



**COLLECTING PLASTIC FOR SCIENCE**

# The river as a plastic reservoir

**It is possible that a lot more plastic accumulates in and around rivers than in the sea, thinks Tim van Emmerik. He is doing research that he hopes will allow predictions of where that is likely to happen. 'Then it can be removed from those specific locations, instead of organizing expensive clean-up operations at sea.'**

**TEXT RENÉ DIDDE PHOTOGRAPHY MARCEL VAN DEN BERGH**

## ‘The bulk of the plastic seems to stay stuck in the river system’

**W**e still have far too little quantitative data about plastic in the water,’ says Tim van Emmerik, leaning on the railing of the bicycle bridge over the River Rhine (Waal in Dutch) at Nijmegen. ‘Many estimates are based on anecdotes and poor data that has not been collected in a consistent way.’ Van Emmerik, an assistant professor in the Wageningen Hydrology and Quantitative Water Management Group, is braving the elements on this rainy winter afternoon with five Master’s and PhD students to test new ways of measuring the quantity, type and origin of plastic in the river water.

The researchers are keeping a tally of plastic waste observed from the bridges over the Waal. Later that afternoon they go to the Rhine, and the next day they stroll along the banks of the Meuse, in search of plastic waste.

‘We are standing here near Nijmegen now, but we also do counts downstream in the direction of Rotterdam,’ says Van Emmerik, pointing at the chilly riverbank as he and the students gather up assorted bits of plastic as



**TIM VAN EMMERIK,**  
a researcher and assistant professor in the Hydrology and Quantitative Water Management chair group

well as beer bottle tops and cigarette butts. All the anthropogenic waste is counted so as to be able to calculate the proportion of plastic waste relative to other kinds of waste. ‘We look near Westervoort, east of Arnhem where the IJssel river splits off from the Rhine, and we measure at Kampen, where the IJssel flows into the IJsselmeer, a large lake.’

On other days they deliberately mark waste and then leave it in the water, hoping to find it further downstream. Some of the research consists of observations of plastic using cameras and drones. The testing sessions are part of the River Plastic Monitoring Project, for which Van Emmerik won a Veni grant in October from the Dutch Research Council (NWO). The goal is to develop a universally applicable monitoring framework with which to collect more consistent data about plastic waste in the rivers. That data should feed models to give a better picture of the distribution of the waste. The models can take into account the influence of dams, waterfalls and other things that affect the flow, not just in the Netherlands but in rivers around the world.

The researchers count and analyse the plastic that floats on the river surface or gets washed up along its banks. That provides a yardstick for the amount that is underwater. At the same time, they are working on improving the calculation models, by measuring the plastic underwater as well using sonar and fishing nets. Researchers hope thus to collect data with which they can calculate the mass balance of plastic: ‘how much plastic comes into the Netherlands via the rivers, and how much flows out of the country into the sea.’ Van Emmerik thinks the bulk of the plastic waste is not found in the sea. ‘We reckon that much more plastic stays on the riverbanks, on the riverbed, and in the floodplains than is widely believed,’ he says.

The plastic soup in the ocean is a theme that occupies young and old. Photos of a sea turtle with the plastic ring from a sixpack of beers around its neck, a cigarette lighter in a petrel’s stomach, and a seahorse with its tail wrapped around a cotton bud have aroused widespread indignation. But in spite of all the attention paid to the plastic soup, researchers still know precious little about it, says Van Emmerik. Until now most of the calculations done have been at the ‘back of an envelope’ level. Right from the start, for example, the suggestion has circulated that ‘80 per cent of the plastic soup in the sea comes from rivers or land.’ ‘It is totally unclear where these figures come from, exactly,’ he says.

### STUDY OF THE SEINE

Van Emmerik’s guess that most plastic waste never reaches the sea is largely inspired by a systematic long-term study by researchers from the University of Paris-Est. They studied the River Seine at three locations for many years, looking both in the river and along the banks and water meadows, says Van Emmerik. One of their locations was upstream, one near Paris and one at the river mouth at Le Havre, where the Seine flows into the English Channel.

