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ESSAY



Connecting the Dots: A Collaborative Ethnography of Plastic Leakages in Indonesia and the Philippines

Anita Hardon^a , Diana Pakasi^b, Irwan Hidayana^b, Efenita Taqueban^c, Eileen Moyer^d, Josephine van Zeven^e, Tridibesh Dey^a, Mark Nichter^f and Michael Lim Tan^c

^aKnowledge Technology and Innovation, Wageningen University and Research, Wageningen, Netherlands; ^bDepartment of Anthropology, Gender and Sexuality Studies Unit, University of Indonesia, Depok, Indonesia; ^cAnthropology Department, University of Philippines Diliman, Quezon City, Philippines; ^dAnthropology Department, University of Amsterdam, Amsterdam, Netherlands; ^eFlorence School of Transnational Governance, European University Institute, San Domenico di Fiesole (FI), Italy; ^fSchool of Anthropology, University of Arizona, Tucson, AZ, USA

ABSTRACT

Plastics are valued for their affordability, durability, and adaptability, making them widely used in industries like packaging, electronics, and healthcare. However, plastic waste has surged, prompting the United Nations to push for a legally binding global treaty to regulate plastics by 2024. Despite ongoing negotiations, no agreement has been reached, highlighting the complexities of global plastic governance. Beyond visible pollution, plastics degrade into micro and nano-particles, releasing thousands of chemicals, many of which are hazardous. This study, conducted in Indonesia and the Philippines—controversially cited as two of the largest contributors to ocean plastic pollution—applies Nading's concept of "leakage". It identifies epistemic, regulatory, structural, and social leakages that hinder effective plastic waste management and fail to protect vulnerable populations from potentially harmful exposures. The authors argue that plastic leakage occurs throughout the entire lifecycle of plastics—from production to disposal. These interconnected leakages challenge dominant representations of plastic waste as a linear problem with clear solutions such as recycling and landfilling. The article advocates for policies that address the systemic nature of plastic pollution, emphasizing the need for corporate transparency, regulatory enforcement, and inclusive waste management. It moreover calls for interdisciplinary approaches that incorporate local expertise, and long-term strategies to reduce plastic-related harms.

PLAIN LANGUAGE SUMMARY

Our team spent three years talking with community members, waste workers, activists, officials, and scientists in Indonesia and the Philippines—two countries that have been alleged to send a great deal of plastic into the ocean. We found that plastic "leaks" everywhere along its life-cycle, not just after people throw it away.

- Knowledge leaks. Thousands of chemicals are mixed into plastics, yet we still lack safety data for about 40 percent of them and few labs in the region can test for their effects.
 - Policy leaks. National and local rules focus on litter and recycling but shy away from limiting plastic production or banning hard-to-recycle sachets.
 - Infrastructure leaks. Community recycling centers often break down or burn excess waste; landfills and rivers let micro-plastics and chemicals slip into soil, water, and food.
 - Social leaks. Clean-up drives, buy-back schemes, and home "up-cycling" are well-meant, but they shift the burden onto already stretched households and informal waste pickers.
- Because these leaks are interconnected, quick fixes like more recycling bins will not solve the problem. We call for policies that cut virgin plastic production, demand full chemical transparency, fund durable waste systems, and respect the everyday expertise of the people who live and work amid plastic waste.

KEYWORDS

Plastics; pollution; planetary health; infrastructure; community remediation

At the entrance to a small beach on the North Sulawesi coast, we encountered Alfred, a local environmental activist organizing community plastic waste collection efforts. Alfred's community is

participating in the mayor's initiative to minimize and gather plastic waste, delivering recyclable materials such as PET bottles to local waste banks to create community revenue. We discussed

CONTACT Anita Hardon  anita.hardon@wur.nl  Knowledge Technology and Innovation, Wageningen University and Research, Hollandseweg 1, 6706 KN Wageningen, Netherlands.

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clean-up efforts while walking along a beach littered with degrading plastic trash. Alfred shared his frustration. Despite improved local waste management, plastic waste keeps washing up on shore. Discouraged, people in the community have lost motivation to clean up.

Valued for their affordability, durability, lightweight, convenience, and amenability to customization (Meikle 1995), plastics are everywhere: in our supermarkets, homes, hospitals, shops, vehicles, food packaging, and dustbins. Petrochemical companies produce plastic polymers; other downstream plastic processors convert these resins, through the mixing of additives and molding into plastics for specific applications, ranging from construction and the built environment to packaging, electronics, textiles, automobiles, tires, household furnishings, medical devices, electronics, cosmetics, and paints.

Examining eight key industrial sectors, Geyer et al. (2017) estimate that 6,300MT of plastic generated before 2015 is no longer in use. Global annual plastic waste has doubled from 156MT in 2000 to 353MT in 2019 (OECD 2022). This worrying trend led the United Nations Environment Program (UNEP) to adopt a resolution in March 2022 requiring its International Negotiating Committee (INC) to prepare a legally binding, global treaty to regulate the entire lifecycle of plastics—resource extraction, refining, production, circulation, use, and disposal—preventing and remediating plastic pollution and its toxic impacts worldwide—by 2024.

While Alfred is concerned about the plastic bottles, cups, and sachets washing up on the shores of his coastal community, scientists and activists are increasingly worried about how these plastic items degrade and fragment into micro and nanoparticles, leaching chemicals that were added to give plastics their various properties. Around 16,000 different chemicals have been identified in plastics, of which 4,200 have been flagged as potentially hazardous (UNEP 2023; Wagner et al. 2024).

This article draws on collaborative, multi-sited ethnographic research conducted in Indonesia and the Philippines—allegedly, two of the top sources of ocean plastic pollution (Jambeck et al. 2015; Cotton et al. 2024). Following Nading

(2017), we adopted “leakage” as a heuristic encompassing chemical leaching into the environment and leaky policies and infrastructure, allowing plastic waste to be released into the environment at various stages of its lifecycle.

Nading analyzes chemicals used in malaria control in Nicaragua as “leaky things having long afterlives implicated in fluid interactions involving complex material-socio-political processes” (Nading 2017, p143). Nading examines the afterlives of the chemicals, pointing to how numeric leakages occur when recipients repurpose the insecticides for the control of rodents and how structural leakages occur when a wider range of actors than envisaged engages in the control efforts.

Extending Nading’s analysis, we point to intersecting epistemic, regulatory, structural and social leakages. We connect the dots between these various kinds of leakage through multi-scalar ethnographic research in the Philippines and Indonesia in light of global calls for regulatory action to contain plastic waste. More specifically, we examine how

1. Environmental scientists and activists, in their efforts to highlight the dual risks of plastic leakage—to both the environment and human health, face epistemic leakages.
2. Regulators attempt to control plastic leakage under pressure from citizens and scientists while navigating powerful economic drivers, often resulting in regulatory leakages.
3. Local governments manage decentralized plastic waste segregation systems, considering resource limitations and varying degrees of political commitment, resulting in structural leakages.
4. Community-based actions designed to manage plastic waste are challenged by the sheer volume of waste, resulting in social leakages.

By focusing on these diverse forms of leakage across four domains, we can move beyond the molecular level studied by environmental scientists, examining also the institutions and infrastructures designed to manage material flows, as well as the communities where plastics are embedded in social relationships. The multi-sited nature of our collaborative ethnography

strengthens our analysis, enabling us to compare and contrast the diverse forms of leakage across rural and (peri-)urban areas in Indonesia and the Philippines. This comparison takes into account variations in local regulations, patterns of plastic consumption, and waste management practices.

