WATER AND THE ENVIRONMENT

Microplastics pollution: African research focus moves to freshwater and human impacts

The spotlight on global plastic pollution has fallen mainly on the marine environment, with disturbing images showing sea creatures choked or strangled by floating plastic debris. Now the science research focus is shifting upstream towards the land and the potential health impacts for Africa's people and freshwater habitats. Article by Tony Carnie.

Tony Carnie

Should we be worried about an ever-growing volume of microscopic plastic particles building up in South Africa's rivers, lakes or tap water? Can these tiny fragments of synthetic pollution harm our health and other life forms? This is the thrust of a series of local research projects initiated by the Water Research Commission to measure the impacts of very small particles of plastic in the country's freshwater environments.

The scope of the research was set out in a recent article in the ***SA Journal of Science*** by WRC research managers, Drs Eunice Ubomba-Jaswa and Nonhlanhla Kalebaila. They note that plastic products are now ubiquitous, with production of this synthetic material increasing from just 1.5 million tons in the 1950s to approximately 322 million tons today.

On the African continent, South Africa tops the list with a production of about 8 987 kilotons of plastic, followed by Egypt (3 977 kilotons) and Nigeria (2 308 kilotons). On a per capita basis, this translates into South Africans consuming more than twice as much plastic compared to people in Nigeria, Kenya or Ghana.

"Huge amounts of plastic are also imported into Africa, contributing further to local plastic consumption," say Ubomba-

Jaswa and Kalebaila, who note that plastic products can also contain several potentially-hazardous additives such as plasticisers, flame retardants, thermal stabilisers or light and heat stabilisers. Largely within a year of production, most of the plastic generated for single-use products (packaging, straws, bottles, bags) has been disposed of as waste, often incorrectly.

The problem is compounded by rapid urbanisation and poor waste management in many African cities, with the result that plastic often ends up in landfill sites, gets burned or is simply dumped into the surrounding environment.

Freshwater environments, such as streams, rivers and lakes, which are in close proximity to plastic waste on land, often become the pollution pathways leading to the sea. "As plastics are not biodegradable, they never truly disappear but continue to break down into smaller and smaller pieces."

This breakdown process can involve exposure to ultraviolet light, mechanical action or animal action, with macroplastics breaking down into secondary microplastics and finally into nanoplastics.

The WRC research managers say that while literature on land-based plastic flows is available, specific research in Africa on the impacts on freshwater and marine environments is only now gaining momentum.

"So far, available information has clearly demonstrated that microplastics are present in both raw water resources and treated (drinking water) sources that reach the consumer. Concentrations ranging from 0.00015 to 12.6 microplastic particles per litre have been reported from studies conducted on raw water sources in China, Europe and the USA. However, to date, very few studies have quantified levels of microplastic particles in drinking water."

Two years ago, in a study commissioned by the WRC, plastic particles were also detected in surface water and groundwater in some provinces and from drinking water (tap) samples collected in Johannesburg and Tshwane.

While concentrations of plastic particles were much lower in comparison to those in freshwater environments in industrialised countries, total microplastic particle concentrations of up to 0.189/L and microfibre counts up to 1.8/L were reported. Preliminary findings from the study also indicated a higher proportion (88%) of finer microplastic particles (sizes of between 20 µm and 300 µm) than that of larger particles in the final treated water.

"Similarly, 83% of samples analysed in a global survey of tap (drinking) water were found to contain microplastic particles. Almost all of these (99.7%) were fibres in the concentration range 0–57 particles per litre." However, due to the lack of standard protocols for microplastics detection and quantification in drinking water, there is narrow scope to compare findings between different reports.

Ubomba-Jaswa and Kalebaila say it is clear that plastic waste generated from industrial and domestic use are the main contributors of microplastics entering the aquatic environment.

"The discharge of inadequately treated waste-water effluent is one route by which microplastics enter the drinking water value chain and also the marine environment. Consequently, water service institutions are under pressure to retrofit existing treatment trains to optimise the retention and removal of microplastics during water treatment. Conventional treatment processes, such as filtration, are reportedly able to remove up to 97% of microplastic particles larger than 300 µm.

"Advanced treatment processes, such as membrane filtration, have been reported to remove 85–99.9% of microplastics in water. Other technologies that have been investigated include

Dr Eunice Ubomba-Jaswa and Dr Nonhlanhla Kalebaila of the Water Research Commission have noted that plastic products can contain several potentially-hazardous additives such as plasticisers, flame retardants, thermal stabilisers or light and heat stabilisers.

