INTERCEPTION

Those working to solve the ocean plastic problem are shifting from managing the symptoms to treating the disease. Chris Fitch explores the prospect of halting the flow of ocean plastic at the source: rivers

The Yellow River (or Huang He) is the second-longest river in China and the sixth-longest river system in the world

A plastic bottle bobs down the murky current of a large river, freshly dumped, its contents having been consumed. It isn't alone. All around are other plastic objects, from bottle tops and coffee lids, to straws and single use shopping bags. In normal circumstances, their final destination would be predetermined – the ocean. But this fateful outcome is soon to be interrupted. As the objects round the next bend, they find themselves being corralled, channelled together, then swallowed into the gaping mouth of a strange contraption. The water itself keeps flowing, and, moments later, carries on downstream, the presence of these unwelcome items now a memory.

The figures for marine plastic pollution are stark and sadly all too familiar. The oceans are littered with more than five trillion pieces of plastic, and, despite spectacular television programmes and well-intentioned beach clean-ups, the problem continues unabated. The long-term implications of plastic in the ocean are profound. Seabirds, fish, turtles and whales mistake these objects for food, starving to death with bellies full of plastic. Their eventual breakdown into micro and nanoplastics means they are now accumulating in our own bodies. Thanks to oceanic plastic pollution, humanity is increasingly part of a plastic ecosystem.

Eight million tonnes is the oft-quoted estimate for how much plastic waste is dumped into the oceans every year, with a 2015 study estimating the true figure to range somewhere between 4.8 and 12.7 million tonnes. The pathways that move plastic from consumer shelves into the ocean differ depending on location, but it's clear that while around 20 per cent of marine plastic is generated at sea, from discarded fishing nets, broken buoys and waste dumped from boats (up to 28 per cent according to a 2018 study), the vast majority comes from the land. And there is one increasingly clear pathway that enables this transportation: rivers.

THE SOURCE OF THE SCOURGE

'I think we have good reasons to believe that rivers are the main source of new plastic flowing into the ocean,' says Boyan Slat, founder and CEO of The Ocean Cleanup, a Dutch foundation attempting to create the world's first ocean cleanup system. 'You can basically see rivers as very long coastlines that flow through heavily urbanised areas.' A 2017 study conducted by The Ocean Cleanup estimated there to be somewhere between 1.15 and 2.41 million tonnes of plastic deposited into the oceans directly from rivers every year. Theoretically, if you stop this flow, the ocean plastic problem is dramatically reduced.

Boyan Slat's (right) Interceptor contains a conveyor belt which pulls material from the water before depositing it into on-board skips

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Many of the world's rivers act as convenient waste disposal systems, especially for millions of poor communities with few other options. 'They can throw the waste on the river banks during the low flow seasons, then the monsoon comes and washes it all away, and they get a nice clean river bank the next year round,' explains Dr Chris Hackney, research fellow in Earth surface processes and sedimentology at the University of Hull. 'It's a very naturally efficient way for them to get rid of their waste.'

'If you have more mismanaged plastic waste, you also find more plastic in rivers,' agrees Dr Christian Schmidt, from the Department of Hydrogeology at the Helmholtz Centre for Environmental Research (UFZ) in Leipzig, Germany. Thanks to the spatial spread of the global population, as well as the absence of effective waste management systems in many developing countries, this means that the majority of the worst-affected rivers are relatively concentrated, with a focus on Southeast Asia and Africa.

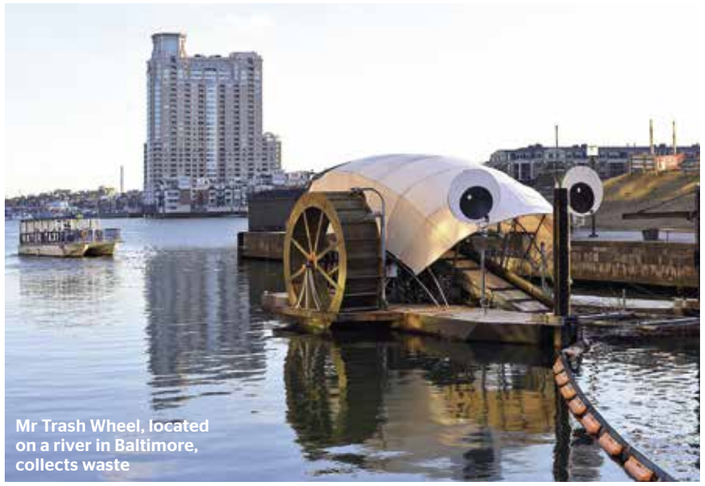
Schmidt was lead author of a high profile 2017 UFZ study that identified ten large rivers whose flows can be considered responsible for the vast majority – between 88 and 95 per cent – of all riverine plastic waste that finds its way into the ocean. Eight of the ten are in Asia, including the Ganges, Mekong, Yellow and Yangtze, plus the Nile and Niger in Africa. While he now feels that data obtained since the study has revealed this focus on just ten rivers to be 'too extreme', his conviction remains that big, iconic rivers play a major role in carrying plastic to the ocean. 'There's a disproportional contribution of large rivers,' he confirms. 'They are very efficient at transporting stuff from land to sea.'

