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'We are Part of Nature': Caring for Wastewater in an Infrastructural Experiment in the Flevopolder

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ABSTRACT
In this article, we pursue a route for understanding the decentralisation of wastewater treatment that moves away from thinking in terms of individual responsibility and technical determinism and mobilises the analytical lens of care to articulate *more-than-human relationality* as an organising principle of governing environmental infrastructures. Drawing on ethnographic fieldwork in the Dutch Flevopolder, we focus on the mundane practices of handling wastewater. We show how households are entangled in a multispecies infrastructure: they engage with wastewater as users of toilets, guardians of bacteria and reed beds, and technology-assisted monitors of pollution. We argue that these infrastructural relations are variously cared for in practice, but remain neglected as part of formalised wastewater management. Finally, we advocate a form of environmental governance that recognises and engages with the waste work undertaken by *all* stakeholders, as they configure an infrastructure in which unruly processes unfold, in a caring, rather than controlling, mode.

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KEYWORDS Infrastructure; environmental governance; care; wastewater treatment; more-than-human relationality

Introduction

'Westmeer is about people and their ideals'. An utterance, perhaps, one doesn't expect to hear at a local 'sanitation event'. Then again, the conjunction of 'sanitation' with 'event' is perhaps more likely to spark surprise. Not in Westmeer, a sustainable housing project in the Dutch Flevopolder and the location for an experiment in the decentralisation of wastewater treatment. This shift away from a traditional, centralised sanitation system is part of an effort to promote innovative forms of

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environmental governance in which not governments but 'people' take the lead. The challenge, a government official explains, lies in 'releasing' people from a 'top-down' governing model and creating a scope for innovation 'from below' so that a decentralised, more sustainable infrastructure for collecting, treating and disposing wastewater unfolds in residents' backyards. *Individual choice* drives this mode of governance. Through hosting events to raise awareness and enthusiasm for sanitation issues, the municipality aims to inform residents about more environmentally-friendly technologies. The hope is that people, motivated by their own ideals, will choose more sustainable and efficient technologies for treating wastewater.

The people of Westmeer accept this challenge, but not unconditionally. While words like initiatives 'from below' sound idealistic, invoking freedom, autonomy and so on, people in Westmeer contend with concerns they qualify as 'ecological'. Here, a resident voices concern during a sanitation event: 'Currently, everyone is responsible for their own individual wastewater treatment system. Being free is great, but we also need guidance.' In particular, residents seek guidance for dealing with ecological challenges that 'exceed individual action'. Engineers and officials appeal to residents as ideologically motivated individuals – per the motto 'Westmeer is about people and their ideals.' Residents, by contrast, urge consideration for the material and *relational intricacies* of wastewater treatment. As the above resident concluded: 'We are part of nature. We should not attempt to control it. We should nurture it.'

Indeed, relational intricacies undermined decentralisation of wastewater treatment in Westmeer. Four years into the infrastructural experiment, the public authorities concluded that organising the collection, treatment, and disposal of wastewater by individual choice did not result in the expected environmental improvements to soil and water. Quite the opposite. Evaluations of the surface water indicated that its quality had deteriorated, most likely as a result of the decentralised, individualised strategy (Van Karnenbeek *et al.* 2021). 'The sum of … individual choices does not automatically lead to a sustainable and robust water system,' the regional authority in charge of monitoring surface water quality wrote. Perhaps, the water authorities speculated, 'the landscape is less *maakbaar* [engineerable] than was long thought.'

Steering wastewater treatment by means of a logic of individual choice (Mol 2008) assumes that residents of Westmeer can make well-informed decisions about their onsite systems. It assumes that cleaning wastewater involves 'matters of fact' (Latour 2004) about, for instance, what pollution 'is' and how to handle it, and that engineers and government officials merely have to inform citizens or consumers how objectively to make the optimal choice. But in the day-to-day practices of wastewater treatment, 'matters of concern' (Latour 2004) emerge that unsettle the claims engineers and officials make about what pollution is and how to go about cleaning it up. For wastewater treatment depends not just on 'people and their ideals', but also on biotechnical treatment systems, bacteria, reed beds and the soil of the Flevopolder – to name a few other actors. If we move beyond framing our examination in terms of decisions about treatment systems into the messy practices of handling wastewater, people do not figure as subject who make choices. Instead, they engage with the wastewater infrastructure as users of toilets, guardians of bacteria and reed beds, and monitors of pollution. Moreover, they start to identify *as part of* a nature in which processes unfold, as opposed to a nature composed of individual creatures (cf. Mol 2017).

The decentralisation of wastewater treatment in the Flevopolder not only constitutes an experiment in new forms of environmental governance, it also constitutes an *infrastructural experiment* (Jensen & Morita 2017) enrolling not just people and their ideals, but also other stakeholders such as microorganisms, plants and clay.[1] Although the on-site wastewater treatment systems (OWTS) that comprise Westmeer's wastewater treatment infrastructure vary in technology and degree of biochemical processing, all include a biological treatment phase, in which microorganisms remove organic matter from the wastewater.[2] Some OWTS are configured primarily with biotic matter, like wetlands in which hydrophytes (aquatic plants) provide a filter bed where microorganisms dwell (see Figure 1). Other OWTS cultivate microorganisms in oxygen-deprived environments in enclosed tanks. In these hybrid systems, materials such as septic tanks, pipes and pumps work in concert with biotic matter, which includes active sludge, microorganisms and oxygen-relieving plants. To function, these biotechnical systems moreover depend on Westmeer's socio-material ecology, with its specific geological history, landscape, density of settlement and household constellations. Thus, decentralisation unfolds as a continuous 'dance of agency'