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Researchers Duan van Aswegen and Carina Verster collect water samples as part of a Water Research Commission study that included analysis for microplastics in freshwater in parts of North West, Gauteng and the Free State.

dissolved air flotation that is capable of removing up to 95%, and disc filter, with a removal efficiency of 40–98.5%."

In most studies, higher removal efficiencies have been reported for larger microplastics, whereas lower efficiencies have been observed for smaller particles with diameters of 20–300 µm.

"Thus, depending on the size and composition, microplastics may not be completely removed during wastewater treatment and there is a high chance that they may enter receiving raw waters, potentially even accumulating in the final treated (tap) water."

Removed particles from waste-water treatment plants have also been detected in sludge. The routine practice of applying biosolids from wastewater treatment plants onto agricultural land as fertiliser results in the accumulation, over time, of microplastics in the soil. This suggests that sludge from treatment plants could be a driver for microplastic contamination of soil.

"Although still to be explored, there is potential for plastic to be remobilised in soil under certain conditions, such as flash flooding, resulting in the contamination of freshwater systems."

According to the two WRC research managers, attempts to understand the uptake of fine particles, including plastic, in mammals and humans have not yielded conclusive findings.

"The inconsistencies in microplastic detection and quantification protocols, as well as lack of epidemiological data, limit the interpretation of the current concentration data sets into meaningful risk assessment. Therefore, more collaborative research among the science community (both academia and water service institutions) is needed in order to understand the flow of microplastics from source to sea, and their removal during water treatment, both waste water and drinking water, and to assess the potential exposure, and risks, to consumers via drinking water."

Since April 2019, the WRC has funded **Project no. K5/2919**, a study that aims to develop more effective biomonitoring of microplastics in South African water resources.

Ubomba-Jaswa says that when completed in 2022 or early 2023 (depending on the potential delays due to the Covid-19 pandemic) there should be greater understanding of novel end points in organism growth, development and survival that can be used as accurate predictors of the effect of short-term and long-term exposure to various shapes and sizes of plastic monomers as well as their additives.

"A greater understanding of the unique eco-threat that microfibres pose will also be elucidated from the WRC project. This will be a key finding as, historically, the unique health effects of microfibres when compared to microbeads have been difficult to assess, even in the marine environment."

The health impacts of plastic in adults can also be quite different compared to babies in the womb, while exposure to phthalates in plastic can cause allergies and asthma, while BPA (bisphenol A) exposure shows in social and behavioural problems (particularly in childhood).

"Population groups with the highest risk of developing a plastic exposure related condition include those that work directly in the plastic industry (extraction and transport, refining and manufacture and waste management) as well as communities situated next to plastic production centres or plastic dumpsites, and whose air and water quality are affected by various plastic emissions.

"Although the body of evidence of the health effects of nano and microplastics continues to grow, there is still a great deal of experimental and observational research needed before a direct link between exposure to these particles and subsequent illnesses can be confirmed."

However, preliminary research findings have shown that nano- and microplastics may be even more harmful, because not only do they serve as carriers and vectors for other harmful chemicals, metals and pathogens, but due to their size, they might be able to physically injure the lung and gut at a cellular level through ingestion or inhalation.

"Any accurate determination of the health risk of exposure to plastics is largely unknown in Africa or among African populations. Consumption patterns of microplastics and subsequent health implications depend on the concentration of exposure and the type of plastic involved. For this reason,