Global calls for regulatory action

Regulators, scientists, journalists, activists, and the general public increasingly consider the material leakage of plastic waste an urgent problem requiring containment (Shen et al. 2020). Containing plastics' material leakage requires overarching legislation and policies that take stock of entire value chains, ideally spanning all economic sectors and addressing the global flow of waste. This would necessitate a high level of legal sophistication and considerable international political will. During the fifth UNEP Assembly's closing session, some signs of political will appeared in 2022 when 193 delegates supported a resolution to end plastic pollution by 2024 (UNEP 2022). Disappointingly, after two years of negotiations, the fifth meeting of the International Negotiating Committee on the Global Plastics Treaty (INC-5) failed to result in a treaty agreement. Negotiations will continue in 2025.

Nonetheless, the negotiations have worked as a catalyst for important plastics research. In support of this regulatory effort, the Minderoo-Monaco Commission on Plastics and Human Health published a significant report (Landrigan et al. 2023) which took stock of all kinds of material leakage, and its adverse effects. As the lead author stated upon the report's release, "Once data have been collected showing that a material like plastic is causing great harm to human health and the earth's environment, it is harder for people to say there is no problem" (NewsRx 2023, 1).

The report presents increasing evidence of chemical-laden micro- and nanoplastics being present in human livers, lungs, placentas, testes, and colonic mucosa. It further documents the leaching of chemical additives, such as Bisphenol-A and phthalates (used as plasticizers), from plastics throughout their lifecycles, citing studies that provide evidence on how this leaching is associated with disruptions in endocrine function and

heightened risks of premature births, obesity, and cardiovascular disorders. Vulnerable populations—young children and older people—are especially at risk, as are workers in recycling plants (Campanale et al. 2020; Rahman et al. 2021; Trasande et al. 2024; Turrone et al. 2021).

The report's authors aimed to enhance transparency and counteract industry efforts by manufacturers to minimize the severity of the crisis, thereby prompting action from policymakers. Reporting back from the unsuccessful INC-5, Taqueban, one of our team members, noted that "The meeting feels more like a corporate conference! Even how folks are dressed." A handful of countries with powerful petroleum industries refused to accept a production cap on virgin plastics or eliminate chemicals of concern from plastic production, proposing downstream interventions at the level of waste management instead. Along with plastic and oil industry lobbyists, these petrostates insisted that strengthening waste management infrastructures and scaling up recycling could contain plastic leakage into the environment and humans (Durrani 2024).

Meanwhile, 85 countries (including the 27 European Union member states, Canada, the United Kingdom, and 56 Global South countries, including the Philippines) supported Rwanda's Standing Up for Ambition Motion (Rwanda Motion 2024), which outlined indispensable elements of an effective treaty. These included adopting a global target to reduce production of primary plastic polymers to sustainable levels and establishing a legally binding obligation to phase out plastics' most harmful chemicals. The Philippines not only backed the Rwanda Motion but also included a high-ranking Department of Health official and the chairperson of the Mother Earth Foundation in its delegation. The Indonesian delegates did not support the Rwanda Motion, opting rather for efficient management of waste. Indonesia has a significant plastic polymer manufacturing sector and a rapidly growing consumer goods industry.

Figure 1 depicts the policy assumption underlying the position that waste infrastructures can contain plastic waste through recycling, incineration and storage in landfills (shown as 'dead ends'). Notably, mismanaged and littered plastics

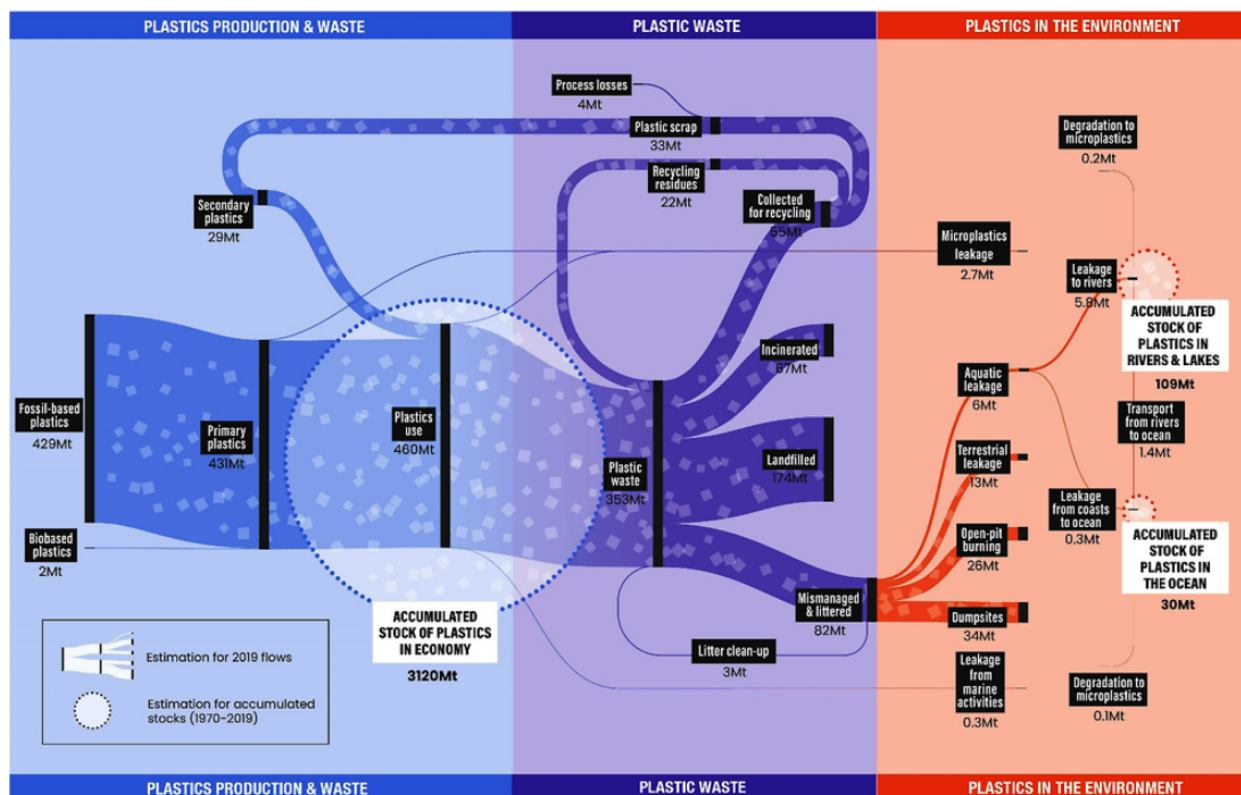


Figure 1. Plastic production, recycling, and waste flows in 2019. *Source* OECD (2022).

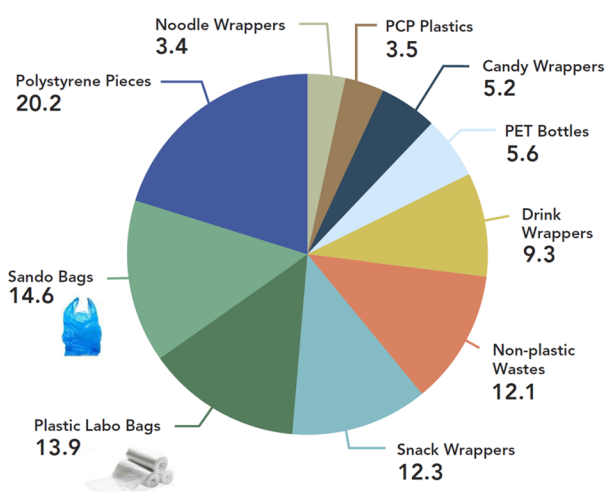


Figure 2. Ten most common waste types collected in a 2020 World Bank survey. *Source:* World Bank (2022, p. 11).

appear as relatively minor flows, only occurring downstream from domains of plastics usage – as reflected in the very thin red lines, right section of the image.

