



Plastic pollution and the open burning of plastic wastes

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ABSTRACT

The open burning of plastic wastes is a practice that is highly prevalent across the globe, toxic to human and environmental health, and a critical—but often overlooked—aspect of plastic pollution. Most of the countries where such burning is widespread have laws and policies in place against it; open burning continues nevertheless. In this article, using data from ethnographic fieldwork in urban and rural sites in India, Indonesia, the Philippines, and Zambia, we examine local practices of open burning and investigate why regulations to tackle it have proven largely ineffective. Adopting a harm reduction approach, we then suggest preliminary measures to mitigate the health risks of open burning by targeting those plastics and packaging types that are most toxic when burned.

1. Introduction

In 2019, an article in the *New York Times* led with the headline, “To Make this Tofu, Start by Burning Toxic Plastic” (Paddock 2019b). Based on data from an environmental report, it described the use of waste plastics as fuel for tofu businesses in Tropodo, Indonesia. The article quickly captured international attention. Plastic scrap is plentiful in Tropodo because it is shipped there, much of it from the USA, ostensibly for recycling. Small-scale tofu makers within Tropodo burn low-grade plastic waste as fuel to create the steam that turns soybean milk into tofu. They then donate the ashes to farmers to be used as fertilizer. Studies have documented alarming levels of toxicants, such as dioxins and polychlorinated biphenyls, in the soil and in the eggs of free-range chickens in the area (Petrlik et al., 2019).

A month after that article, a follow-up detailed how the Indonesian government was tacitly allowing the practice to continue: “Rather than enforce a ban on the burning of waste plastic, much of which came until

recently from the United States, the Ministry of Environment and Forestry appointed a panel of Indonesian experts to counter the report released last month by Indonesian and international environmental groups” (Paddock 2019a). As this article notes, Indonesia has existing laws against the open burning of plastic wastes. Why, then, were they still being thus burned? And why was the focus on the burning of plastic wastes in Indonesia rather than on the export of those wastes from the USA? Neither of these two aspects—the open burning of plastic wastes, predominantly in the Global South, and the shaming of populations there for what is, in fact, a global plastic waste crisis—is novel to this case.

The open burning of plastic wastes—which we define as the burning of waste plastics in open fires without managing for the emission of byproducts, such as gases and ash, into the ambient air or soilⁱ—is widespread across the globe. It occurs even in the Global Northⁱⁱ but is especially prevalent among low and middle-income countries (LMICs) in the Global South. Estimates of the scale of open burning among LMICs

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ⁱ Formal management—as in incinerators—need not mean effective management, and the line between controlled and uncontrolled open burning can be hazy; Tridibesh Dey elaborates on this in a forthcoming publication.

ⁱⁱ There have been reports of the practice in Estonia (Maasikmets et al., 2016), Hungary (Hoffer et al., 2020), and Poland (Ciešlik and Fabiańska 2021).

range from around 40 % to 65 % of total municipal solid waste (Christian et al., 2010; Velis and Cook 2021; Wiedinmyer, Yokelson, and Gullett 2014). Plastic waste is growing exponentially alongside plastic production, and plastics form a significant and ever-growing proportion of burned trash.

A significant source of air pollution, the open burning of mixed wastes produces a variety of adverse environmental and human health effects. Plastics are a particularly problematic waste stream when it comes to open burning; a study attributed 90 % of black carbon emitted from burning wastes to polyethylene terephthalate and polystyrene, two types of plastics (Reyna-Bensusan et al., 2019). The open burning of plastics is associated with an increased risk of heart disease, respiratory issues, neurological disorders, nausea, skin rashes, numbness or tingling in the fingers, headaches, memory loss, and confusion (Adetona et al., 2020; Azoulay et al., 2019; Irianti and Prasetyoputra 2018; Kováts et al., 2022; Velis and Cook 2021; Verma et al., 2016; Wiedinmyer, Yokelson, and Gullett 2014). Some toxic emissions, such as polycyclic aromatic hydrocarbons, have been linked to cancer and birth defects (Balcom, Cabrera, and Carey 2021). Ash from open burning contaminates the soil and enters groundwater and the food chain. Plastic packaging, which accounts for approximately 40 % of global plastics produced, frequently contains additives “such as fillers, plasticizers, flame retardants, colorants, stabilizers, lubricants, foaming agents, and antistatic agents” in addition to adhesives and coatings (Groh et al., 2019: 3255). Additives containing metals, including cadmium, chromium, lead, mercury, cobalt, tin, and zinc, are particularly dangerous (Groh et al., 2019: 3264).