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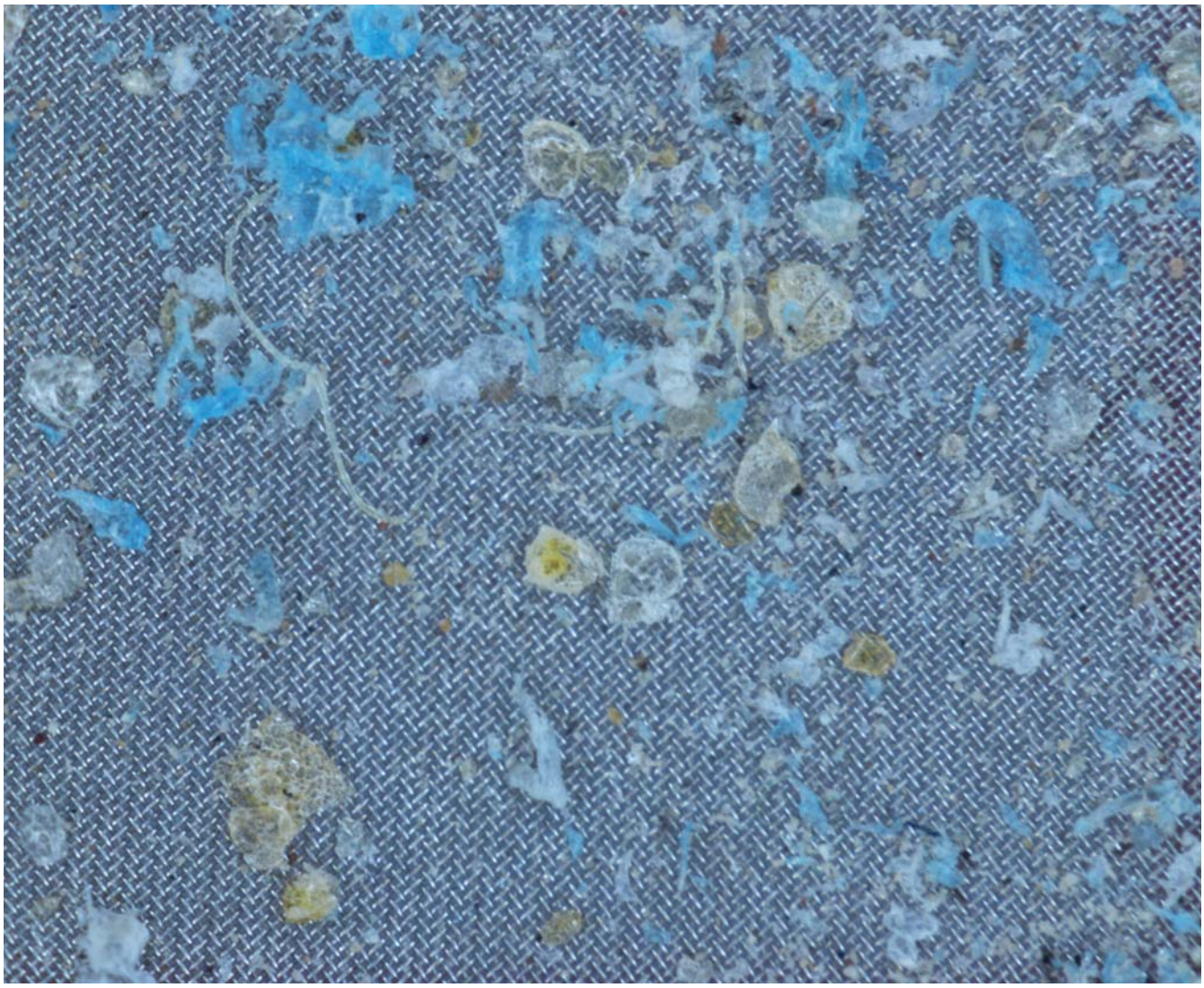
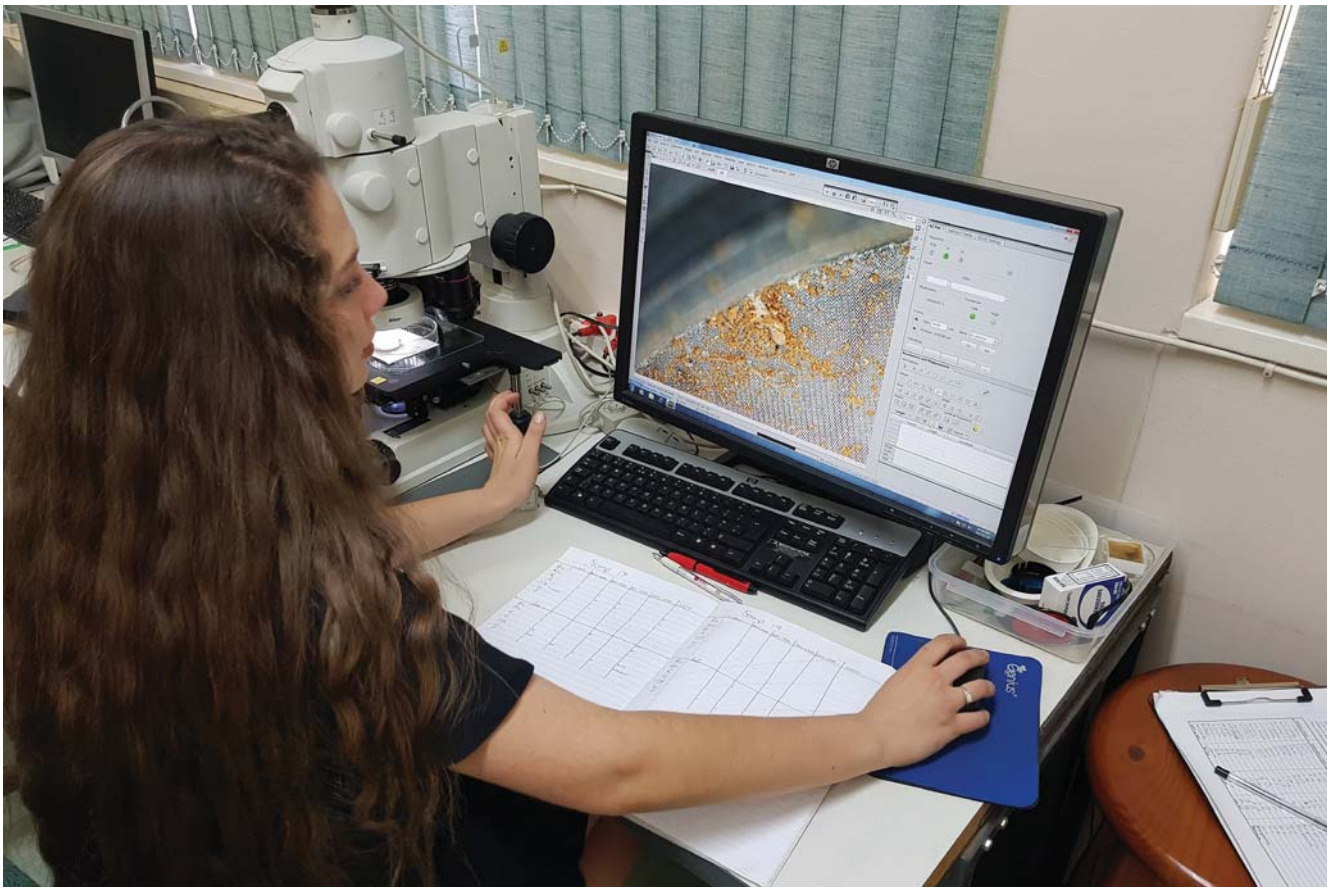