Insights from our multi-sited ethnography call for reconceptualizing these policy assumptions regarding the minor role of post-consumption material leakage of residues in plastics waste

production.¹ Our analysis points to pervasive and multivalent leakages throughout the life-cycle of plastics waste production, including at waste management facilities that are expected to contain waste. In doing so, we answer the call of Boudia and colleagues who invite us to “remain mindful of the absences, inaction, and nondecisions that leave residues out, uncoun- ted and unaccounted for” (Boudia et al 2022, p123).

Collaborative ethnography

Our research of the multiple modes of leakage combined a critical analysis of existing environmental studies on plastic material leakage and leaching, scrutiny of Indonesian and Philippine regulations and policies, and, crucially, ethnographic fieldwork on waste management and community responses in areas of Indonesia and the Philippines heavily impacted by plastic waste.

From December 2021 through 2022, Universitas Indonesia students conducted focused ethnographic studies in three peri-urban communities located within fifty kilometers of Jakarta: Bogor District (Citayam), Tangerang City (North

Paninggilan), and Depok City (Cinangka, Sawangan). Students conducted ten ethnographic interviews with waste activists, local authorities, private landfill operators, and residents at each site. They also performed mapping exercises with local participants, triangulating their findings in six focus groups (two per site). Additionally, in 2024, the authors conducted ethnographic research in North Lombok and Central Lombok and Purwokerto City, Central Java. The latter two sites have implemented zero-waste policies.

In the Philippines, Taqueban conducted multi-sited fieldwork with a team of anthropology students attending classes remotely during the pandemic in their home communities (Tarlac, La Union, Eastern Samar, Laguna, South Cotabato, Aklan, and Dinagat Islands, and two towns near Metro Manila). Like their peers in Indonesia, the students conducted ten ethnographic interviews in each site, performed mapping and triangulated their findings in two focus groups. In 2024 and early 2025, the authors did additional fieldwork in Puerto Princesa, Baguio and Marikina.

In the collaborative analysis phase of our research, we used critical cartography, a method informed by countermapping that challenges dominant spatial representations and constructs alternative visions (Zwer & Rekacewicz 2021), to visualize our key insights. Our maps highlight multivalent leakages. In the conclusion of this article, we offer an alternative to the perspective presented in [Figure 1](#).

While doing focused fieldwork across multiple sites allowed for collaborative articulation of the various forms of leakage, we are aware that covering so many different sites in one article limits the ethnographic thickness of our account. For readers interested in more details we refer to the site-specific articles that we are also writing (see Pakasi et al. 2024).

Epistemic leakage in environmental health research

In environmental science, leakage refers to the physical escape of plastic waste into the environment, the physical degrading of plastic items into micro and nano-particles and leaching as a chemical process wherein chemicals migrate out of

macro, micro and nano plastics subject to ambient environmental conditions.

In Indonesia and the Philippines, most studies of plastic material leakage have focused on the physical escape of (micro) plastic waste, mainly into the marine environment. For example, during August and September 2020 in the Philippines, 915 volunteers from the Break Free from Plastic (BFFP) Movement audited over 38,000 pieces of litter found on 17 beaches and in urban areas. The aim is to identify the manufacturers of plastics that end up in the oceans. Sachets, used by corporations like Nestle, Unilever, and Proctor & Gamble to sell small quantities of goods affordably to low-income consumers, were the most frequently found waste items (Break Free from Plastic 2020). BFFP then pressured multinationals to assume responsibility for their waste and the Philippine government to ban single-use plastics. Similarly, in 2023, 476 volunteers from Trash Hero, an Indonesian BFFP member NGO, performed an audit, counting 9,698 sachets across 34 locations (BFFP 2024). Sachets consist of multiple layers², making effective recycling impossible, and their light weight means that the wind can carry them to far away locations, which contributes the physical escape of these plastic items. (BFFP 2024; Rangel-Buitrago, Galgani & Neal 2024).

A World Bank report, calling on the Philippines government to reduce waste, surveyed 1,400 items of waste collected from the Pasig River, one of the most polluted in the world (World Bank 2022) that runs through Metro Manila, a city with 14 million inhabitants. The aim here was to find out what kinds of plastics escape most. The researchers found that polystyrene, plastic food, and carrier bags comprised nearly half of the waste. Another third of the collected items consisted of thin, multilayered wrappers from noodles, drinks, candy, and snacks.

The focus on the physical escape of plastics means that in both countries we know little about the leaching of potentially harmful chemicals from these plastics items. This 'epistemic leakage' occurs because Indonesian and Philippines research institutions do not have the resources to study chemical leaching, which requires more sophisticated laboratory technologies (Vriend et al. 2021) – doing surveys of the physical escape

of macro plastics (and micro-plastics) is relatively cheap.

Global reviews like the above-cited Minderoo-Monaco Commission do take stock of existing evidence on the potential harm of plastic leaching, but they too face challenges because the safety profiles of many chemicals used to give plastic items their properties remain unknown. Why not? Barry (2005) points out that that chemistry is a science of associations in which molecules are “informed.” In the case of plastics, this involves chemical engineers giving plastic specific properties by trying out, and modifying chemical cocktails. Manufacturers, however tend to conceal the exact composition of the materials which they consider trade secrets, and government regulations do not demand such transparency contributing to epistemic leakage.³ As a result, we only know a fraction of the safety profiles of the chemicals we encounter every day (Landrigan et al. 2018)⁴, which adds to epistemic leakage.

Environmental chemist Helen Wiesinger and colleagues (2021) pointed to epistemic leakage when they reviewed available safety data for 10,000 chemicals used in plastics. Scattered, limited data on safety in the public domain hampered their analysis. Wiesingers’ research team could not find hazard data for some 40% of the substances used in plastics – a remarkably high proportion.⁵ We visualized this epistemic leakage, through our practice of critical cartography, see Figure 3. The red line shows the steps in the analysis by Wiesinger and colleagues; the grey boxes in the lower section of the image represent the volume of substances with unknown hazards data. Of the 6400 chemicals for which a hazard classification is possible, 2486 (38%) are substance of potential concern - colored orange; and 1254 (20%) of high concern – highlighted in red.

Environmental health researchers face further epistemic leakage when determining the cumulative effects of plastic chemical cocktails in the “living labyrinths” (Bensaude-Vincent and Stengers 1996, p263), where plastic products are used, re-used and disposed of, considering also the heat and humidity that shape leaching in our field sites⁶. The failure to account for the accumulation of these toxicities in every-day lives aggravates epistemic leakage. Consider the harm caused to

people living downstream from this landfill in Puerto Princesa, Philippine, see Figure 4.

Local administrators said that run-off from this sanitary landfill is treated, but on probing we found out that the treatment is not directed at microplastics or chemicals leaching from the mountain of waste. As a result, plastic residues can freely flow into the adjacent river, where children play, cows and goats drink, and mothers do their laundry. The river ends in the nearby bay where fishermen catch an abundance of sea life, sold by their wives in neighborhood stalls.