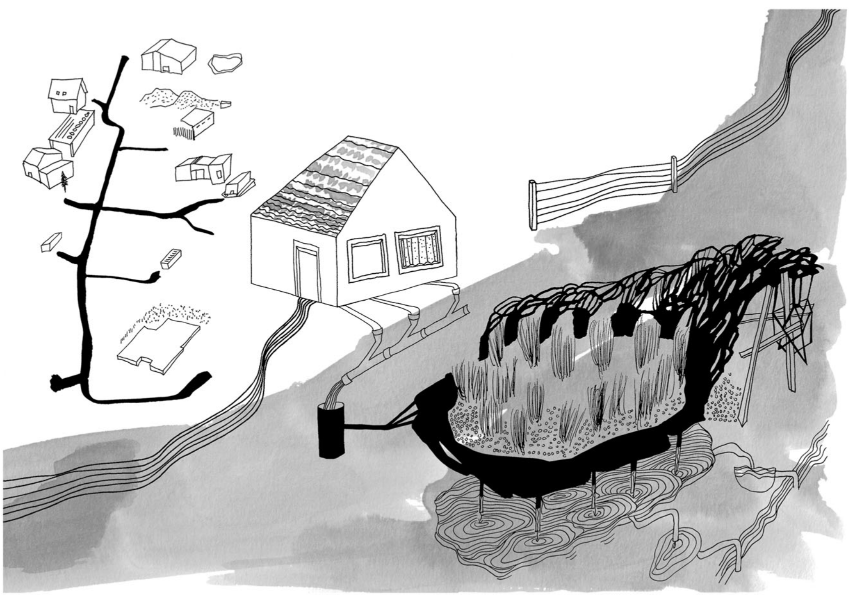

Figure 1. The 'organic development' of an infrastructure for wastewater treatment in Westmeer: each household instals an on-site wastewater treatment system (OWTS) in the backyard. The biotechnology depicted in this backyard is a Wetland-type OWTS and functions by dint of organic treatment, consisting of septic tanks and natural/biological purification filters of marsh plants or willows that work in symbiosis with microorganisms in the systems' roots. Artist Sophia Tabatadze.

among inhabitants of the polder and newly introduced wastewater treatment systems in which all actors continuously adjust to one another in 'a dialectic of resistance and accommodation' (Pickering 2017: 138).

Anthropological studies of infrastructure highlight spill-overs between the grey, cement-based, technology-guided infrastructure and the green, soil-based, natural environment. Ashley Carse's (2012) research on the Panama Canal demonstrates how the forested, agricultural landscapes along the canal became part of infrastructural management. Similarly, Nikhil Anand's (2011) study of the hydraulic infrastructure responsible for distributing drinking water among Mumbai's households reveals how predominantly Muslim settlers' efforts to maintain 'pressure' on the pipes and pumping system emerges from the inconstancy of water, how it seeps and leaks through the cement-based pipes and pumps. Despite their focus on spill-overs between infrastructure and nature, these two studies still presuppose a difference between a nonhuman world 'out there' – the Panamanian forest or the urban configuration of water in pipes – and the work of engineers and settlers as a result of which these natural and technical worlds may or may not enter the domain of *human* politics. However, akin to Atsuro Morita's (2017: 740) irrigation infrastructure in the Chao Phraya Delta, wastewater treatment in the Flevopolder involves 'multispecies relations *within* the infrastructure', rather than 'the encompassment of "nature" by infrastructure', or vice versa.

Inspired by Morita's insights, in this article we draw upon a science and technology studies-informed approach to infrastructure as 'ontological experiments' (Jensen & Morita 2015, 2017) to articulate *more-than-human relationality* as an organising principle of governing environmental infrastructures. Rather than assigning a priori different capacities to either humans or nonhuman stakeholders, this approach illuminates how what comes to be known as 'social', 'technical', or 'natural' in a particular setting is precisely the outcome of infrastructural arrangements (Jensen & Morita 2017: 618). From this point of view, infrastructure is not a reflection of human politics. Rather, infrastructures *do* politics for they 'produce novel configurations of the world' (618). As a result, the politics being implied here go beyond human intentions, engineerability and control. As Casper Bruun Jensen's (2017: 236) research on Phnom Penh's sewage infrastructure reminds us, 'once infrastructure becomes a source of nutrition for trees, the values and politics inscribed on the urban landscape cease to be wholly based on the human.' Decentralising an infrastructure for wastewater treatment is a messy, hands-on task precisely because, as our interlocutors suggested, engaging with biotechnical systems is not a matter of human engineerability, but requires *nurturing* multispecies relations.

We focus on the nurturing of these multispecies relations – among people and bacteria, among woodchips and devices, among clay and wastewater – as part of the ongoing maintenance of an environmental infrastructure.[3] Yet, we do not subscribe to the popular understanding of 'nurturing', that is, cherishing multispecies relations in a generalised way, but rather seek to explore nurture as situated practices of caring (Mol *et al.* 2010). We learn from the anthropology of technology that caring forms a discriminatory mode of engagement: it cannot extend to everything and, in the name of care, harm or even death may occur (Law 2010; Murphy 2015). Thus, 'acts of care are always embroiled in complex politics' (Martin *et al.* 2015: 627). Caring for waste-water, thus, also calls for choice, but entails different considerations, namely, choosing what to sustain, and who or what may flourish or wither, while engaging in relations with microorganisms, plants, or soil. Multispecies ethnographies of waste management show us that waste work frequently entails 'unheralded multispecies collaboration' (Hoag *et al.* 2018: 88) and a 'filthy flourishing' (Doherty 2019) that often remains unrecognised (see also De Wilde & Parry 2022). Taking these insights into account enables us to show how, in Westmeer, certain relations become licensed and authorised, and continue to be cared for in the world of formalised wastewater management. Whilst other relations are undermined by a lack of knowledge and regulatory norms, and thus fail to be adequately cared for as part of environmental governance.

Our article is organised as follows. First, we present a timeline of the emergence of Westmeer's decentralised infrastructure for wastewater treatment and explain our methodological choices. In the empirical section, we trace the daily path of wastewater: (1) flushing, (2) processing and (3) discharging. We follow infrastructural matters of concern as a motley crew of stakeholders perform the slow, subtle adaptations that constitute the day-to-day care and maintenance. Reflecting on the importance of the infrastructural relations that emerge as caring for domestic wastewater unfolds, we furthermore probe the concerns voiced in response to the announcement of a (re)turn to a centralised sewage system. In the conclusion, we argue that in the governance of environmental concerns to do with wastewater some infrastructural relations are known and valued, while other relations are cared for, in practice, but remain neglected, in policy. We advocate for a form of environmental governance that entails *ongoing* engagement with and recognises waste work undertaken by *all* stakeholders, as they configure an infrastructure in which unruly biochemical and geological processes unfold, not in a controlling mode, but in a caring mode.

An Ongoing Infrastructural Experiment in Westmeer

The Dutch Flevopolder is a marsh landscape that the damming of the Zuiderzee artificially reclaimed from the sea in the 1950s. During its relatively short history, it has served as agricultural land. Recently, the local municipality made 4000 hectares available for an urban settlement of approximately 15,000 residences. In Westmeer, the organising principle is that not governments, but 'people make the city'. Due to this unconventional development strategy, the settlement grows incrementally, as people gradually purchase and develop plots of land and infrastructures. An incremental approach also applies to wastewater treatment.[4] Each household in Westmeer is responsible for collecting its own dirty water (from sinks, toilets, showers and washing machines) and for choosing and purchasing an onsite wastewater treatment system (OWTS) to cleanse that water before discharge into the environment.

