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EMERGING POLLUTANTS: PROTECTING WATER QUALITY FOR THE HEALTH OF PEOPLE AND THE ENVIRONMENT

THEME V

Priority emerging pollutants: microplastics, nanomaterial, and trace chemicals

Wastewater discharge from an industrial plant
© Wondimu Kebede

KEY POLICY MESSAGES

- Prioritize research and policy to address emerging substances that are highly toxic, persist in the environment, or that have value as indicators of water or environmental quality. This list will necessarily grow and evolve over time.
- Plastic pollution is ubiquitous around the globe and adversely affects humans, wildlife, and the environment, but much remains unknown about the extent of these effects—especially microplastics, which are increasingly found in all environments.
- Technologies to improve our ability to identify and remove or degrade emergent pollutants are being developed, but their applicability and effectiveness on larger scales are still limited.
- Education and outreach activities are needed to raise public awareness about the sources of emerging pollutants, activities to mitigate their release, and efforts and approaches to eliminate them from use where possible.

This Policy Brief presents the summary and key policy messages of research findings presented in the sessions under Theme 5 "Priority emerging pollutants: microplastics, nanomaterial, and trace chemicals" of the UNESCO-IWRA Online Conference on Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment, held online from 17-19 January 2023.

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Some emerging contaminants should receive priority in research and policy due to their toxicity, environmental persistence, or value as indicators of environmental conditions.

Priority topics for research include microplastics, per- and polyfluoroalkyl substances (PFAS) and pharmaceuticals and personal care products (PPCPs, such as shampoos, antibiotics, pain reduction medications). In addition, the potential applications for nanomaterials have both benefits—for filtration and other methods for degrading or removing contaminants—and potentially harmful implications, such as ingestion by aquatic species.

