A novel approach to sampling microplastics

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6 January 2025

Applied Ocean Sciences is creating a sensor that is faster, more efficient, and less expensive than current sampling methods and will be the first sensor to allow near real-time abundance measurements for microplastics in a water sample

The world's biggest tiny problem

Microplastics are turning up everywhere we look for them. Microplastics (plastic particles < 5mm) have been found in various parts of the environment, including the oceans, the atmosphere, soil, and sea ice. They're also making their way into our food and water, appearing in seafood, fruits, vegetables, beer, soda, tea, sea salt, honey, and both tap and bottled water. Alarmingly, microplastics are also being found within the human body – detected in our blood, lungs, and stool – and even in the placenta and breastmilk, revealing that exposure begins at the earliest stages of development. While research on the effects of microplastics on human health is still relatively preliminary, the harmful impacts of chemicals associated with plastics are well-documented.[1]

California is the first governmental body in the world to mandate testing for microplastics in drinking water.[2] Over the next two years, the state will conduct quarterly monitoring at 30 water treatment plants, refining the process before extending the program for another two years. But traditional methods to monitor microplastics in drinking water, like Fourier Transform Infrared (FTIR) spectroscopy or Raman spectroscopy, are incredibly time and labor intensive.

Dr Jennifer Brandon knows this firsthand. She has spent hundreds of hours funneling liters of seawater into filters and then using the traditional methods to identify microplastics on those filters piece by piece. Current methods require focusing a microscope on each individual microplastic particle and then identifying the type of plastic via FTIR or Raman spectroscopy, which passes specific wavelengths of light through the plastic. This often must be done in total darkness so as not to disturb the spectroscopic reading.

Spectrometer readings such as these give scientists a 'spectral fingerprint' for the exact plastic polymer type of each microplastic, and markings on the microscope help measure each particle's width and length. These traditional methods take days to analyze a single liter of water and cost $1000 or more per sample. Sometimes, however, a research question does not need such specificity, but there is no current way to know the total amount of microplastics in a sample of water without analyzing each piece of plastic individually.

A new sampling technique

All current analysis methods of microplastics consist of visual or spectral inspection. Dr Brandon and her colleagues at Applied Ocean Sciences are turning these traditional sampling methods on their heads by using acoustic techniques to detect and characterize microplastics in water. Measuring for microplastics with sound allows for new opportunities to analyze the particles while they still remain in a fluid. Rather than isolating and identifying each microplastic piece individually, the entire sample can be measured at once, drastically cutting down on sampling time, cost, and effort. The ultimate goal is to provide a fully automated, near real-time bulk abundance measurement for microplastics in a sample of water. What used to take days or weeks can now be done in minutes.

In order to acoustically sample something as small as microplastics in water, Applied Ocean Sciences (AOS) uses very high acoustic frequencies – i.e., ultrasound. Classical ultrasonic fluid sensing techniques, such as those used to detect bubbles in blood or defects in fuel, rely on ultrasonic scatterometry or pulse-echo imagery to detect the presence of anomalies. The novel ultrasonic processing system developed by AOS leverages physics similar to ultrasonic resonant spectroscopy and bulk attenuation tomography to analyze the difference in bulk modulus, or incompressibility, between microplastics and water. In this system, plastic particles in the fluid resonate when excited at specific frequencies, a response detectable by the sensor's ultrasonic receiver. Furthermore, the suspension of particles in a fluid changes the overall medium's viscosity; at the device's small spatial scales and high acoustic frequencies, the reduction in amplitude of sound due to viscous effects is observable and strongly correlated with concentration. Thus, sand, biological detritus, bubbles, and plastics all react differently to being excited by acoustic wavelengths. These different viscous effects and excitation frequencies enable Applied Ocean Sciences' sensor to identify the contents of a water sample, distinguish plastics from other materials, and provide rough estimates of the size ranges and concentrations of the plastic particles.

The impacts of a new kind of sensor

The ability to quickly and affordably measure the bulk concentration of microplastics in samples like drinking water introduces significant environmental, health, and policy implications. This technology will empower scientists to sample the ocean, rivers, and other bodies of water more often, to understand how microplastic concentrations change over small time scales with events like storms, currents, and seasons, and to have those results nearly instantly.

It will also support scientists, policymakers, and community members to improve environmental and health monitoring, like California's drinking water monitoring efforts. Applied Ocean Sciences envisions these sensor results being treated as an initial screening tool, where water is first read through their sensor, and samples flagged with high microplastic abundance will then be analyzed again via the more precise FTIR or

Raman methods. The rapid data collection will allow water treatment plants and other environmental monitoring networks to detect pollution or leaks the same day and prevent further damage, rather than waiting a week or more for results from traditional tests.

This interdisciplinary project combines Applied Ocean Sciences' expertise in acoustics, microplastics, and sensor development, and it has diverse applications as well. Applied Ocean Sciences looks forward to adapting this sensor for applications beyond drinking water and expanding its use beyond benchtop monitoring to help tackle the global microplastics issue with more user groups and across more disciplines, by helping them obtain easy, fast, and affordable microplastics data.

Footnotes

1. McGlade, Jacqueline, et al. "From pollution to solution: A global assessment of marine litter and plastic pollution." (2021).
2. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/microplastics.html

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- OAG 045 - January 2025

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- SH - Applied Ocean Sciences