The French researchers saw an increase in plastic bags, bottles and packaging at Paris, but recorded hardly any plastic at Le Havre over a period of 10 years. They drew a radical conclusion. ‘The bulk of the plastic apparently stays stuck in the river system. It gets laid down along the way in the water meadows and even further inland, or festooned on the bushes along the riverbank like Christmas decorations,’ says Van Emmerik, who participated in the research on a regular basis. ‘Now and then, I stepped on plastic objects from the 1970s.’

The researcher expects to find equally old plastic in the Netherlands, possibly with the



help of a mechanical digger. ‘We’re scratching around on the banks now, but later we will take samples from deeper in the soil of the riverbanks to analyse how much plastic waste is stored there,’ says Van Emmerik. ‘We hope to be able to forecast where the most plastic waste accumulates. That can then be removed from those specific locations instead of organizing expensive and complicated clean-up operations at sea.’ He hazards the hypothesis that 95 per cent of the plastic is absorbed by the river – in the sediment, in the riverbed, and along the banks.

This idea could have far-reaching consequences. Most researchers and NGOs have focused all efforts on the issue of the plastic soup in the seas and oceans, but perhaps most of it stays in river systems, which would make the quantity of plastic in the river system much bigger than that in the sea. ‘That could explain the enormous gap

## ‘The river plastic could explain the enormous gap in the mass balance’

in the mass balance between the amount of plastic produced and used in consumer products, and the amount at waste processing plants and municipal waste services,’ says Van Emmerik. Student Yvette Mellink has written a PhD proposal for a similar plastic-monitoring study in the urban con-

text. With this kind of research, the River Plastic Monitoring Project hopes to get a fuller picture of the plastic waste that ends up on the street, in the parks, and in the canals and waterways. In canals and waterways, large amounts of rubbish often accumulate at the same place, making clean-up operations easier. A similar thing happens at weirs and dams, causing damage to the pumps. Van Emmerik wants to find out what kinds of plastic waste pile up there. ‘If it’s plastic bags, for instance, that is an extra argument for policymakers to ban disposable plastic bags.’

The researchers are taking a particular interest in the Biesbosch nature reserve, which resembles a plastic reservoir. Large quantities of rubbish are deposited on the banks and in the vegetation by the tidal currents that come this far inland.

Although Van Emmerik currently concentrates his measuring activities for this >

## ‘The ultimate goal is that no more plastic ends up in the environment’



Bits of plastic, beer bottle tops, cigarette butts and other anthropogenic waste accumulated on the river bank.

project in the Netherlands, he does want his system to be universally applicable. His team of PhD and MSc students do a lot of research in the deltas of Indonesia, Vietnam and Bangladesh. There are particularly large amounts of plastic circulating in the deltas of Asia due to their large populations and the poor waste disposal infrastructure. To take one example, Van Emmerik thinks the watershed of the Ciliwung river in Jakarta retains about 97 per cent of the waste deposited in it.

### SHAMPOO FOR MEN

Meanwhile, at Wageningen Economic Research, Wouter Jan Strietman and his colleagues are working on a reliable method of identifying where plastic waste came from. Strietman mainly focuses on plastic in the sea, but also thinks the standard monitoring of shoreline waste does not give a full enough picture. ‘You tick an object off on

the list, noting the quantity and the type of plastic,’ says the social geographer. ‘But this does not give you any idea about the origin and, more importantly, the possible links between waste streams.’

In the Litter-ID method he helped to develop, Strietman not only counts plastic waste, but also tries to identify its sources and the reason it has ended up where it is. To this end, he analyses whole containers full of plastic waste collected on a beach or even an island.

‘If you look at the fine print and other details of the plastic’s appearance, that helps you to detect patterns,’ says Strietman. ‘and that knowledge then helps you get a better idea of the sources and causes.’

On Spitsbergen, for example, Strietman and his colleagues found waste from net repairs on fishing trawlers that fish around the island. ‘We also found a lot of domestic waste with Russian writing on it, such as

milk cartons and plastic shampoo bottles. We notice that nine out of 10 shampoo bottles were labelled “for men”. Who throws them in the sea? We suspect that the main source is the crew of Russian fishing boats.’