Westmeer's municipal vision policy, which specifies guidelines for incremental development, conceives decentralised wastewater as being 'treated and reused as much as possible in cycles within Westmeer' and engagement with wastewater as organised 'probably not on an individual but on a collective scale'.[5] The vision policy outlines the principles for individual choice of wastewater treatment as a well-informed market transaction: A (group of) resident(s) reaches out to OWTS suppliers and collects relevant information, such as the system's discharge norm certification, treatment mechanisms and capacity. After considering this information carefully and weighing each option against Westmeer's ambitions for environmental sustainability, residents choose an environmentally-friendly treatment option. The supplier installs the system correctly in the backyard of the purchaser(s) and provides instructions about correct use, such as avoiding using products that may harm the system. Household members correctly use and maintain the OWTS and the OWTS, in turn, delivers clean (enough) water that complies with the legal requirements of discharge norms.

In the concrete daily activities of wastewater treatment, decentralisation proved far less predictable. About two-thirds of Westmeer's current 1,250 households opted for *individual* instead of collective systems and the vast majority *discharges* the wastewater directly into the surface water, rather than recycling water within their households. The mismatch between expectations and practice had not as much to do with a lack of a collective 'spirit' or ideals as with the conditions the 'organic development' strategy set. When selecting a suitable treatment device, our interlocutors found making good decisions about wastewater treatment options difficult due to a knowledge divide between themselves and OWTS suppliers. Most residents therefore opted for the 'certainty' promised by a certified treatment system that meets the legal requirements, rather than for innovative technologies that experimented with recycling wastewater. Moreover, due to the area's 'incremental' expansion, residents did not develop their plots of land simultaneously. This created an obstacle to collective organisation of a sanitation system. Beyond this, most households own individual plots of land and erecting an onsite collective treatment facility was deemed challenging due to lack of space. While the designers of the Westmeer experiment expected people to make decisions based on their 'ideals', in practice, legal matters and material conditions steered their decisions.

Once installed in Westmeer, the biotechnical systems did not perform as promised. Regional water authorities remain legally responsible for maintaining the quality of local surface water so as to protect the environment.[6] Westmeer residents thus first require permission from the water authorities to discharge domestic wastewater into the surface water and apply for a 'discharge permit'. This specifies the maximum load of organic matter, notably phosphate and nitrogen, that wastewater flow may introduce into the surface water.[7] Once a treatment device is installed and operational, the water authorities sample the discharge for compliance with the device's permit. The vast majority of them failed to comply with discharge standards. In Spring 2021, the public authorities decided to implement a 'two-year improvement period' to develop a *functional* decentralised infrastructure for wastewater treatment. The aim of the improvement process was to enhance the functioning of the OWTS so they would comply with the legal discharge norms and allow the decentralised wastewater experiment to remain within the legal prerequisites. To that end, the public authorities invited various stakeholders to participate in working groups: the water authorities, residents, OWTS suppliers, the municipality and the province. This improvement period and the activities constituting infrastructural maintenance form the object of our empirical analysis. At the moment of writing, however, Westmeer's infrastructural experiment continues to develop and its success remains unknown.

To engage with the open-ended outcomes of this infrastructural experiment, we adopted a long-term approach to our study. FS immersed herself in ethnographic fieldwork conducted diachronically over a period of four years. She carried out pilot research in the summer of 2018, when managing wastewater in Westmeer emerged as a pressing concern for the municipality and the water authorities. From 2018 to 2021, FS participated onsite and online in public meetings about the issue Westmeer's wastewater treatment. During that same period, mostly FS and occasionally MdW conducted site visits and interviews to learn about stakeholder's concerns and wastewater treatment practices in different settings (individual households, collective pilot sites and offices). Additionally, we performed document analysis to track the transformational developments of wastewater as a matter of concern over time. We analysed research reports, newsletters, leaflets, relevant legislation, administrative regulations and the meeting minutes of working groups. We traced the questions, problems and concerns stakeholders raised.

Cleaning Wastewater, Caring for Infrastructural Relations

Water authorities, governmental authorities, residents and suppliers of onsite wastewater treatment systems tasked with developing a functional decentralised infrastructure for wastewater treatment identified three practices necessary for the successful treatment of Westmeer's wastewater: (1) *flushing* wastewater – the influent – that flows into an individual treatment system, (2) *processing* wastewater in the system and (3) *discharging* wastewater – the effluent – from the system after treatment. In each practice, a specific matter of concern emerged and needed to be cared for.

Flushing, and Maintaining Metabolic Engagement

In ongoing efforts to maintain home cleanliness, flushing happens as part of the mundane of practices of any Dutch household. Households in Westmeer are no exception to that rule. But because those households were part of a decentralised infrastructural experiment that moved the collection and treatment of wastewater from centralised arrangements to individual backyards, various stakeholders monitored their influent, which flowed into onsite wastewater treatment systems (OWTS). The introduction to a survey, widely distributed through Westmeer's monthly newsletter, placed emphasis on residents' household routines:

> Did you ever wonder whether your on-site wastewater treatment system (OWTS) works better if you take longer showers? Have you considered the effect on your OWTS of painting your

> hair at home? Or how well your OWTS can handle the disposal of frying fat? As a daily user of your OWTS, you may not realise the impact your actions can have on the functioning of your treatment system.

Wetland-type OWTS function by dint of organic treatment, consisting of septic tanks and biological purification filters of marsh plants or willows that work in symbiosis with microorganisms in the systems' roots. The aerobic and anaerobic bacteria dwelling beneath the roots eat the organic materials containing nutrients – such as phosphate and nitrogen – and, in so doing, clean the wastewater. These metabolic relations are key to the system, but flushing constitutes a crucial mediating practice that directs the nutrients in the wastewater from the household through sinks and toilets to the OWTS. Put differently, flushing is a mode of feeding, since the bacteria performing the cleaning need the nutrients that arrive with the wastewater. Household members consequently claimed to mind what they poured down their sinks. They reported not using bleach, wet wipes, chloride, or other cleaning products that contained 'inorganic ingredients' that could harm the microorganisms at work, and thus the functionality of their systems.