In the next section we show how regulators in Indonesia and the Philippines spurred by activist surveys (and global concern about marine pollution), seek to contain the escape of plastic litter, but fail to act to prevent harms caused by the leaching of largely unknown chemical cocktail, often affecting vulnerable communities, in the Philippines and Indonesia.

Regulatory leakages

Over their lifespan, plastics are subject to a fragmented system of jurisdictions, each possessing distinct, uncoordinated, and incompatible regulatory frameworks, resulting in regulatory leakages that perpetuate the leaking and leaching of harmful plastic materials into people’s everyday lives. Our scrutiny of the policy documents and published studies show policies and plans to regulate plastics are uncoordinated, partial and slow to come into effect (Rucevska et al. 2024) – they leak. Where they exist, they focus on the end-of-life management of physical waste. The potentially harmful chemicals that leach into human bodies and ecosystems (except for a few specific chemicals with well-established hazard profiles such as Bisphenol A) are not regulated, adding to regulatory leakage.

In Indonesia, the National Plan of Action on Plastic (NPAP 2020) emphasizes the shared responsibility of various stakeholders, requiring commercial and industrial entities to collect and transport their plastic waste to designated disposal sites, recycling facilities or landfills, in line also with emerging Extended Producer Responsibility legislation (Wang and Karasik 2022). NPAP operates according to the 3R (Reduce, Reuse, Recycle) principle.

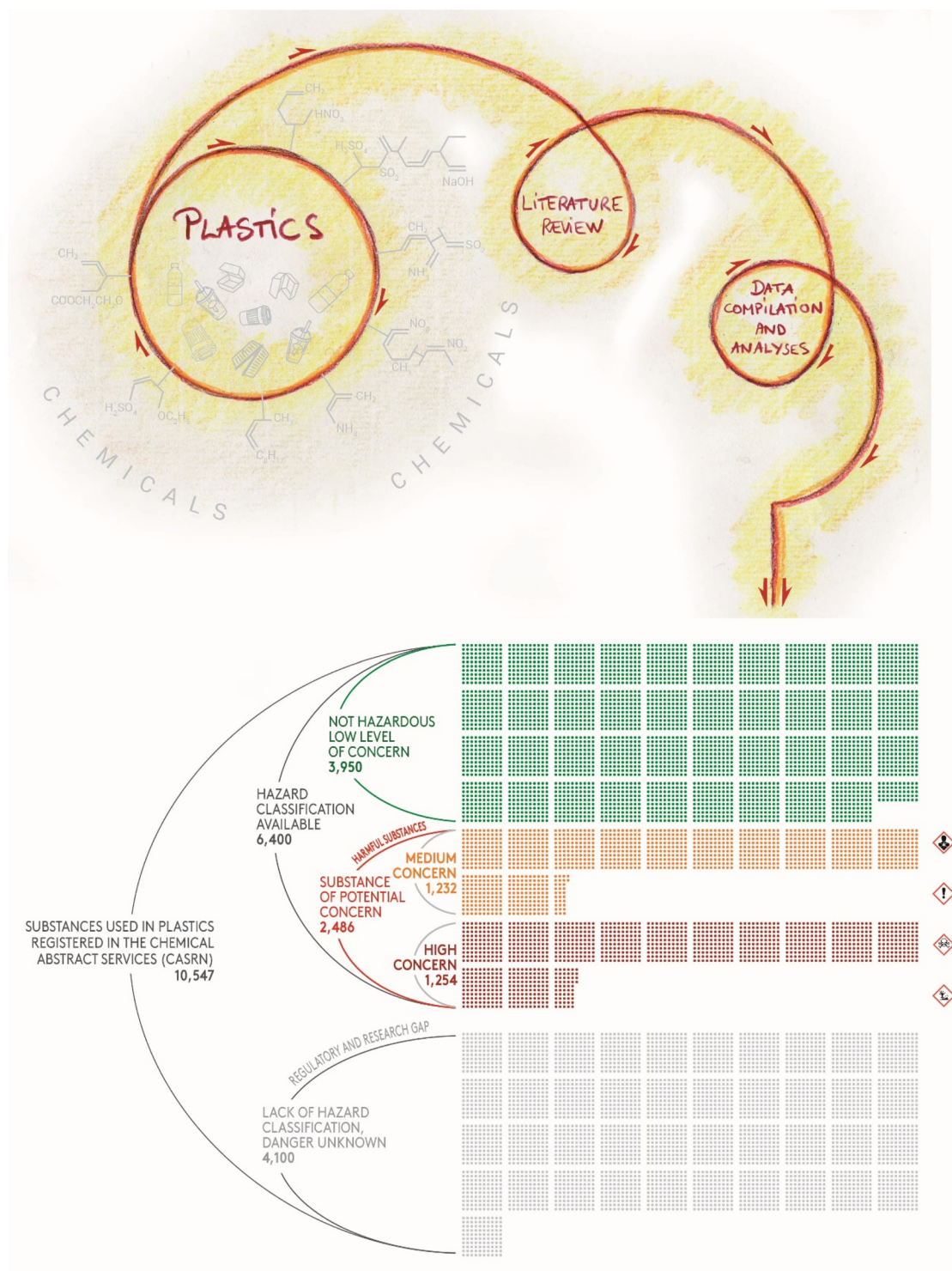


Figure 3. 40% Of the 10,000 substances used in plastics are missing data on safety. Source Wiesinger et al. (2021, 9339).

To augment this effort, the Ministry of Environment and Forestry Regulation Number 14 of 2021 set up a waste bank infrastructure, managed by communities, businesses, and/or local governments. Citizens are encouraged to bring waste with resale value for recycling to these banks, which generally accept all ‘dry waste’

(Pakasi et al. 2024). In addition, around 40 local governments in Indonesia have implemented restrictions or outright prohibitions on single-use plastics, particularly plastic bags, straws, food containers, and cups (Kamaruddin et al. 2022).

Our review of the regulatory literature reveals that across these instruments, informal plastic



Figure 4. The Puerto Princesa sanitary landfill. *Source:* Anita Hardon, January 2025.

waste management—an essential contributor to waste reduction—is neither officially recognized nor financially compensated (Wang and Karasik 2022), another manifestation of regulatory leakage. Furthermore, actions outlined in the policies, including the 3Rs are inadequate and suffer from insufficient funding (Arifin et al. 2023; Kamaruddin et al. 2022), as we also observed in our fieldwork in waste management sites, to be elaborated on further.

In the Philippines, the Ecological Solid Waste Management Act of 2000 (RA 9003) mandates that local government units (LGUs) segregate plastics waste at material recovery facilities (MRFs). The legislation also provides for developing a list of non-environmentally acceptable products (NEAPs) slated for prohibition according to a future timeline. However, the regulation stipulates that phasing out these products should only proceed if viable alternatives are available to consumers. In 2009, a technical working group established

guidelines for phasing out non-environmentally acceptable products (NEAPs), which included plastic carrier bags, polystyrene packaging, sachets, and baby products containing phthalates (NWSM 2013), revealing some concern for the harmful chemicals that can leach from plastics.

The Philippines Extended Producer Responsibility Act (Republic Act No. 11898) was adopted in 2022 to further reduce plastic waste. Large enterprises (with assets exceeding 1.7 million USD) were expected to account for 20% of their plastic waste footprint by the end of 2023, and to recover 80% of it by the end of 2028, facing fines of up to 340,000 USD for non-compliance (DENR 2023). These targets are more stringent than those in Indonesia, where companies are required to reduce their footprint by 30% by 2029.