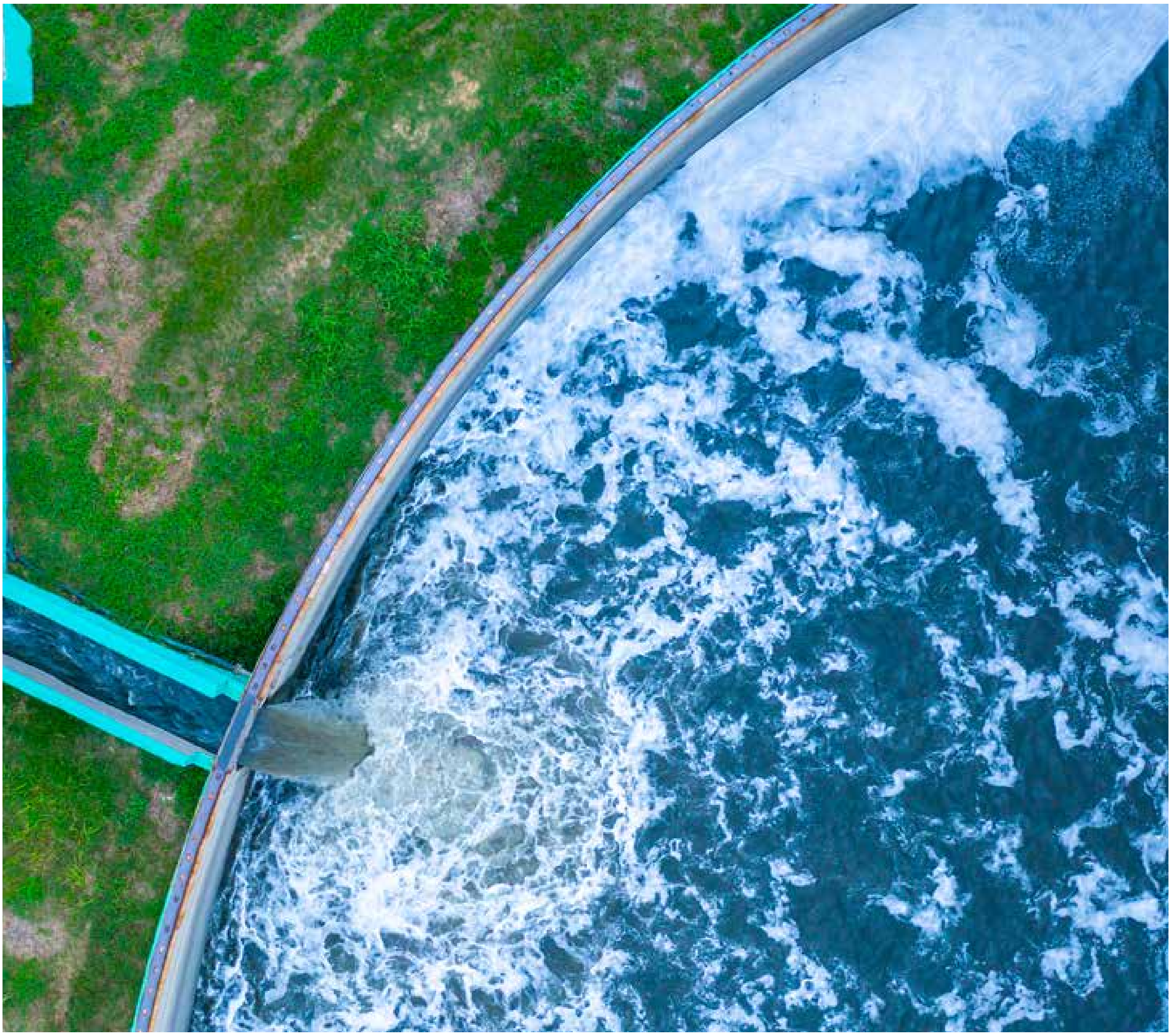
MICROPLASTICS

Among emerging contaminants, microplastics have received much attention from the research community. Microplastics are tiny pieces of plastic in the environment resulting from release via consumer products and clothes washing, the breakdown of plastic debris in the environment, and industrial wastes. Microplastics are considered to be priority emerging contaminants for various reasons, including the potential for ingestion by organisms and the potential to transport other substances on microplastic surfaces, potentially increasing exposure of aquatic organisms to toxic chemicals. In this way, microplastic particles do not behave like traditional toxicants because their characteristics cause them to engage with other substances in ways that differ from other particles. Key issues driving research about microplastics globally include analytical techniques for their detection in environmental media and tissues, the need to better understand bioaccumulation (the buildup of chemicals in organisms), bioavailability (the extent to which a substance can be taken up by an organism), transfer within the food web, and amplification of toxicity.

Microplastics are priority emerging contaminants

Microplastics can be a vector of contaminants in the environment because different types of contaminants sorb (or attach) to their surfaces. Sorption processes depend on the characteristics of the contaminant; the characteristics of the microplastic, such as the surface area, particle size, and polymer composition; and on the characteristics of the environment, such as the pH or the presence of organic matter. A research study in Brazil examined the interaction of pesticides and biodegradation products, specifically by studying fipronil, an insecticide commonly used in the country in the growing of sugar cane and corn. Fipronil undergoes biotic and abiotic transformations in aquatic environments to create transformation products (fipronil sulfide, fipronil sulfone, and fipronil desulfinyl), which are considered more toxic and persistent than the original pesticide. The study evaluated the sorption of fipronil and two of its transformation products in both ultrapure water and water from the Atibaia River, which contains high amounts of organic matter. All three of the compounds were highly sorbed by the microplastics in ultrapure water, while the sorbtion capacity observed in river water was lower, in part due to natural organic carbon in the water. The study underscored the importance of testing real environmental matrices in order to better understand how plastic pollution will interact with water in the environment.

Microplastics enter aquatic systems through community and industrial wastewater system effluent disposal, or via runoff from the land during precipitation. Wastewater treatment processes have been identified as a key step to reducing the amount of microplastics that enter the environment, particularly until other technologies can be developed and/or mature.



PFAS

Per- and polyfluoroalkyl substances (PFAS) are manufactured chemicals that have been widely used in industry and consumer products for decades. PFAS are long lasting chemicals, the components of which break down very slowly over time. Due to their extensive use and persistence, PFAS have been found in water, air, aquatic species, and soil—as well as in food products and the blood of people and animals—across the world. PFAS are also present at low levels in a variety of food products, and studies have linked PFAS to harmful health effects in humans and animals.

Research has explored various methods for removing PFAS from water resources, as conventional water treatment methods are not effective in doing so. Granular activated carbon (GAC) and ion exchange treatments have been successful, but membrane systems are most promising. Membranes can act in two ways, with both size exclusion (bigger molecules are strained by the membrane surface) and electrostatic interaction (a small electric charge increases contaminant removal) mechanisms. Researchers in this field have noted a lack of studies of PFAS in Western Africa, as well as a need for studies on the use of plastics and other PFAS-containing consumer products. There is a need for increased awareness, research, and action on PFAS across Africa.

PFAS are long-lasting pollutants

PPCPS

Pharmaceuticals and personal care products (PPCPs) are a group of chemicals that include drugs (both prescription and over-the-counter medications) and non-medicinal consumer chemicals, such as fragrances and ultraviolet blockers in sunscreens. Antibiotics are increasingly present in wastewater effluents and in wastewater solids byproducts (e.g., sludge, biosolids). Many PPCPs enter aquatic systems because they cannot be treated effectively using conventional water treatment processes. This can present a problem in part because water reuse and recharge are commonly used for water conservation. Research in Brazil is in progress to test the effectiveness of removal methods for various PPCPs in water intended for reuse and recharge. The results of a multibarrier process (incorporating reverse osmosis, oxidation, and activated carbon) were found to meet the Brazilian government's guidelines for potability. The presence of PPCPs in wastewater solids may have implications for agricultural practices although wastewater solids contain important nutrients for plant growth.

Some pharmaceutical chemicals may be removed from the environment using green degradation techniques, such as the application of microalgae. In Brazil, the biodegradation of sodium diclofenac (DCF), a common anti-inflammatory chemical, was tested using Tetraselmis sp, a marine microalga, as the degrading organism. The study demonstrated that the algae can be used to degrade and remove DCF, but the efficiency of the process is low. While promising, more research is needed on these technologies before they can be widely deployed.

The metabolism of ciprofloxacin, an antibiotic used to treat a variety of bacterial infections, by humans and animals is limited. Approximately 70% of the antibiotic is excreted into waste discharge, ending up in wastewater treatment plant effluent, wastewater plant sludge or biosolids, or animal manure. Wastewater treatment solids byproducts and animal manure may be used as fertilizer in agricultural practices. Ciprofloxacin has high sorbtion in soil, and it is immobile, persistent, and accumulative. A study evaluating the effect of ciprofloxacin on the soil invertebrate Enchytraeus crypticus over time found no significant difference in the reproduction rates of the first two generations but a significant decline in reproduction for the third. The implications of this research are not fully understood, and more research is needed on trace antibiotic releases to the environment.

Many pharmaceuticals enter aquatic systems because they cannot be treated effectively using conventional technology

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