Still, measurements of the influent taken as part of a water expertise company's explorative research indicated *something* was not right with the wastewater flowing into the system. Soon thereafter, measurements of Westmeer households' water consumption showed that the water treatment capacity of the onsite treatment systems did not match the amount of wastewater Westmeer households provided them. In 41 per cent of households, water consumption was less than 150 litres per person per day, which formed the standard for calculating the total volume of domestic wastewater to be processed by an OWTS.[8] The research report suggested that Westmeer households were perhaps 'too water conscious'. Here's Willem, a Westmeer resident, justifying the municipality's frugal water usage:

> We signed up because of Westmeer's mission [of sustainable housing]. This means being conscious of our water consumption. We use as little as possible because everyone here is of the opinion, 'That tap shouldn't be on for hours'.

When it concerns sustainability, frugality may seem a laudable value. However, when it comes to the functioning of individual treatment systems, a certain volume of water is necessary to prevent the system from being overloaded with organic materials. Being cautious with water consumption may actually lead to too high of concentrations of organic materials for bacteria to consume.

While frugality can leave bacteria with too much organic material to consume, underuse of the system can have the opposite effect, leaving them with too little to feed on. In Westmeer, underuse of the system occurred as a result of a mismatch between the size of the system and the number of people using it for sanitation. Thomas, a resident who treated his wastewater with an organic wetland system in his backyard, was well aware of the mismatch between its considerable size and the number of users. At the time of purchase, he was in a romantic relationship and considering expanding his family in the near future. Hence, he chose an OWTS that could serve a family of four. Unfortunately, during the system's installation, he broke up with this partner. Living alone, his OWTS received the influent of only one user. To Willem and his wife Annette it also became quite apparent that unexpected fluctuations in the number of users of sanitation systems can drastically alter the amount of influent flow. They were owners of a tearoom located on their plot of land and their customers also made use of the toilets:

> On peak days, if we have forty to sixty people walking around here, then all of our three toilets are available, and they are used continuously. To every guest we can say, 'Thank you. You contribute to our water supply!'.

Their system can accommodate up to sixty guests. But when the COVID-19 pandemic hit the Netherlands, the country entered lockdown and they had to close shop for a few months. When they finally were able re-open, they could only serve half as many customers as before, between whom they had to ensure a minimum distance of 1.5 metres. This affected not only their business, but also the performance of their treatment system. Willem explained:

> It makes quite a difference whether you have sixty people, or whether you host a few … about ten people. And well … every wee counts here! If there had been a measurement by the water authorities at that particular moment, our system [would have been] completely worthless.

Willem and Annette's experience during the pandemic illustrates the importance of a steady flow of wastewater in providing continuous nourishment for the bacteria in an on-site wastewater treatment system.

To stabilise the flow of wastewater, another group of neighbours explored an alternative to individual household treatment, namely, clustering the influent from multiple households into a collective OWTS, or what in Westmeer is colloquially called a CBA (Collective Wastewater Treatment). One resident who partook in this experiment explained the benefits in a newsletter:

> We are a heterogenous group of pensioners, single-, and two-earner households and families. This means that we use water at different periods during the day and thus produce a more continuous supply of wastewater. Therefore, our system will work better than the individual OWTS you often encounter in Westmeer.

Clustering multiple households enabled reliable hydraulic load distribution and thus stabilised the flow of wastewater required to keep the onsite treatment system operational, that is, to keep the bacteria constantly fed (Figure 2).

Thus, a continuous flow of wastewater did not occur naturally as a result of ordinary flushing and disposal practices, but required households to engage in continual adaptations (Henke 2019). For one, households stopped using astringent cleaning products containing substances that help render their homes spotless, but which also harmed the bacteria dwelling in their OWTS (see also Smits & Ibáñez Martín 2019). Second, the households collaborated by merging their influent in a collective system. They employed neighbourly relations to improve wastewater flow to suit the bacteria's metabolic work. But while adaptations in social relations and water usage may help to sustain a steady flow of wastewater to feed bacteria, there are limits to what a single household can do to improve the working of their OWTS by adapting

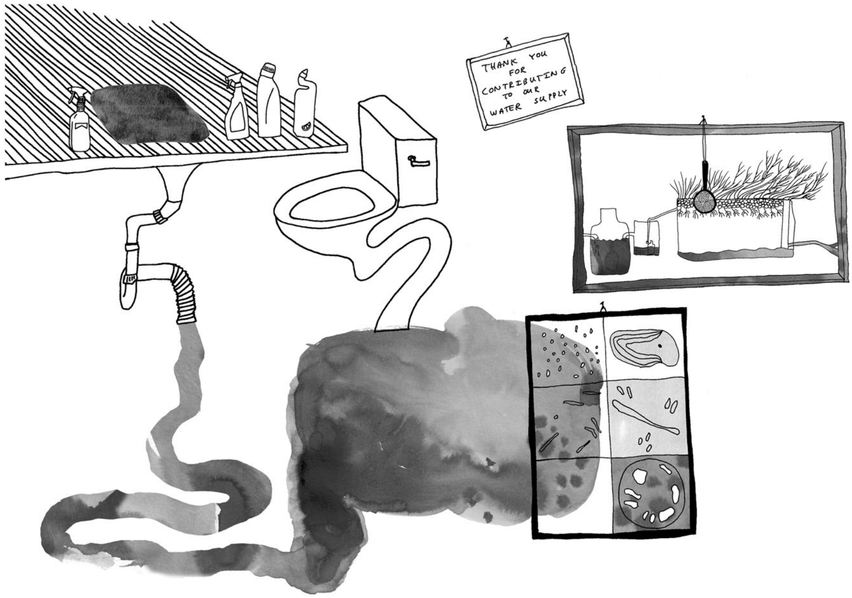

Figure 2. Feeding bacteria: 'Thank you for contributing to our water supply'. The flushing and disposal practices of Westmeer's households are crucial to maintain the microbial metabolic engagements on which the on-site treatment systems depend. Artist Sophia Tabatadze.

its flushing habits. Participants in the Improve your OWTS working group pointed out that different systems react differently to water usage practices and suggested, 'We have to move on to naming solutions by attending to the technicalities of OWTS type.' This brings us to the second practice concerning influent entering treatment systems: the processing of wastewater.