When we think of plastic pollution—which has come to global prominence as an urgent environmental challenge—we rarely think of the open burning of plastics. The focus, within the media and public discourses, tends to be on marine plastics, plastic litter, and microplastics (e.g., Pathak and Nichter 2021a). The phenomenon has not elicited much detailed social and behavioral research either. Most countries where open burning is widespread have legislation in place against the practice—why, then, does it continue unabated? In this article, we investigate this discrepancy through ethnographic fieldwork in India, Indonesia, the Philippines, and Zambia. We selectively highlight examples of local patterns of open burning in these countries to make the case for the open burning of plastics as a critical—but largely overlooked—dimension of plastic pollution and a global health and development problem. Tracing the problem of plastic wastes back to unbridled plastic production, we go on to describe measures—beyond bans on open burning—to mitigate the most toxic aspects of this problem.

2. Methods and theoretical orientation

The cases featured here are drawn from long-term observations in diverse communities in India by the first and second authors. These were augmented by more targeted pilot fieldwork by members of our “Plastic Lives” consortium—a group of social science scholars investigating human–plastic entanglements throughout the plastic lifecycle. In India, ethnographic observation and unstructured interviews with those engaged in open burning were conducted in Arunachal Pradesh (Roing), Maharashtra (Dhule, Kolhapur, Mumbai, Pune, Talegaon), and Telangana (Hyderabad). This was supplemented with fieldnotes from long-term observations in Gujarat (Kutch), Maharashtra (Mumbai, Talegaon), Karnataka (Dakshin Kanara), and Uttar Pradesh (Lucknow) (Pathak and Nichter 2019; Pathak and Nichter 2021b). Building on insights from India, our consortium developed a guide for focused ethnographic research on community and household burning practices. This guide was applied (December 2021–July 2022) in purposively selected communities in Zambia, the Philippines, and Indonesia—countries that differ in terms of policies against open burning. As a result of varied and dynamic COVID-19-related restrictions, the fieldwork occurred in communities that the country researchers could access.

In Indonesia, a focused ethnographic study was conducted by social

science students from the Universitas Indonesia in three peri-urban communities located within a 50 km range from Jakarta: Bogor District (Citayam), Tangerang City (North Paninggilan), and Depok City (Cinangka, Sawangan). In each community, students conducted ten ethnographic interviews with those regularly engaged in burning, waste activists, local authorities, and private landfill operators. Those who regularly burn waste were asked to map out areas in their communities where waste was burned. The students validated their findings in six focus group discussions (two per site).

In the Philippines, the focused guide was applied by anthropology students at the University of the Philippines. These students conducted fieldwork in their home communities (they were attending classes remotely at the time) in nine towns within the provinces of Tarlac, La Union, Eastern Samar, Laguna, South Cotabato, Aklan, and Dinagat Islands and within two towns in the vicinity of Metro Manila. They too conducted ten ethnographic interviews in each site and validated their findings in two focus group discussions. Participants were also asked to mark spaces in their immediate vicinity where they disposed of waste as part of a mapping exercise.

In Zambia, the focused ethnographies were carried out in five communities in the vicinity of Lusaka by two social science researchers from the University of Zambia. They conducted six interviews in each community, which were augmented by mapping areas where waste was burned. Participants were drawn from rural (low density) and urban (low, medium, and high density) areas and included low-, medium-, and high-income earners. The ethnographers in each of the country studies selected respondents who have experience with managing plastic waste, including waste collectors and workers at local waste disposal sites. We are writing up our focused ethnographic method for studying open burning practices in an article for *Practicing Anthropology*, in which we outline our interview guide, describe how we combine cartography and ethnography, and outline the ethics safeguards (i.e., assurances of anonymity) needed when studying open burning practices in countries where such burning is prohibited.