### CRISP PACKETS

For Strietman, the participation of local groups such as shopkeepers, fisheries, environmental organizations and residents is important for the analysis. It has been very revealing at times. On the beaches of West Greenland, for example, a lot of packaging was found of the sort you take with you on a day trip, such as crisp packets. ‘At first, residents we spoke to there said, “that comes from elsewhere,” because, just like us, they thought it was all brought in from faraway on the ocean currents. But further research revealed that most of that stuff had been used by local residents, hunters and fishers, and had been bought locally. They make day trips by boat, and apparently they throw their snack packaging in the water.’

Strietman has an anecdote about a miniature boat his colleague Eelco Leemans found on the volcanic island of Jan Mayen, north of Iceland. The little toy turned out to be a free gift that came with packets of breakfast cereal in British supermarkets in the 1950s. Little ‘lobster tags’ with the codes of lobster pots found on the coast of Iceland, Scotland and even Zeeland in the Netherlands could be traced to fisheries in the north-eastern United States and Canada.

In short, plastic waste is a fingerprint of a community, which with Sherlock Holmes-like detective work can sometimes lead you to the source, as Strietman’s research has shown. ‘With our research, we squeeze out as much information as we can. And with all the new information that produces, we can now tackle the plastic problem at source in a far more precise way than was previously possible.’

Jeroen Dagevos, head of programmes at the Plastic Soup Foundation (PSF), has noticed that research in this field has progressed to a higher level. ‘Fifteen years ago, pretty much all we said was: “all that plastic on the beach doesn’t look very nice”,’ he recalls. ‘Now we’re finding out more and more about the plastic soup in the oceans, seas and rivers. And research is also being done on plastic in the air, in food and in the soil. We are gaining more and more knowledge about the fragmentation of pieces of macroplastics into smaller microplastics and even nanoplastics.’

### PET BOTTLES

Dagevos thinks more precise and quantitative information is crucial if we are to be able to halt the flow of plastic pollution. ‘A couple of years ago, during inventories we made with the North Sea Foundation and the IVN nature organization along the banks of the Meuse, we found more plastic granules the closer we got to Chemelot near Geleen. That was evidence that something was going badly wrong on that enormous industrial estate full of chemical companies,’ says Dagevos. Research on plastic contributes to new measures, then. For many years the business world insisted that the number of plastic PET bottles littering the streets was not very high and that a deposit on such bottles was therefore unnecessary. ‘It was very useful then that research proved that a deposit would keep up to six million bottles out of the litter in the Netherlands,’ relates Dagevos. ‘If in the near future we can forecast where and near which rivers the most plastic accumulates, then we can remove a lot more of it from the environment through targeted operations. But of course, the goal remains to ensure that eventually no more plastic ends up in the environment.’

[www.wur.eu/river-plastics-analysis](http://www.wur.eu/river-plastics-analysis)



PHOTO PETER VAN AALST

### MODELLING A DISASTER AT SEA

‘An experimental ecosystem,’ is what Edwin Foekema calls the 30 tanks at the research location of Wageningen Marine Research in Den Helder. Each tank contains five cubic metres of water from the Wadden Sea, full of plankton, and a layer of sand with seabed fauna such as worms, shellfish and young sole. The researchers dub this kind of tank a ‘mesocosm’. ‘It’s a representative model of the nursery that the Wadden Sea forms,’ says Foekema.

In this mini-Wadden Sea, Wageningen Marine Research simulates the MS Zoe disaster, when the freighter of that name lost 300 containers on New Year’s Day 2019. Apart from television sets, textiles and car parts, two kinds of intermediate plastic products ended up in the sea. ‘Some of these were HDPE pellets of five millimetres in diameter, which are used to make things like lunch boxes.’ These pellets float. The other pellets were much smaller polystyrene pellets (of 0.5 millimetres), which sink. Researchers put these plastic particles in the different tanks in varying concentrations. Then Foekema left these mesocosms undisturbed for eight weeks in the spring, which is when most marine fauna has a growth spurt. ‘Larvae settle in, and reproduction is going on at full speed, so we expect that at least in the tanks with the highest concentrations, there will be subtle effects of the presence of plastic particles, such as a disturbance to the foraging behaviour of some species.’

The research, commissioned by the Dutch Public Works Directorate, is currently being reviewed. ‘No very serious effects have been observed,’ says Foekema. The experimental ecosystems lend themselves to research on other urgent matters as well, he believes, such as the effects of rising temperatures on the acidification of sea water.