Processing, and Tinkering with Biotechnical Relations

Adapting neighbourly relations or tearoom hospitality ensured a certain volume, more or less, of influent flowing *into* the onsite treatment systems. But once there, the wastewater had to be *processed* with the help of biochemical processes occurring in microorganisms and the host ecosystems in which those microorganisms lived. At this point, maintaining biotechnical relations became a matter of concern. Monitoring and tinkering with the 'treatment performance' of OWTS addressed this concern. Household members in their domestic routines were the first to detect any symptoms of a dysfunctional OWTS. Thomas, who had installed a system with a constructed wetland filter, in which marsh plants live in symbiosis with numerous microorganisms that break down the organic materials in the wastewater, routinely used his sense of smell and sight to detect odours or appearances that seemed 'off'. While giving a tour of his plot of land, he explained that his wetland seemed healthy and emphasised that his reed bed 'looks really good'. How did he know that his wetland with reed beds was still alive? When a stench lingered, Thomas knew *something* was wrong with the system. Similarly, Willem and Annette monitored the colour of the water in their toilets. Since they reused their wastewater to flush the toilets, they had grown accustomed to a 'yellowish' colour. But, at some point, the water turned brownish, an awkward colour about which their customers started asking questions. Willem and Annette were puzzled:

> Well, then you start looking for a cause, you know, like, how come? It has to come from somewhere. You start to observe the colour: is it darker or lighter [than normal]? In the beginning, there were little flecks of mud in the water. So we suspected that the mud came from the tanks were the reused effluent is stored … . So then they [the supplier] came to clean the tanks.

System users' sense of a disruption in the interactions between reed beds, bacteria and mud in the water thus served to alert OWTS suppliers. Still, some residents were of the opinion that if something was wrong with the performance of a pump, they were not responsible for it. This was not a clear-cut issue when it concerned the biotic (bacteria, reed beds) or abiotic (mud, sand) matter that were part of onsite treatment systems. OWTS that use constructed wetlands, for instance, require seasonal harvesting of their canes or willows, while systems working in combination with a septic tank require dredging of the accumulated sludge once or twice a year to ensure biochemical processes such as diffusion and sedimentation. Without timely maintenance, an OWTS cannot treat water optimally. But maintaining the biotechnical relations of the OWTS proved insufficient for attaining optimal performance. Rather, the technology *itself* also required adjustment to the ecosystem that hosted the OWTS. Tinkering with biotic and abiotic matter turned out to be crucial for the technologies to treat water optimally.

Seeking to improve nitrogen removal from wastewater, supplier X tinkered with the biotic and abiotic matter in its OWTS, experimenting with three different wetland models to find a suitable carbon source for Westmeer's soil. The first wetland systems, installed between 2016 and 2018, contained too much and too fine-grained red sand for the Flevopolder landscape. This resulted in poor or limited hydraulic permeability, blockages and a lack of additional carbon sources for adequate nitrogen removal. Subsequently, supplier X experimented with adding multiple carbon sources: choosing woodchips because of their cost efficiency and sustainability. Yet, while woodchips decreased nitrogen levels in the wastewater, the presence of other substances, such as phosphates, increased slightly. Overall, the woodchips did not improve the system's treatment of Westmeer wastewater. This, the supplier's report speculated, was probably due to the addition of *too many* woodchips, wrongly positioned in the filter system. In 2019, the supplier tested different quantities and types of woodchips and upgraded the model. Although measurements revealed a positive trend in terms of the number of OWTS that complied with discharge norms after changes to biotic and abiotic matter, the report stressed that continued effective treatment was difficult to maintain. This was because the woodchips caused unpredictable interactions with wood species from various systems and with the local ecologies in the plots of land. Moreover, the report estimated that, while 75 per cent of the systems should be able to comply with discharge norms as a result of tinkering with woodchips

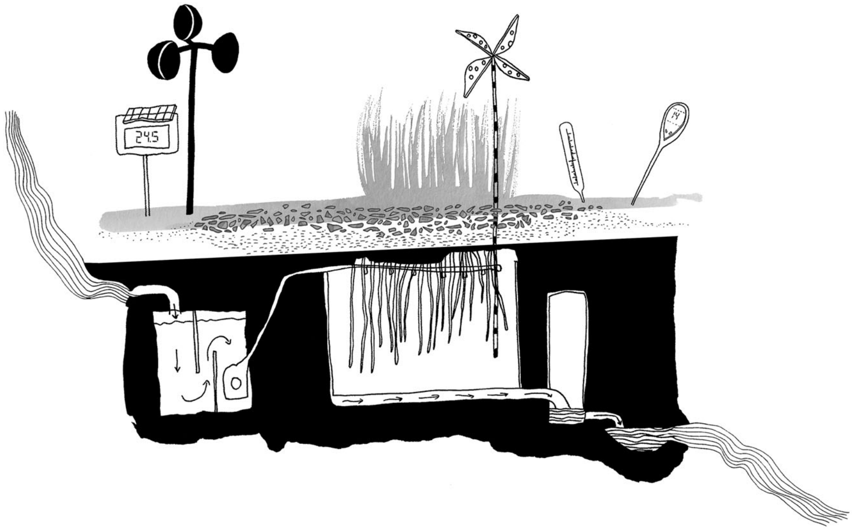

Figure 3. 'Unruly woodchips': woodchips are tinkered with to improve the functioning of the biotechnology. The treatment performance is monitored by estimating and measuring the health of the reedbed and climate conditions. Artist Sophia Tabatadze.

and other biotic and abiotic technology, a number of systems would never meet the discharge norms, due to extreme climate conditions, such as long periods of drought or rainfall (Figure 3).

This section demonstrates that how OWTS treated wastewater was an ongoing matter of concern in Westmeer. Humans cared for wastewater to support the biochemical relations at work in the OWTS, but simultaneously cared for the ecosystem that hosted the OWTS. Biosensors closely monitored the performance of OWTS. Abiotic and biotic matter, like the woodchips, were tinkered with and subtly adjusted over and over and again to improve processing of wastewater from Westmeer's households. Maintenance work was distributed among various participants; humans, biotic and abiotic matter, and objects qualified as 'technical'. But what technologies, humans and 'natural' elements each do while processing wastewater cannot always be clearly disentangled. For optimal functioning, the OWTS, as 'hybrid systems', rely on the ecologies in which they are embedded. Wood species may be modified, adapted, and resized, but as biotic matter they too react, adapt and mutate while interacting with their host environments. A 'dysfunctional system' can thus only be evaluated in relation to its implementation in specific ecologies. This takes us to our next practice: discharging the processed wastewater.