Tiny fragments of plastic which were sieved from freshwater samples. Municipal tap water samples were also collected from the City of Johannesburg and Tshwane. Microplastics in tap (drinking) water generally had much fewer plastic fragments compared to the raw water samples.



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Carina Verster of North West University examines microplastics filtered from freshwater samples.

human health risk values calculated for population groups outside Africa are not reliable as a true reflection of exposure, because exposure patterns are different and cannot necessarily be extrapolated."

A separate three-year WRC-funded study, that began in April this year, will also investigate the ecological and human health effects of microplastic contaminants in the Diep and Plankenburg rivers in the Western Cape Province. By the conclusion of this study, there should be baseline data on the human health effects and risk that the local population around these two rivers face.

The WRC hopes that the health and ecological risk models and training information from this study should also be available for use by other African countries which have similar plastic and waste management issues.

Ubomba-Jaswa says South Africa is actively involved in the global fight against environmental pollution and the WRC will continue to fund and support research to assess the health risks attributable to plastic-contaminated water. She notes that there will be particular focus on mixtures or "cocktails" of chemical/plastic exposure rather than on single chemicals alone.

It will also be important to conduct toxicity studies that consider increased exposure and dosage concentrations to plastics in light of extreme weather events.

"Cohort studies which, for instance, involve pregnant women and their children until they reach adulthood, are also key to understanding the long-term effects of plastic exposure in relation to different illnesses (developmental disorders, cardiovascular diseases, etc.).

"As we gain a better understanding of how best to mitigate against the negative effects of plastic on our health, it is clear that reducing the production, use and disposal of plastic in South Africa and throughout Africa will be key to protecting human and environmental health."

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Khaya Mgaba from Rhodes University is conducting ecotoxicity tests on fish embryos using plasticizer samples.