As anthropologists working at the interface of medical and environmental anthropology and science and technology studies, we position ourselves within an emerging transdisciplinary field dedicated to the study of cumulative toxicities as a feature of the Anthropocene. Studies within this field examine how entanglements between chemicals and humans have shaped ways of being and living in the contemporary world (e.g., Abrahms-Kavunenko 2021; Alaimo 2010; Checker 2007; Geissler and Prince 2020; Hardon 2021; Lee 2020; Liboiron, Tironi, and Calvillo 2018; MacLeish and Wool 2018; Murphy 2008; Nading 2020; Perczel 2021; Roberts 2017). Anthropological work on waste has emphasized the importance of ethnography in providing nuanced narratives of toxic waste management and in highlighting the failure of interventions to respond in locally salient ways. Research in Kampala, Uganda, by Jacob Doherty, for example, illustrates how heterogeneous policies that play out on the national and municipal levels allow for the amplification of what he terms the “politics of cleanliness” embedded in both moral and materials worlds (Doherty 2022:4). His work suggests that state-centric solutions that are increasingly shaped by global sustainability policies may have limited impact on local waste management practices, including the burning of plastics and other toxic wastes. Even more compelling, Little’s (2021) ethnography of e-waste management in Ghana shows the ways that international policies and bilateral trade agreements often compound the problem of the accumulation of toxic waste in places where urban unemployment is experienced by national and municipal policymakers as a more pressing issue. The recovery of metals such as copper, silver, and gold from e-waste leads to a near-steady burn of toxic fires that are not only tolerated but held up as an example of job creation; our consortium’s work on South Africa has documented a similar theme (Musariri and Moyer 2022). Little draws upon Marder’s (2020) term “pyro-politics” to conceptualize this complex interweaving of environmental, social, and economic reasoning that leads to a policy and legal domain that is patchy at best.

Elsewhere, we have referred to heterogeneous plastics policies as “leaky by design” to highlight the ways that regulatory loopholes are exploited by producers, users, and those responsible for disposal to escape efforts to prevent ecological and human damage (Hardon et al., forthcoming). Green regulatory measures in one place (i.e., Europe or China), when combined with global circuits of production and trade, may result in “spillage” into other regions. Given these realities, we recommend a harm reduction approach for local interventions aimed at targeting those plastics and plastic packaging types that are most pernicious when burned.

3. Policies against open burning

The open burning of plastic wastes occurs even in countries with policies aimed at such open burning. We saw frequent and pervasive burning across our field sites despite laws in place against the practice. In India, the burning of plastic wastes in the open was banned in 2013 (National Green Tribunal 2013). In response to the lack of implementation of this ban, a 2016 judgment set up fines of Indian Rupees 5,000 (around USD 64) for “simple” burning and 25,000 (around USD 320) for bulk waste burning (The Hans India 2016). In Indonesia, in our field site in Tangerang, the burning of wastes containing plastics is prohibited under the city regulation number 3 of 2009, article 19; according to article 24, it carries a maximum imprisonment of three months or a maximum fine of Indonesian Rupiahs 50,000,000 (around USD 3,300) (Tangerang City 2009). The city regulation is in accordance with law number 18 of 2008 concerning waste management, article 29, which prohibits open burning that is not in accordance with the technical requirements for waste management in the country (Republic of Indonesia 2008). In the Philippines, the Clean Air Act of 1999 (Republic Act 8749) includes a ban on the incineration of waste, and the Ecological Solid Waste Management Act of 2001 (Republic Act 9003), sets the legal parameters for the country’s waste management, waste prevention, and recycling (Republic of the Philippines 1999, 2001). These laws are supplemented by ordinances by local government units. On the island of Panay, for example, we were told that the municipality penalizes waste burning with a fine of Philippine Pesos 2,000 (around USD 37) and one day of community service. In Zambia, the Statutory Instrument Number 65 of the Solid Waste Regulation and Management Act, 2018, identifies the intentional open burning of any wastes and the burying of non-organic wastes as punishable offenses (Government Republic of Zambia 2018).