Discharging, and Upholding the Quality of the Surface Water

After processing, wastewater is ready to exit the onsite treatment systems. It is discharged into ditches, streams and eventually rivers and seas. Until the twentieth century, sewage systems in the Netherlands discharged wastewater directly into the surface water. The disposal of untreated sewage water into surface waters, however, adversely affected aquatic life. The wastewater's organic material piled up in the surface waters, causing an overgrowth of algae that blocked the passage of light and oxygen, which other aquatic life needs to survive. To protect the health of surface waters and their aquatic inhabitants, the government installed large wastewater treatment plants (WWTPs). Since the 1970s, environmental regulations have prohibited the disposal of untreated sewage.

Yet, no wastewater treatment method to date manages to remove all organic material and harmful substances. WWTPs therefore rely upon large bodies of water to dispose of the wastewater safely. When wastewater is discharged from a treatment plant, the effluent becomes diluted in large volumes of surface water. Dilution is thus considered a crucial factor for tackling pollution in surface water.[9] Decentralised wastewater treatment systems employ dilution in similar ways. The difference is, however, that WWTPs collect wastewater from multiple sites and discharge one stream of effluent directly into surface waters, such as canals and rivers. Meanwhile, in Westmeer, the surface water consists of small creeks, ditches and artificial watercourses surrounding households' plots of land. Wastewater does thus not 'flow away' from the settlement, but instead remains nearby.

The water authorities consider enforcing strict discharge norms key to maintaining water quality and preventing pollution in Westmeer's closest surface waters. Regional water authorities are responsible for safeguarding the quality of surface waters and conduct legally-binding measurements to assess compliance with discharge norms. In Westmeer, they perform their assessment by measuring the quality of processed wastewater at the moment it leaves the OWTS. Daniel, a water engineer, explained that this is not as easy as it appears: 'To measure is to know, but *how* do you measure exactly?' Although engineering standards regarding what and how to measure are the starting point, the water authorities themselves readily admitted that there were different ways to measure and that the specific timing and location of measurements influence the results:

> We know that it's a snapshot. [The measurement] depends on a lot of variables. There can be a difference between mornings and evenings. We see differences between summer and winter. Temperature also matters: the higher the temperature, the better the bacteria function, the better the purification will be. That's why we often say: 'one measurement is no measurement.'

Thus, environmental circumstances at any given moment, including dry summers and fluctuating temperatures, affect the quality of effluents.

Likewise, the question of *where* to measure came up several times during stakeholder meetings. Some residents argued that the water authorities' measurements should take into account dilution when an OWTS discharges effluent into an enclosed ditch, or pond, or on the households' own parcel: 'If you measure [the quality of water] in that particular ditch and it's good, then there is no problem, is there?' The water authority engineers stressed, however, that users' permits specify the quality of the processed wastewater must have achieved as it exits the system, *before* it flows into the surface waters:

> As a water authority, we are responsible for water quality and we also see these self-managed ditches referred to here as part of the surface water. So, we're not going to say, well, at the end of the ditch where there is an overflow, that's where we are going to measure. No, [to check compliance with the norms] we measure *at the source*, so in fact just *where the discharge emerges* from your system. You are licensed for that discharge, and you are not licensed for the quality of water in a ditch.

In practice, however, delineating a boundary between the source of the discharge and the environment on which systems depend to safely dispose of wastewater is elusive and not maintainable. It turned out that many residents did not discharge into the waterways, but onto the *soil* instead. In one information meeting, a government representative explained that, ideally, residents should discharge the treated wastewater 'into an organically growing network of ditches.' However, the waterways in Westmeer were not uninterruptedly connected:

> How did we start out? Every household would purify the wastewater themselves and every household would ensure that the water drains properly. So, you discharge into a ditch and the idea is that all those ditches together would become a kind of network of waterways, through which the water is drained to larger waterways, the canals and rivers … In practice, we often see things other than what was intended and different from what is stated in the land use plan. Many households have chosen to build a pond and to discharge their treated wastewater there. Or, the wastewater disappears into a ditch, a gully, a trench, whatever you want to call it, not connected with the neighbours'.

As a result, the processed wastewater did not flow towards surrounding surface waters but drained directly into the soil.

While the quality of surface water came under the jurisdiction of the water authorities, the quality of the soil was a matter of municipal responsibility. The municipality therefore hired a research team that specialised in subsurface issues to investigate the effects of wastewater discharges on the bubble of fresh water below the Flevopolder landscape. The results were surprising. It turned out that the area's clay soil many layers functioned to filter the effluent before it reached the surface waters:

> When the OWTS complies with the discharge norm, the soil performs an extra purification on the effluent. After about three years, the water purified in this way ends up back in ditches via horizontal seepage flows. Because the fresh water bubble under Westmeer is located deep under a clay layer, the risk of it being contaminated by discharge into the ponds and isolated ditches is negligible.[10]

The soil, thus, became an unexpected participant in maintaining the surface water quality (Figure 4). But while the soil may optimise wastewater treatment and contribute to decreasing pollution, disposing of wastewater directly into the soil cannot (yet) be authorised with a permit and is thus considered an unlawful activity.

Thus, rather than being a passive recipient in the equation of discharged effluent, ecological relations contribute to safe disposal of processed wastewater. The engagement of biotic and abiotic matter, that is, nonhuman actors, help enact a functioning, stable infrastructure: rather than merely containing the processed wastewater, geological elements such as sand and clay contribute to maintaining water quality by providing an additional purification step. However, despite their engagement with