Between 2012 and 2022, a larger number of municipalities and provinces in the Philippines than in Indonesia issued ordinances regulating single-use plastics (SUP). According to the World

Bank (2022), there are 489 such local-level bans in the country⁷. The bans target non-branded, single-use plastics, such as Styrofoam cups, food containers, plastic bags, and stirrers. The success of city-level bans on plastic pollution depends on the quality of their implementation, enforcement mechanisms and the extent to which administrators tolerate non-compliance. One of the rare studies of a city ban focused on the Baguio central market. The study revealed that compliance with the ban on using plastic bags depended on the line of business. Businesses selling dry goods “moderately comply, while those selling wet goods violate the ordinance because customers expect plastic ‘labo’ bags to keep their purchases from leaking (Killip and Dadulla 2023).

A city official working on single-use plastic bans in Puerto Princesa (which implemented such a ban in 2018) explained that the municipality’s jurisdiction does not extend to banning the plastic sachets manufactured by large corporations, owing to substantial economic interests. He asserted that national-level regulation is necessary to address the activities of these corporations. City officials distribute biodegradable bags to prevent single-use plastic bags in local markets. However, sellers in the local markets complain that the biodegradable bags tear easily. They, therefore, add a layer of thin plastic.

These local bans also depend upon local political support. Newly elected officials may demonstrate a lack of interest in the environmental policies of their predecessors. In November 2023, the Philippine Congress House Ecology Committee approved a nationwide ban on plastic straws, stirrers, and bags, to support the local actions. The committee chair noted that “these measures are aimed to provide an upstream solution to the problem of plastic waste (Business World 2023).” However, single-use sachets which emerged as major pollutants in the above-mentioned surveys are notably absent from the list. Perhaps the non-decision of the regulators is caused by their fear of opposition from the manufacturers who rely on sachets to sell their branded products to the bottom of the pyramid market (Pralhad and Hart 2002), or it is related to their assessment that there is no alternative for this form of packaging yet. Either way, ignoring the problems

caused by single-use sachets is another manifestation of regulatory leakage.

Regulatory leakage in both countries is multi-faceted, caused by fragmented regulatory actions which fail in both countries to prevent plastics from escaping into the environment, and leaching into human bodies. Although more local governments in the Philippines are attempting to reduce plastic use, their efforts appear to have limited impact.

Leaky infrastructures

The third research area in our multi-sited, collaborative ethnography comprises waste management infrastructures designed to contain plastic waste streams – infrastructures that anthropologists have studied extensively for their inherent leakiness (Eitel 2023; Reno 2016). Indonesian and Philippine policies support hybrid public-private-resident waste management systems requiring plastic pre-sorting, but these systems fail to capture all plastics, let alone the degraded byproducts. Similar to observations made by Eitel (2023, p 146) in Phnom Penh, Cambodia, our ethnographies show how plastic residues “ooze” out of these infrastructures.

In Indonesia’s decentralized waste management infrastructure, local governments encourage communities to establish waste banks and *Kelompok Swadaya Masyarakat* (KSM community-based groups) to handle waste collection, sorting, and recycling at TPS3R facilities (*Tempat Pengolahan Sampah* Reduce, Reuse, Recycle). TPS3R facilities receive government-funded machinery, but local authorities and communities often lack the manpower to operate them and the technical expertise to repair them when they break down (Rucevska et al. 2024).

In North Lombok, we observed many TPS3R facilities struggling to function due to low community participation and insufficient funding, especially when the sorting machines broke down. At one TPS3R we visited, only two male KSM members managed the facility, collecting and sorting waste from 180 households twice a week. Each household paid just Rp15,000 (~USD 1) per month, while the KSM members had to pay Rp600,000 (~USD 40) weekly for a truck to

transport non-recyclable plastic waste to the district landfill.

Although the workers sell recyclable materials like plastic bottles and cardboard to companies that recycle these materials, they were overwhelmed by the volume of waste, particularly as their plastic shredder was broken. To reduce the quantity of plastic waste sent to the landfill, they resorted to burning it, a form of structural leakage that is often unaccounted for. Burning the waste frees up space in the facility, but it causes unhealthy emissions, and contributes to climate change, see [Figure 5](#).

In contrast, in Purwokerto, Central Java, the waste management system works better. Committed to a zero waste policy, the local government supports KSM-managed decentralized recycling centres called PDU (*Pusat Daur Ulang*). It has invested in 15 such PDU. We visited PDU Sokanegara one morning. Manually sorted by female workers, waste from the surrounding communities arrived in carts and small trucks. The workers separated cardboard, PET bottles, plastic cups, and compost material to sell to go-betweens, see [Figure 6](#). The rest went into the conveyor machine, which divides the waste into two: bubur sampah (rubbish slurry), used to make fertilizers and feed maggots (sold as animal feed) and dry waste that serves as 'refuse-derived fuel' (RDF). Clothes, Styrofoam, pampers, and sanitary napkins unsuitable for RDF are sent to the TPA (*tempat pemrosesan akhir*) for processing by a pyrolysis machine. The PDU enforces a one-day rule for managing waste to

avoid piling up. The workers must sort and process all waste each day before 4 PM.

The KSM can pay its workers Rp1,000,000 (USD 66) monthly from the income it receives selling valuable waste. In addition, the workers can earn an average of Rp40,000 (USD 2.60) daily, selling organic waste to farmers.

Despite the claims of a zero-waste system, our visit to the TPA site on the outskirts of town revealed evidence to the contrary. One of the main ways to reduce waste here is by selling carefully sorted RDF for use in a nearby cement factory. However, the RDF piled up in the facility when the cement factory was under maintenance, reflecting



Figure 6. Sorting waste at the PDU sokanegara, banyumas regency. Source Irwan Hidayana, August 2024.



Figure 5. Plastic waste burned (left) and piles of plastic (right) at a TPS3R facility in North Lombok. Source Diana Pakasi, July 2024.

one of the “dirty little secrets” of waste management (Hird 2022, p37). Its success depends on the operations of facilities that can use the residues.

We further observed the pyrolysis process at the site, which involves heating low-grade plastics to create plastic paving stones and roof tiles. Here too we observed structural leakages. The process generates fumes that pose a health risk to workers, see Figure 7, but none were observed using personal protective equipment. In addition, a visible accumulation of recycled materials was observed at the facility. Because the paving tiles were impractical as they floated in heavy rain or floods, nobody wanted to buy them.

The Philippines’ recycling and sorting infrastructure is much less developed than in Indonesia. LGUs are responsible for managing waste flows through material recovery facilities, but these facilities have not been equipped with machines to help with the sorting. Although informal waste collection is rendered illegal in the country’s solid waste management law, informal waste pickers primarily collect recyclable materials. These individuals deliver the collected items to junk shops, which sell them to recycling companies in Manila. Statistics show that the infrastructure is leaky. Only half of high-value plastics such as PET bottles are recycled (World Bank 2021).

Philippine cities face the challenge of overflowing landfills, a problem compounded by urbanization

and population growth, which further restricts the availability of land. Some cities have adopted “no segregation, no collection” ordinances. Quezon City, for example, has enforced this rule by establishing different days dedicated to biodegradable and non-biodegradable wastes (Coracero et al. 2021). Our informants tell us that the ordinances are ineffective in practice, given that the government-sponsored garbage collectors pick up any waste they find on the streets. They have an incentive to do so as they can then sort and sell any valuable waste they see in their trucks. Officials in the mountain city of Baguio (where the landfill has been closed down and transformed into a city park) have resorted to transporting waste to the Tarlac Landfill (160km and three hours’ drive away).

