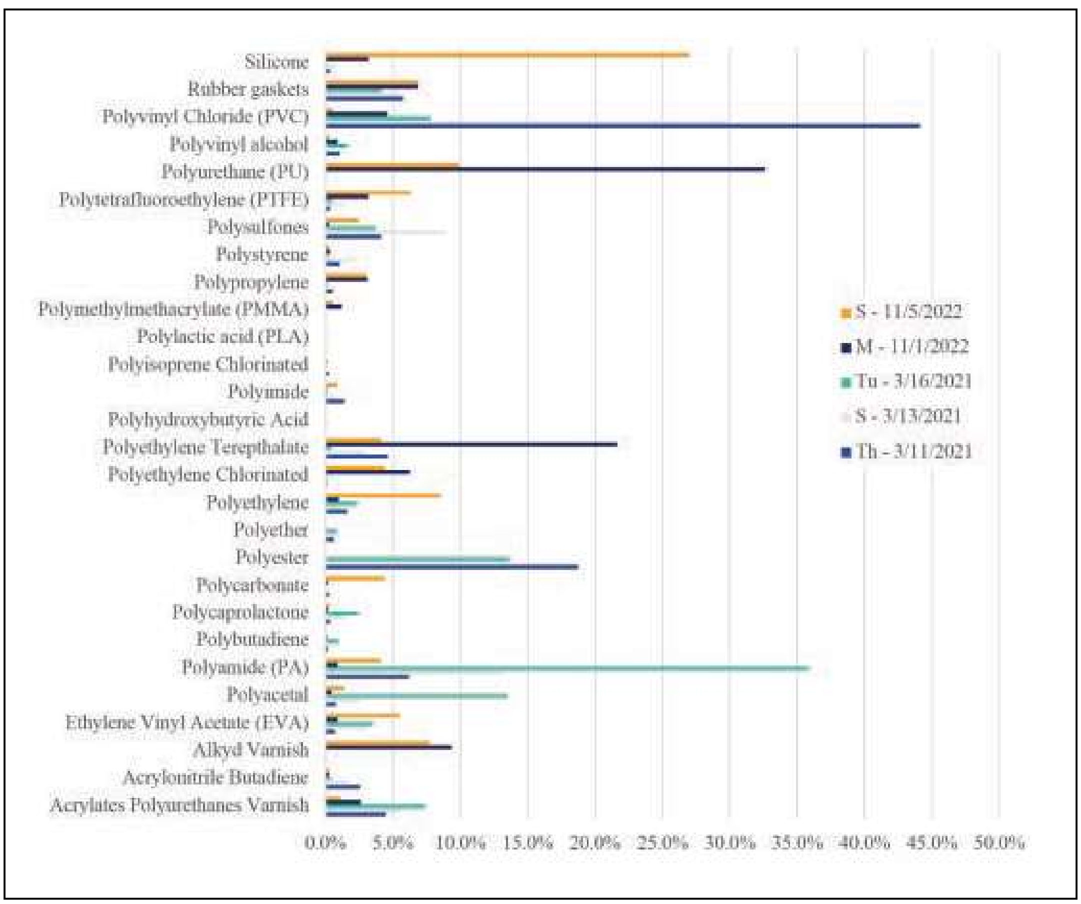
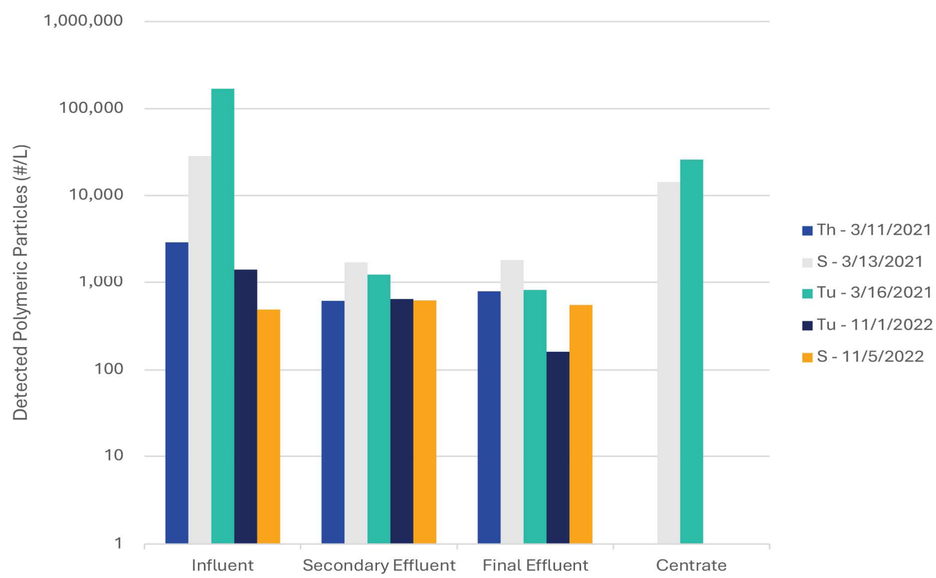


Figure 3. Detected Polymeric Particles in the Treatment Process



While the tertiary sand filters removed little of the microplastics, their improved performance on specific days is intriguing. It is worth further research to determine whether alum dosing can be optimized for removal of both phosphorus and microplastics. If this were possible, microplastics could be concentrated in the filter reject stream, creating an opportunity for sidestream treatment using a dissolved-air flotation or membrane filtration process. Both technologies have been shown to be effective at removing microplastics but would not be applied economically to the entire treatment flow.

Because of their ubiquity, microplastics entering WRRFs and the environment are most effectively diminished by source reduction. However, understanding the process removal and fate of microplastics in WRRFs is the first step in potential advanced treatment to reduce the quantity of microplastics leaving WRRFs in dewatered solids. Facilities should develop a holistic approach when considering microplastics mitigation. Finally, further study is needed to evaluate the effectiveness of sidestream treatment of recycle streams, such as centrate and filter reject, in reducing the number of microplastics in the effluent and dewatered biosolids.

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Further Reading

The following resources provide additional insights regarding the fate and treatment of microplastics.

Li, Jingyi, Huihui Liu, and J. Paul Chen (2018). "Microplastics in Freshwater Systems: A Review on Occurrence, Environmental Effects, and Methods for Microplastics Detection," *Water Research* (Vol. 137), pp. 362–374.

Okoffo, Elvis D., Stacey O'Brien, Jake W. O'Brien, Benjamin J. Tscharke, and Kevin V. Thomas (2019). "Wastewater Treatment Plants as a Source of Plastics in the Environment: A Review of Occurrence, Methods for Identification, Quantification, and Fate," *Environmental Science: Water Research & Technology* (November), pp. 1908–1931.

Raju, Subash, Maddison Carbery, Aswin Kuttykattil, Kala Senathirajah, S.R. Subashchandrabose, Geoffrey Evans, and Palanisami Thavamani (2018). "Transport and Fate of Microplastics in Wastewater Treatment Plants: Implications to Environmental Health," *Environmental Science Bio/Technology* (Vol. 17), pp. 637–653.

Sun, Jing, Xiaohu Dai, Qilin Wang, Mark C.M. van Loosdrecht, and Bing-Jie Ni (2019). "Microplastics in Wastewater Treatment Plants: Detection, Occurrence, and Removal," *Water Research* (Vol. 152), pp. 21–37.

Zhang, Zhiqi and Yinguang Chen (2020). "Effects of Microplastics on Wastewater and Sewage Sludge Treatment and Their Removal: A Review," *Chemical Engineering Journal* (Vol. 382, article 122955).