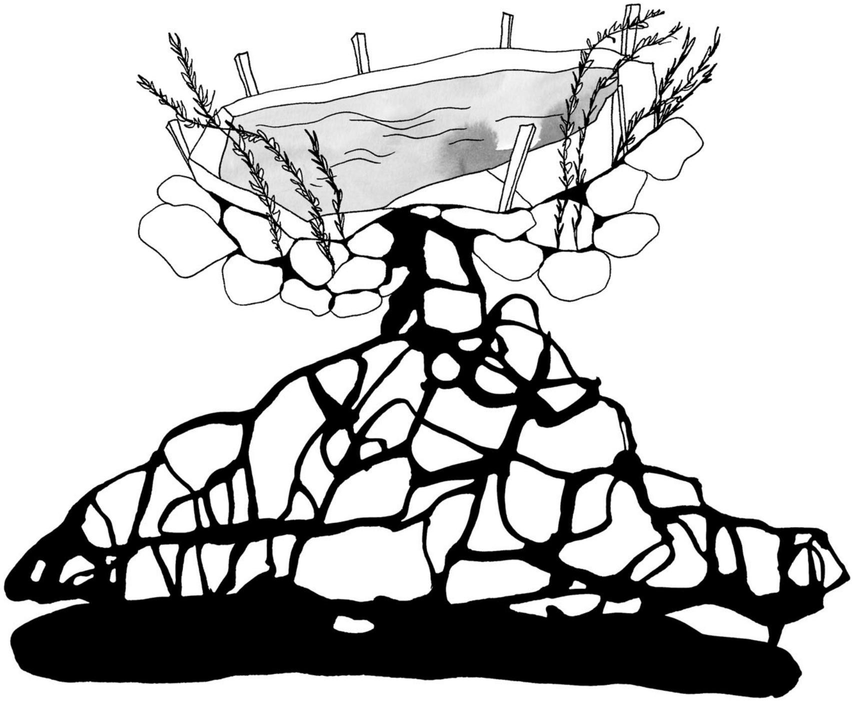

Figure 4. 'The soil as a filter': After being discharged in a pond, the clay in Westmeer soil absorbed the processed wastewater and slowly improved its quality by purifying it through its many layers. Artist Sophia Tabatadze.

Westmeer's experimental wastewater infrastructure, the water authorities did not acknowledge these material entities as public stakeholders. Measuring the processed water at the 'source' of discharge, right before it merges into the surrounding environment, prevented policy from noticing Westmeer soil's contribution to maintaining the quality of the settlement's water.

A Sewage System, After all

Despite all the work undertaken in order to achieve a functional decentralised infrastructure, the risk of environmental pollution lingered. Eventually, in order to prevent further deterioration of the quality of the surface water, Westmeer's local authorities announced the construction of a centralised sewage system. These days, households are allowed to continue treating and discharging their own domestic wastewater under the condition that they bring their OWTS up to the standard to the required discharge norms. If they fail to do so during the 'two-year improvement' period, they will have to connect to the centralised sewage system, as all future households will be required to do.

While the municipality will care for the centralised sewage, the users of the sewage system will have to lay their own pipes to connect to the main infrastructure. In discussing this option in a working group, multiple concerns are raised by inhabitants: whose responsibility was this 'below-the-ground' work' and how will the municipality 'prevent the infrastructure beneath our feet from becoming a jungle of pipes, a criss-cross of privately-owned and privately-maintained infrastructures'? The discussions on pipes, mills and pumps illustrate how, with the (re)turn to a centralised sewage and treatment infrastructure, the multispecies collaboration in wastewater management remains unacknowledged and becomes once again 'technologically mediated and epistemologically "opaque"' (Hoag *et al.* 2018: 90).

Even when the treatment of wastewater will no longer be the official responsibility of the residents in Westmeer, a sewage system will continue to connect households with the biotechnical systems of the centralised wastewater treatment plant (WWTP). There, the wastewater will continue to nourish (or harm) the microorganisms that treat it and the processed discharge eventually makes its way into rivers, lakes and seas – encountering new ecologies. The sewage system is not a substitute for the infrastructural relations that emerge around wastewater, but rather configures these relations *differently*. Once the sewage system is in place, engagement with wastewater as an explicit matter of concern, as part of domestic activities, technical configurations and (un)welcoming ecologies, may dissolve into the background, promoting a belief in the 'engineerability' of wastewater disposal techniques (Gabrys 2009). While in the short run, (a return to) the sewage system may prevent deterioration of Westmeer's water quality, in the long run, it risks concealing enduring infrastructural relations and the situated practices of caring for them (Star & Strauss 1999).[11] But just as decentralisation does not automatically result in ecological reparation, it seems reasonable to assume that environmental improvements do not automatically follow from recentralising the responsibility for treating waste. That is, to realise a functional infrastructure, a sewage system, too, requires ongoing care, adaptations and adjustments with respect to all the related actors involved in its use.

Infrastructural Politics: Of *Which* Nature are 'we' Part?

In this article, we consider the decentralisation of wastewater treatment in the Flevopolder as an ongoing infrastructural experiment. By tracing infrastructure-in-the-making in the messy practices of flushing, processing and discharging wastewater, we articulated *more-than-human relationality* as an organising principle in the infrastructural configuration and governance of treating wastewater. This stands in stark contrast to the human-centred governance strategy the local authorities propose. They configure the implementation of a sustainable wastewater treatment infrastructure as either a matter of decentralised or (re)centralised responsibility. Here, we argue that representing the implementation and maintenance of wastewater treatment as a *matter of care* (Puig de la Bellacasa 2017), helps us, environmental anthropologists, to tell a different story: not one of humans failing to achieve the ecological ideal of sustainability, but instead one of infrastructural fluidity among humans, their technologies and 'nature' – a fluidity that, at times, proves remarkably helpful in cleansing wastewater. Our focus on multispecies relations, and how these are (un)cared for while maintenance of a wastewater treatment infrastructure unfolds, teaches us three lessons about the infrastructural politics of governing waste.

First, a focus on caring for those infrastructural relations – among people and anaerobic bacteria, among woodchips and devices, among clay and wastewater – shows that what initially appeared to be a governance strategy in which 'people and their ideals' figure prominently, is actually a complex socio-material experiment in which multispecies relations configure the infrastructure in unheralded and unruly ways. These configurations shifted as the wastewater experiment unfolded: from maintaining metabolic relations, to tinkering with biotechnical relations, to upholding the quality of the surface water. Our study demonstrates that caring for a wastewater treatment infrastructure produces concerns that may not be assuaged by drawing boundaries between infrastructure and its environment, singling out problems pertaining to 'society', 'technology' or 'nature'. It also cannot be addressed by simply 'being as fluid as the flow' (Pickering 2008: 10). This is because shifting concerns and the means of handling those concerns creates *shifting boundaries*, including: (a) boundaries across species (Barua 2021) and (b) boundaries between an environmental infrastructure and the ecologies in which it is embedded (see Morita 2017). How these shifting boundaries – and the complex adjustments they require from a wide variety of human and nonhuman actors – cohere, add up, or conflict shapes the politics of care. This politics does more than simply represent or symbolise a world that already exists 'out there': rather, it shapes how infrastructure may become part of nature, and vice versa. Let us illustrate this point by contrasting the engagement with infrastructure of the Flevopolder soil with that of the woodchips. The cleaning capacity of the many thick layers of clay in the soil was an unexpected effect of the discontinuous network of waterways in Westmeer. It prevented the processed wastewater from discharging directly into the water table, acting as a purifying filter and helping maintain surface water quality. The woodchips, in contrast, were intentionally mobilised as a carbon source to help cleanse wastewater. However, imported wood species interacted in unpredictable ways with the mechanics of the OWTS and the Flevopolder landscape, affecting the treatment systems' capacity to clean in unforeseen, and sometimes undesired, ways. We should thus pay attention not just to adaptations emerging as various stakeholders become intimately entangled, but also to how entities qualified as belonging to the natural realm – like imported wood chips or clay soil – reconfigure infrastructure in unpredictable and *heterogenous* ways.