Many Philippine households, especially those in rural and densely populated peri-urban areas with narrow roads, lack municipal garbage collection services. Without regular waste disposal infrastructure, local residents resort to dumping their garbage in open fields and waterways or burning it daily in their backyards mixed with leaves, despite a countrywide ban on this practice (Pathak et al. 2023).

In the domain of waste management, leakage is structural, linked to how waste infrastructures are organized. While cities like Purwokerto have made significant progress in organizing plastic sorting, our research indicates that achieving zero-pollution targets will be challenging when considering the emissions from RDF and pyrolysis, which contribute to climate change and adverse health outcomes among waste workers. Moreover, achieving zero-waste depends on the demand for plastic waste as a resource for energy production or recycled products (Colombijn 2020).

A Greenpeace USA report, published before the 2023 Paris Global Plastics Treaty negotiations, challenged industry claims that recycling and recovery infrastructures are solutions to the plastic waste crisis, see Figure 8. The report compiled research showing that recycling can increase plastic toxicity, endangering consumers and recycling sector workers (Greenpeace USA 2023). Heating plastics during recycling (as at Purwokerto TPA) can generate new toxicants capable of infiltrating recycled products.



Figure 7. Pyrolysis machine at banyumas TPA producing dense smoke. Source Irwan Hidayana, August 2024.



Figure 8. Greenpeace raises concerns about recycling's toxicities. *Source* Greenpeace USA (2023).



Figure 9. Plastic trash along railroad tracks, citayam, Indonesia. *Source* Putri Rahmadhani, December 2021.

As noted by Dr. Therese Karlsson, science advisor to the International Pollutants Elimination Network (IPEN): “Plastics are made with toxic chemicals, and these chemicals don’t simply go away when plastics are recycled....Simply put, plastic poisons the circular economy and our bodies, and pollutes air, water, and food...Real solutions to the plastics crisis will require global controls on chemicals in plastics and significant reductions in plastic production” (Greenpeace USA 2023).

Leaky community responses and remediation efforts

As plastic production continues to accelerate and existing waste management infrastructures prove inadequate in preventing plastic leakage, communities are experiencing growing piles of trash that are getting harder and harder to ignore, causing social distress which we analyze as a form of social leakage. Remote locations, railroad tracks, roads, and tracts of unclaimed land are inundated, inevitably becoming spaces where plastic garbage piles up and from which it flows.⁸

In Indonesia, in line with the government’s shared responsibility policy, private individuals collect waste door-to-door and bring it to landfills for a fee. But, to avoid trash collection fees, many households sort and burn their own waste. Plastics are often burned along with leaves and other refuse, see Figure 10.

Afterwards, it is not uncommon to find the resulting ash used as compost or for landscaping, unknowingly releasing toxic chemicals into the soil, water, and air (Pathak et al. 2023).

In North Lombok, garden and beach mapping with women activists revealed plastic waste discarded in gardens, along roadsides, and in the river flowing to the local fishing beach, which they referred to with disgust. Together with these activists, we examined how households manage different kinds of plastic waste more closely (Pakasi et al. 2024). Surveys of 20 households in Tanjung and Teniga, North Lombok, revealed differentiated waste management strategies: reuse of clothing; sale of recyclable plastics and paper; and river disposal of menstrual products, diapers, cans, and plastic bags, with backyard burning of Styrofoam, a highly toxic practice (Boffetta et al. 2009).



Figure 10. Open burning in private yard, Depok, Indonesia. Source Muhammad Fani, December 2021.



Figure 11. Plastic litter on Tanjung beach. Source Diana Pakasi, July 2024.

During a focus group discussion in Tanjung Village, participants pointed out that the items most thrown into the river include sanitary napkins and baby diapers. Our interlocutors tried setting up CCTV cameras to catch the polluters, but this failed. The waste dumped into the river eventually washes to the ocean, littering the beach (Figure 11).

In discussions with members of village community groups regarding the issue of diaper disposal – the most significant source of community waste as reported in the survey (see Table 1)– we inquired about the potential of promoting reusable diapers to reduce the amount of plastic

waste. Some respondents indicated they had already adopted reusable diapers but noted the inconvenience they experienced during the rainy season due to extended drying times and while travelling. These real-life conditions hamper social mobilizations to reduce plastic waste.

Fieldwork conducted in the Philippines by Taqueban and her team offered further insights into informants' ambivalent attitudes toward plastics. While acknowledging the utility of plastics, here too informants expressed growing concern regarding litter, particularly in coastal communities where trade winds contribute to the continuous accumulation of plastic debris on their shores, rendering clean-up efforts largely ineffective.

Talking to mothers of small children in Tarlac, the student researchers found that they value the affordability of plastic products used for childcare and typically keep durable items for future

children. They also noticed that household members save and reuse plastic containers and bags whenever possible. Another observation made across the country was that households often assist informal waste pickers by pre-sorting valuable materials (including plastic bottles and aluminum cans, see Figure 12) and placing them separately for collection, preventing the mess of pickers searching through household trash – acts of care which remind us that how communities dispose of waste also “reflects, shapes and recreates social relations” (Isenhour 2022, p 111).

These relations of care can be weakened when communities are drawn into buy-back schemes for plastic packaging—initiatives led by companies to meet Extended Producer Responsibility targets—which may contribute to social leakage.

Extended Responsibility initiatives tend to shift the onus of managing plastic waste onto the people at the end of the pipeline who live with the trash (Mah 2021). Such efforts result in social leakage because they create the impression that clean-ups, recycling, and repurposing can solve the plastics problem, reducing pressure on governments to regulate plastic production. As Liboiron (2021, p16) points out: “You can't ‘clean up’ plastics because they exist in geological time, and cleaning shuffles them in space as they endure in time. You can't recycle them out of the way because it means ever more will be produced, and there is no ‘away’ at any rate.” Meanwhile, activists view these initiatives skeptically, fearing they represent little more than greenwashing efforts. As such, they could diminish the political will necessary to pass stringent regulations to reduce plastic pollution, including

Table 1. Types of waste, quantities, and waste treatment in tanjung and teniga.

Type of waste		Total weight (kg)/month	Waste treatment
Plastics	Plastic bottles, cups, containers, etc.	3	Sold to waste banks or waste pickers
	Food packaging	2	Thrown into the river
	Plastic bags	2.5	Thrown into the river
Glass	Bottles	9.5	Reused or sold
	Other	3.7	Reused or sold
Metal	Aluminum cans	2	Thrown into the river
Fabric	Used clothes	10.6	Reused
Styrofoam	Food packaging	3.4	Burned in backyards
Organic	Leftover food, vegetables, fruit	40	Thrown into the river, fed to chickens
	Paper/cardboard	6	Reused, sold to waste bank or waste pickers
Other	Menstrual pads	14	Thrown into the river
	Baby diapers	130	Thrown into the river



Figure 12. Collecting bottles for informal waste pickers. Source: Efenita Taqueban, July 2024.

bans on sachets and measures to eliminate non-recyclable plastics, reinforcing regulatory leakages.

Across the Philippines community-based organizations and schools promote upcycling and creating arts and crafts from plastic waste as a means of income generation, viewed also as a pedagogical method for instilling environmental stewardship in students. Left with piles of plastic garbage in a country where burning it is illegal, people

turn garbage into plant containers, building materials, and sports equipment (see [Figures 13 and 14](#)). However, when we probe, participants in these initiatives acknowledge the limited market demand for products made from plastic waste, which undermines the efforts.

