Combatting Microplastic Pollution with a Magnetic Filtration System

Many keystone species like the sea otter help maintain the balance of their ecosystems. This helps to allow other organisms to flourish and contribute to a successful ecosystem. A road block for this universal process of life can be microplastics. **Microplastics** are small plastic particles, no larger than 5 mm in size, that are broken down over time from larger pieces of plastic debris. Due to their miniscule size, these particles are often bypassed by standard filtration systems and accumulate in aquatic environments. According to the National Oceanic and Atmospheric Administration, marine ecosystems have become heavily impacted by microplastic pollution as it can easily be disguised among food and digested by marine life, entering the food chain.

Microplastics go beyond being just a source of pollution that persists in the environment for decades. They also carry toxic chemicals from plastic manufacturing and production. Studies show that microplastics have made their way into the human food supply and drinking water. Average filtration systems are not suitable for capturing such small fragments effectively, and more advanced systems are often too expensive for customary use, especially in developing communities. Coastal cities, stormwater systems, and wastewater treatment plants are particularly at risk, as they represent critical areas where microplastics can either be intercepted or allowed to enter marine ecosystems.

To address the large threat to the environment caused by microplastics, I created a model that has the ability to limit the presence of microplastics in waterways. My model is affordable and simple, and can be set-up with minimal technical requirements. It uses magnetic separation, designed especially to remove microplastic particles from bodies of water. It also uses a process called **hydrophobic interaction**. This is the idea of nonpolar molecules building up in aqueous solutions. My model uses iron filings coated in vegetable oil to attract microplastic particles. Microplastics are hydrophobic, meaning they are more likely to cling to other hydrophobic substances through hydrophobic interaction. Using this process to our benefit, our model enables oil-coated iron particles to interact with microplastics. Because of this interaction, the microplastics can be easily removed from water using neodymium magnets.

The system contains an area that models as a body of water; a magnetic extraction unit that collects the microplastics; and a filtration stage. Contaminated water flows through the water chamber. The water chamber contains oil-coated iron fillings. The hydrophobic iron fillings cause the microplastics to adhere to them. At the magnetic extraction site, neodymium magnets are placed around the circumference of the water chamber or in the downstream collection to attract the iron and microplastic substance. Following this process, the water is passed through a secondary filtration system, a mesh filter, to remove any remaining particles.

I designed the model with accessibility and sustainability in mind. With an average total of $120-$150, my working model consists of **industrial scale neodymium magnets ($90-$110); iron fillings ($5-$10); mineral oil (~$1); and filtration mesh ($20-$30).** Compared to advanced filtration systems that can cost thousands of dollars and require maintenance, this model is affordable, scalable, and environmentally friendly. It costs less than $0.10 per liter of treated water, it’s scalable and can be replicated in larger systems using larger material, and it's environmentally friendly as reusable magnetic materials and non-toxic oil reduce waste and secondary pollution.

This model can be installed into existing community and industrial water systems. In coastal areas, it can be installed in storm drains to intercept runoff after rainfall events. In water treatment plants, it can serve as a pre-treatment or post-treatment step to specifically target microplastic contaminants. In marine conservation zones or harbors, floating units based on this model can continuously treat water. Schools and community science programs can also build small-scale versions for education and monitoring.

Microplastic pollution represents a silent but severe threat to ocean health and human well-being. The proposed magnetic filtration system offers a practical, cost-effective, and scalable solution that maximizes the chemical nature of microplastics. With support from the community, this innovation can be a powerful tool in preserving our oceans for future generations, we can turn the tide on microplastic contamination.