Second, while infrastructures, as ontological experiments (Jensen & Morita 2017: 618), may spark open-ended and heterogenous collectives that are differently valued, the infrastructural fluidity between these entities is likewise difficult to govern. Governing infrastructural configurations – through regulations that stipulate environmental protections, i.e. legislation concerning who is responsible for the health of the soil and waterways, technologies that collect or discharge wastewater, and so on – may render *certain* multispecies relations *in* the infrastructure explicit, such as the relation between bacteria and humans, while ignoring or neglecting others (see Morita 2017:

740). For example, the Flevopolder clay soil' capacity to filter the processed wastewater may be the purest expression of engagement 'from below' with this environmental infrastructural experiment. It is the type of initiative Westmeer's local authorities seek to encourage, albeit only among the municipality's human inhabitants. Yet, the water authorities and the municipality do not formally recognise the soil's filtering labour as infrastructural engagement, precisely because it is too unruly an adaptation (yet) to be anticipated, engineered and integrated into the wastewater treatment infrastructure. And so, despite the soil's vital ecological and infrastructural importance, it remains uncared for as part of formalised wastewater management (Puig de la Bellacasa 2014; Salazar *et al.* 2020).

And finally, where does all this leave anthropologists concerned with ecological sustainability and waste management? While waste, thanks to multispecies ethnographies thereof, is now commonly understood as a multispecies happening, the work that is involved in cleaning or doing away with waste, remains only partly recognised. This may be because the lives and deaths of some species are considered disposable themselves (Doherty 2019), or because waste management is 'technologically mediated' and therefore remains 'at a distance' and unrecognised by the handlers of waste management systems (Hoag *et al.* 2018: 90). However, in our case, the waste management technology in question is also a biochemical and integral part of household routines. This means that with the shift of environmental governance towards decentralisation, people, in the role of infrastructural caretakers, now engage explicitly with the micro-organisms living in their systems, the growth cycle of aquatic plants and the pH-value of the soil on which a functioning technology depends. By smelling reedbeds, observing the response of woodchips, and analysing the response of the soil, people gain knowledge and awareness of the fragility of the transformative processes they qualify as 'nature'. Through adapting their practices and adjusting biotechnologies accordingly, people start caring for an infrastructural version of nature of which they are part (see also Abrahamsson & Bertoni 2014).

Yet, in the case of Westmeer, the knowledge gained through trial and error, remained 'uncertified' (Pickering 2008) as part of formalised wastewater management, leaving those multispecies relations neglected. The prospect of a centralised sewage system in Westmeer suggests a final stage of experimentation, in which the problem of the municipality's deteriorating water quality is considered properly resolved by means of a technically-engineered, solution. This engineered solution takes into account human knowledge, but as Anna Tsing reminds environmental anthropologists, 'how can we expect to appreciate more-than-human sociality if we can't get around the limitations of specifically human knowledge?' (2013: 28). The work on which we shed light in this article suggests an alternative, more-than-human understanding of engineerability: 'it is not just that infrastructure must be built, invested in and so forth, but that it is inhabited, exploited and lived by nonhuman others' (Jensen 2017: 236). Indeed, in our infrastructural experiment in the Flevopolder, matter and species continue to relate, respond, adapt and transform within, beyond, and sometimes in spite of, infrastructure. This form of engineerability entails *ongoing* engagement with the multispecies waste work of *all* stakeholders, as they configure an infrastructure in which unexpected biochemical and geological processes unfold, not in a controlling mode, but rather in a relational, caring mode.

Notes

1. Centralised wastewater treatment plants also rely on living microorganisms to perform the bulk of the cleaning process. Tora Holmberg's (2021) case study of a sewage management plant in Sweden provides an example of this and emphasises the importance of recognising wastewater treatment as a multispecies achievement in which microorganisms and other animals play a crucial role.
2. This study was undertaken following local ethics committee approval. To ensure anonymity we use pseudonyms for places, respondents, and organisations.
3. See also Domínguez-Guzmán *et al.* (2021) on caring for fragile water infrastructures in Peru.
4. Authors addressing open defecation in regions lacking piped water infrastructure in the Global South (e.g. Black & Fawcett 2008; Jewitt 2011) explore decentralisation as a safe alternative to ensure basic health, provide privacy, and protecting women and girls from sexual harassment (Datta & Ahmed 2020). In the Global North, by contrast, decentralisation is explored to experiment with innovative technologies to recover nutrients, close cycles, and to treat contaminants to which conventional, centralised treatment plants do not attend (cf. Vasconcelos Fernandes *et al.* 2015).
5. To prevent the municipality's identification, we cannot include the source in our references. The document is publicly accessible and disseminates information about the development plan and guidelines.
6. The Dutch 'water authorities' are public-private bodies with financial independence, but which public health laws and public governance structures hold accountable for protecting the environment.
7. Besides specifying the quality standards for phosphate and nitrogen removal, the discharge permit that applies to Westmeer specifies norms for removal of the biological oxygen demand (BOD), the chemical oxygen demand (COD), ammonia, and other unresolved substances. However, because measurements indicated exceeded norms primarily for phosphate and nitrogen, we focus on these two standards.
8. Beoordelingsrichtlijn, Attestering van IBA-systemen, 2000.
9. The slogan in wastewater treatment has long been 'the solution for pollution is dilution'. Current research on the presence of 'contaminants of emerging concern' (Fernandes *et al.* 2021: 2), such as microplastics and pharmaceuticals, questions the efficacy of dilution in tackling surface water pollution and explores new treatment technologies such as bioremediation processes (12).
10. The report did warn, however, of the danger of medical residues. The soil does not remove these when it filters waste and they end up in the surface water.
11. See also Ureta (2016) for an analysis of how notions of 'management' or 'technological fixes' limit the politicisation of waste and its handling.

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