While community remediation seems beneficial, our analysis highlights potential negative health consequences. Our Filipino and Indonesian interlocutors are generally unaware that Styrofoam is



Figure 13. Plastics beautify backyards, balete, the Philippines, 2021. *Source:* King Biray, Marie Calizo, Carla Lumba, Katherine Navarrete, anthropology field school students under Efenita Taqueban's direction).



Figure 14. Reusing plastics as surfboards and fishing spoons, 2021. *Source:* Regina Buco, Patricia Maloles, Julia Ocampo, Pamela tagle, anthropology field school students under direction of Efenita Taqueban).

one of the most dangerous plastics in our environment. While state and local ordinances banning Styrofoam use in food packaging exist in both countries, they are rarely enforced. Take, for example, Filipino children's repurposing of Styrofoam floaters into surfboards (Figure 13). At first glance, this represents a seemingly beneficial use of plastic waste. However, Styrofoam may contain styrene, exposure to which has been linked to cancer and other health issues (Boffetta et al. 2009). Beyond the toxicity associated with its combustion, recent environmental health research indicates that the widespread use of Styrofoam in food packaging and as flotation devices in fisheries is a significant source of microplastic pollution in oceans due to its propensity for disintegration (Chan and Not 2023).

Another example entails the use of plastic containers for home gardening. In our Indonesian and Philippine field sites, community gardeners frequently repurpose plastic containers for cultivating edible plants, unaware of the potential for these containers to leach harmful chemicals and degrade into microplastics, particularly under prolonged exposure to direct sunlight (Li et al. 2024; Zimmermann et al. 2021). We are only starting to understand the extent to which environmental conditions such as heat and humidity fuel leakage of plastic additives into foods and water (Wei et al. 2024), the latter often distributed from rivers and springs through low-grade

plastic pipes. Community gardens are particularly prevalent in resource-constrained urban areas where arable land is scarce or industrial activities have contaminated the soil. The leaching and accumulation of plastic residues in food-growing soil raises concerns about the long-term cumulative effects on human health (Stratova, DiGiangi, and Genon 2018).

Connecting the dots

In their analysis of residues, Boudia et al. (2018, p167) urge scholars to "employ multivalent concepts to explore the multifaceted nature of chemical environments, both concrete and abstract," while drawing attention to the "inactions and nondecisions" that leave residues unaccounted for. In this article, we have responded to this call using "leakage" as a multi-scalar analytical tool. We have unraveled situated and intersecting epistemic, regulatory, structural and social leakages which challenge societies' efforts to contain potentially harmful plastic materials. Our investigation centered on the diverse and complex nature of plastic materials whose health and environmental effects are not fully understood, as well as the shortcomings of "leaky" regulations, failing infrastructures, and social mobilizations addressing plastic waste.

The open and inherent nature of these different kinds of leakages was visually represented in

a summary flowchart co-created with other scholars during a residency held at Aarhus University in March 2023⁹ (Figure 15). This image provides an alternative to the dominant representation of plastic flows (Figure 1). In it, leakage is not a relatively minor failure on the part of downstream infrastructures to contain plastic waste; it occurs across all the locations where plastics are produced, researched, regulated, used, contained and recycled. The image provides a ‘counter map’ to visualizations that adopt chain imaginaries, where plastics are recycled or stored neatly in landfills, forming a dead end in Figure 1.

As the flowchart illustrates, “leakages” are clearly interconnected. The conveyor belt imagery connects the dots, highlighting the mechanisms that perpetuate multifaceted leakages. The epistemic difficulty of assessing plastic chemical safety hinders effective regulation, a challenge further

compounded by plastic producers’ and manufacturers’ greenwashing initiatives intended to dampen the growing sense of urgency that virgin plastic production needs to be reduced. Greenwashing includes regulatory calls for engaging communities in clean-ups, through the adoption of Extended Producer Responsibility legislation, suggesting that practical steps have been implemented to control plastic litter. Manufacturer’s labor of confusion undermines regulatory action to prevent harms from chemicals leaching from plastics.

Regulatory leakage includes the lack of political will to ban the use of single-use plastics. Regulators in Indonesia and the Philippines engage in gaslighting (Grandia 2020) when they ban non-branded plastic bags, straws and stirrers, ignoring the massive use of thin plastic foil sachets to distribute and promote consumer

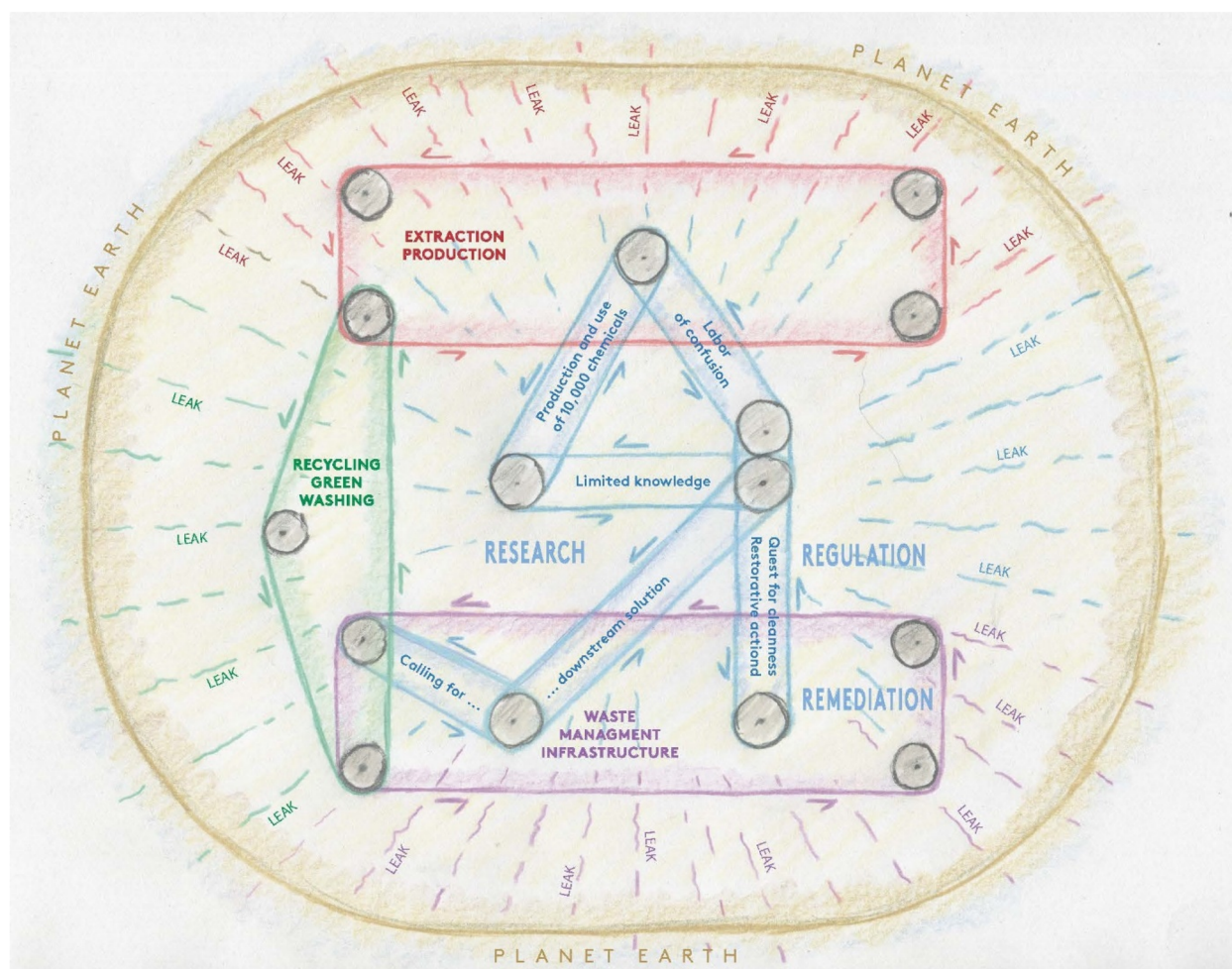


Figure 15. Summary flowchart developed during our residency, refined by philippe rekacewicz. Source Philippe Rekacewicz, October 2023.

goods to low-income populations in Indonesia and the Philippines. Their inaction prioritizes the economic interests of plastic producers and manufacturers over the health of populations and the planet.