Although, perhaps not as efficient as we might like. The path of plastic bottle from consumer, to river, to ocean, is complicated by the long period of time that plastic debris can spend in rivers before eventually reaching the river mouth. 'Rivers are still often understood mainly as conduits of plastic pollution, that channel pollution from where it occurs into the ocean,' says Dr Stefan Krause, professor of ecohydrology and biogeochemistry at the University of Birmingham. 'I think we are developing more and more understanding that not

only are the oceans long-term sinks, but also rivers themselves are. In some conditions, plastics can actually cycle for years or decades in many rivers, and in particular accumulate in the river corridors and river sediment for a very long time.'

The consequential impacts of plastics, especially microplastics, accumulating and lingering in rivers and other freshwater systems can be significant. 'In terms of the plastic impacts, I'm not saying that it's not important what comes out of the rivers and is delivered to the oceans, but we see environmental impacts being at least as important in freshwater systems themselves,' adds Krause. He explains how plastic can clog infrastructure such as irrigation and drainage systems, and, just like in the ocean, break down into nanoplastics that enter human bodies, potentially causing adverse health effects. 'I can see that it's attractive to think that if river corridors retain plastics for a longer time, oceans get less affected,' he says. 'But similarly there's a risk for freshwater ecosystems.'

For a multitude of reasons therefore, getting plastic out of both rivers and the ocean as quickly as possible is a priority. Cleaning up the ocean is only half the battle. 'The most effective way of cleaning up the oceans is stopping it getting there in the first place,' says Hackney. 'You can remove everything that's there already, but if the tap is still on, then everything is still flowing into river systems and then out into the oceans. It's just going to pile back up again. So the most effective way to remove that pollution is to stop it at the point of source.'


Mr Trash Wheel, located on a river in Baltimore, collects waste

THE INTERCEPTOR

To anyone connected to the world of plastic pollution, the work of The Ocean Cleanup will be familiar. Founded in the Netherlands in 2013 by then-teenage prodigy Boyan Slat, the organisation has spent half a decade generating headlines about ambitious technology capable of waiting patiently in the oceans and trapping floating debris – some with more success than others. Their prototype was first tested in the Netherlands in 2017, with large scale iterations installed in the Pacific last year, with the aim of reducing the 'Great Pacific Garbage Patch' by half over the first five years of deployment, and entirely by 2050. Slat has been heralded as a young entrepreneur capable of changing the world, including becoming a United Nations Champion of the Earth in 2015.

Now, the organisation is expanding its scope of operations by also targeting rivers. 'What we believe is that to truly rid the oceans of plastic, both the legacy side as well as the inflow side need to be tackled,' explains Slat, who speaks repeatedly about 'closing the tap'. Aware of a data problem, the organisation conducted their own research in this field, including the installation of cameras on bridges across rivers around the world. These scanned the water flowing below, and used artificial intelligence to collect vital information about the quantity of plastic deposited by each river. The results identified that out of roughly 100,000 rivers in the world, there are one thousand that are the biggest culprits, contributing roughly 80 per cent of all plastic deposited into the ocean.

Slat's solution to this borrows from the tactics already employed in the ocean. By strategically installing floating 'Interceptors' in the sections of large rivers with the heaviest concentrations of waste, he aims to catch plastic and other debris before it reaches the ocean. 'Dirty river in, clean river out,' Slat quipped, at the Interceptor grand launch event. Solar powered, these contraptions look like large floating bin lorries, whose gaping mouths contain a conveyor belt which pulls material from the water before depositing it into various large on-board skips.

The Ocean Cleanup claim that a single Interceptor can extract 50,000 kilograms


The Nga Nam floating market takes place in the Mekong Delta in Vietnam. The river is a significant contributor to ocean pollution and one target for Boyan Slat's interceptor


Waste lines the banks of the Mekong River

UK RIVERS

British rivers may not be among those most heavily polluting the oceans, but the UK is not immune. A 2018 study conducted by researchers from the University of Manchester was the first to collect data about the extent to which urban rivers in the UK are contaminated with microplastics. 'As the first industrial city, the rivers of Manchester have a long history of being grossly polluted,' explains Professor Jamie Woodward, head of geography at the University of Manchester. 'However, they've improved in the last three decades, and now they've got reasonable habitat quality, and fish have returned.'