The waste management infrastructures in Indonesia and the Philippines are based on a model of decentralization and shared responsibility. The call for shared responsibility fails to acknowledge the disproportionate burden placed on resource-poor communities in managing waste (see also Eitel 2021, Hird 2022), which we refer to as social leakage. Our fieldwork documents the frustration experienced by community members who struggle to manage the accumulating plastic waste in their environments. It also draws attention to care-based relationships between households and informal waste pickers, who compensate for the inadequacies of formal waste infrastructures (Isenhour 2022). These relations are challenged by emerging Extended Producer Responsibility efforts, which threaten to put informal waste pickers out of business, resulting in further social leakages. Initiatives by large manufacturers, such as Unilever and Nestle, to engage communities in recovering plastic packaging may actually weaken existing informal waste collection infrastructures, and while community remediation initiatives can offer short-term relief from visible plastic pollution at specific locations, some practices may worsen less visible toxicities related to the leaching of chemicals from plastic products into people's bodies and the environment. Our analysis calls for attention to such slow violence which, as Nixon argues, "occurs gradually and out of sight, a violence of delayed destruction dispersed across time and space" (Nixon 2011, p2).

Connecting the dots, it's clear that the sheer volume, ubiquity, and changing composition of plastics, coupled with the challenges faced by regulators and scientists, require a rethinking of current policies. These policies allow the continued production of virgin materials and the use of new, untested chemical composites. While an emerging body of environmental and activist research has made plastic leakage visible, our analysis suggests that an exclusive focus on material leakages narrows the scope of action.

The fifth Intergovernmental Negotiating Committee (INC-5) meeting addressed ambitious targets for reducing plastic production and regulating hazardous chemicals—objectives we support as essential for mitigating plastic material leakage. However, the failure to agree on the text for a global treaty and the consequent delay in setting and implementing crucial international regulations highlight the need to investigate interconnected epistemic, regulatory, structural and socio-material forms of leakage.

Managing the plastics crisis and containing plastic waste will require the adoption of strategies that address complex and evolving social relationships, and regulatory systems. But complex environmental problems are not easily fixed. We hope that our analysis of intersecting leakages can support environmental researchers' quests for chemical transparency, push manufacturers to disclose the chemical content of their plastic products and stop using single-use sachets to distribute and market their products, encourage regulators in Indonesia and the Philippines to adopt more stringent and comprehensive regulations, and help design waste management infrastructures and remediation efforts that build on people's situated expertise, and acts of care, while also recognizing that many people's livelihoods depend on the plastic waste management industry. Our analysis also suggests that in our attempts to fix the problem, we need to be aware of the blind spots and inactions that perpetuate leakage.

Notes

1. See Corvellec, Stowell and Johansson 2022; Hobson 2021, for critiques of the 'circular' paradigms that underly the efficiency promise of Figure 1.
2. Sachets have an airtight inner plastic layer to protect the product, a foil barrier against moisture and heat, and an outer flexible layer upon which manufacturers print text.
3. Also referred to as environmental ignorance (Uekötter and Lübken 2014) or agnotology (Proctor and Schiebinger 2008).
4. Also referred to as environmental ignorance (Uekötter and Lübken 2014) or agnotology (Proctor and Schiebinger 2008).
5. Similarly a 2024 study on the safety of food contact chemicals used to store, process, package, and serve foodstuffs found that for 10,789 of these chemicals,

no evidence of safety could be provided (Geueke et al. 2025).

6. Environmental epidemiologists Gross and Birnbaum (2017, 2) have called on environmental scientists “to account for the fact that individuals are exposed to multiple chemicals every day, from the point of conception to the end of life,” exposures which increase over time due to the continued use of “forever chemicals” such as PFAS (Renfrew and Pearson 2021).
7. Plastic diet (an advocacy group for plastic regulations in Indonesia) reports on their website (accessed June 19th 2025) that 39 cities have adopted regulations on single use plastics, see https://plasticdiet.id/dokumen-peraturan-pelarangan-plastik-sekali-pakai-di-indonesia/#pll_switcher.
8. Schlehe and Yulianto (2020) note in their study of waste management in urban and rural communities in the Special Region of Yogyakarta, a social orientation in which “the main responsibility is to keep one’s house clean; after that, due to effective social engineering, come shared responsibility for the kampung” (p16). Waste-lands such as those along the rail roads, are deleted to the local government.
9. This residency was hosted by Gauri Pathak, of the Global Studies Department at Aarhus University, with funds that she received from the Carlsberg Foundation Young Researcher Fellowship Program (CF-20-0151; Project, ‘Plastics and the Anthropocene).

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No potential conflict of interest was reported by the author(s).

Notes on Contributors

Anita Hardon is Department Chair of Knowledge Innovation and Technology at Wageningen University and Research and Professor of Anthropology of Care and Health at the University of Amsterdam’s Faculty of Social and Behavioural Sciences.

Diana Pakasi serves as an Assistant Professor in the Department of Sociology at Universitas Indonesia. She is also a researcher at the university’s Center for Gender and Sexuality Studies.

Irwan Martua Hidayana is an Associate Professor in the Department of Anthropology at Universitas Indonesia. He is also Chair of research cluster Global Health, Wellbeing and Care at the Department of Anthropology, Universitas Indonesia.

Efenita M. Taqueban is an Associate Professor in the Department of Anthropology at the University of the Philippines Diliman. She also serves as a legal advocate with the Legal Rights and Natural Resources Center, focusing on indigenous and rural community rights.

Eileen Moyer is Department Chair of Anthropology and Professor of Anthropology of Ecology, Health, and Climate Change at the University of Amsterdam. She is also affiliated with the Amsterdam Institute for Global Health and Development.

Josephine van Zeben is the Chair of Transnational Law at the Florence School of Transnational Governance, European University Institute. Previously, she served as Professor and Chair of the Law Group at Wageningen University.

Tridibesh Dey is a Research Associate in the Knowledge, Technology, and Innovation Group at Wageningen University & Research. He specializes in the anthropology of science and technology, particularly synthetic materials like plastics and is known for scientific contribution as part of the Scientists’ Coalition for an Effective Plastics Treaty (SCEPT).

Mark Nichter is a Regents Professor Emeritus at the University of Arizona’s School of Anthropology. He is renowned for his work in medical anthropology, global health, and ethnomedicine.

Michael Lim Tan is a Professor Emeritus at the University of the Philippines Diliman, where he previously served as Chancellor. A medical anthropologist and veterinarian, he is recognized for his contributions to public health and social science in the Philippines.

ORCID

Anita Hardon  <http://orcid.org/0000-0002-2761-5502>

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