Nevertheless, their research discovered substantial microplastic loads in all the river bed samples taken from 40 testing sites around Greater Manchester, and even calculated the city's River Tame to have the highest known microplastic contamination in the world. 'But I don't think the River Tame is particularly exceptional,' continues Woodward. 'I think there are other rivers around the UK which are heavily contaminated with microplastics.' The most significant contributions came from industrial microbeads, plastic fibres from washing machine effluent, glitter, pieces of film and foam, and fragments of larger pieces of plastic that had broken down. After retesting the same sample sites after a large flooding event, they found a 70 per cent reduction in microplastics, indicating that this debris was ultimately being washed into the sea.

With a length of about 6,695 kilometres (4,160 miles) the Nile is the longest river in Africa (and possibly the world – though this title is also claimed by the Amazon)

of material from the river per day, with each having a total capacity of 50 cubic metres. Once filled, the Interceptor will autonomously notify a local partner and request they come to empty it – the only point at which it requires direct human interaction. 'The ambition is to be as close as possible to deploy and forget,' explains Slat. The technology is perhaps inspired, at least in part, by similar operations already in situ, such as 'Mr Trash Wheel' – a charismatic waste extractor located on a river in Baltimore, Maryland – but with more capacity, higher sophistication, and on a far larger scale.

At time of writing, there are two Interceptors currently in place – in the Cengkareng Drain in Jakarta, Indonesia, and the Klang River in Kuala Lumpar, Malaysia – with two more ready to begin operations in Vietnam and the Dominican Republic. Slat hopes to have a dozen operational by the end of next year, with a doubling in each of the following years. His ambition, and that of the entire organisation, is to have plastic intercepted in each of those top 1,000 most polluting rivers within five years. This doesn't necessarily mean deploying a thousand Interceptors. 'You can imagine that, maybe in the future, there will be other organisations or companies that develop complimentary solutions,' he emphasises. 'Where a complimentary system is better suited than our Interceptor, we would happily collaborate.' Local partners will serve the needs of each Interceptor, he claims, integrating them into the waste processing system operating in that location.

Of course, there is a cost to the production and deployment of at least several hundred Interceptors, something in the order of hundreds of millions of dollars. To justify this, The Ocean Cleanup has worked with accounting firm Deloitte and claims there is an annual economic cost to the world from the continued clogging of the oceans with never-ending currents of plastic of between $6 billion and $19 billion, due to the resulting impact on industries such as tourism, fisheries and aquaculture, making the machines a (relative) bargain. Whether this argument is enough to ease the efforts of the organisation away from philanthropy and into the cut and thrust of the real world remains to be seen.

CASTING DOUBT

In a world of limited resources, some question whether money is best spent on such high profile, silver-bullet initiatives, as opposed to focusing on improving waste disposal and refuge collection, as well as increasing recycling and the use of alternative materials to limit the amount of plastic waste generated in the first place. For many experts working in this field, the contribution such initiatives can have is uncertain, especially given the scale of the issue. 'I think the role that clean up schemes – not only The Ocean Cleanup operation – can play, is heavily contested,' says Dr Stefan Krause. 'I certainly don't think it will be able to solve the problem alone.'

'I'm pretty sceptical about these collection initiatives,' adds Dr Christian Schmidt. 'I wonder whether you can really run and maintain such a collection system over the timescales that are relevant for this problem. If you want to have a long-term impact, you need to have this stuff in place for a very long time, we are talking about decades.' Schmidt also highlights the risk of capturing vast amounts of organic material that currently flows into the ocean, including large quantities of carbon necessary for the global carbon cycle. 'The amount of particulate material that comes down a large river, it's really huge,' he says. 'Even in those highly contaminated rivers, most of the material is organic, like plants, leaves and other material that falls into the river. Just a tiny fraction of it is plastic.'

For many experts, the contribution that clean-up schemes can have is uncertain given the scale of the issue

For his part, Slat argues that ecological studies by The Ocean Cleanup have shown that this is not a major concern. He goes as far as suggesting that the removal by Interceptors of invasive water hyacinths would be a secondary benefit, aiding the health of waterways that could otherwise be choked to death.

Plastic pollution is complex. Even Slat acknowledges that Interceptors should only ever be thought of as part of the solution to the problem. 'At the end of the day, I don't care whether a piece of plastic gets stopped by being collected on the streets, versus the piece of plastic getting caught in the Interceptor,' he insists. 'The only thing that matters is what is the fastest and cheapest way to stop more plastic from going into the ocean. I think that interception in river mouths is the way to do that.'

Clearly, the scale of the plastic pollution crisis doesn't only permeate through the oceans, but also has tentacles that reach into the tens of thousands of waterways that flow into them. Only in recent years has the gathering of critical data made it possible to begin thinking about truly 'closing the tap'. Whether such an objective can be achieved through the deployment of grand scale infrastructure, or whether it will depend on less exciting legislative and regulatory changes to cut-down mismanaged waste remains to be seen. Most likely it will take a combination of the two. ●

In Mopti, Mali, people prepare for a market along the Niger river