Our research revealed four key, often overlapping, themes implicated in the lack of efficacy of these policies. The most pervasive of these were 1) gaps in waste management services, including the absence of waste collection, constraints posed by the costs or time required to access such collection, frictions between various arms of waste management services, and a lack of effective ways of dealing with waste after collection. Related to this was 2) a focus on the aesthetics of place. Such a focus often resulted in 3) policies or interventions aimed at tackling plastic pollution that highlight litter and end up encouraging open burning. Overall, these dimensions were influenced by 4) assessments made by locals regarding the harms related to various ways of handling wastes. We now examine each of these four aspects further.

4. Gaps in waste management services

A vast body of literature within waste management and environmental science has documented open burning as a common method for dealing with waste in locations with limited or inadequate waste collection services (e.g., Ajay et al., 2022; Ayelerua 2020; Chaudhary et al., 2021; Ferronato and Torretta 2019; Kováts et al., 2022; Naidja, Ali-Khodja, and Khardi 2018; Velis and Cook 2021; Wiedinmyer, Yokelson, and Gullett 2014). Many communities, whether urban, peri-urban, or rural, lack waste collection coverage. It is not uncommon for households and neighborhoods that are overburdened with wastes to be

left to fend for themselves. Meanwhile, with economic development, consumption-oriented economies, and exponential growth in plastic packaging (not least as a result of contemporary manufacturing and supply chain infrastructures; see also Hawkins 2013, 2018), there has been an explosion in volumes of trash, especially non-biodegradable trash that lingers over long durations. Approximately two billion people worldwide lack access to solid waste collection services, and they dispose of their trash through burying, burning, or dumping into waterways or open ground (Reyna-Bensusan, Wilson, and Smith 2018). Our fieldwork confirmed that open burning was most commonly used as a waste management technique when waste collection was absent, but it also provided other ethnographic insights into this issue.

We found that waste was burned even in areas with waste collection coverage because of the costs or wait times posed by these services. For example, in Indonesia, burning emerged as the most common way of getting rid of plastic wastes or reducing waste volumes in all three of our field sites, despite these sites being served by private waste collection. Open burning was seen as an option for those unwilling to pay the monthly collection fee of between Indonesian Rupiahs 25,000–50,000 (approx. USD 2–4). In some cases, people reported burning small plastics along with organic wastes in their yard and setting aside larger plastic wastes for trash pickup. Households burned their mixed wastes every two days, either in the mornings between 10 and 11 am, after household cleaning, or between 4 and 5 pm, upon returning from work. Waste burning was also carried out at a community level by mutual agreements between households within a neighborhood. In these cases, households would be informed of the burning so that they could ensure that clothes were not left on clotheslines to be exposed to smoke. In the monsoons, an accelerant, such as gasoline, was used to ignite damp wastes.

In Zambia, we heard of the burning of wastes not just as a result of garbage collection services being deemed unaffordable but also because collection was not frequent enough. As one community member noted:

We burn unwanted plastic waste here. Every day after sweeping the surroundings we pick up the waste and burn it. Some of the plastics are not strong enough for reuse, easily tear up, therefore we burn them. Burning is not a good practice, but here we have no choice but to burn the plastic waste because waste is only collected once a week and the plastics easily fill up the trash bags. So, in order to avoid that and to prevent plastic from being blown by the wind in all directions and messing up the surroundings, we burn them.

This frustration with long periods between garbage collection was echoed in the Philippines, where one resident put it succinctly: “the garbage man hardly ever comes by.”

The contrasting interests and agendas of those involved in waste collection, sorting, and disposal also encouraged open burning. In the city of Dhule, India, a doctor running his own hospital recounted how mixed waste was burned in the open as a result of a lack of coordination between different arms of the municipal services. Municipal sweepers would clear out trash (leaves and branches but also littered plastic bottles and packaging waste) from the city’s gutters and collect that trash into small piles. However, these piles were erratically collected by the *thekedaar*, or contracted sanitary official. (Our interlocutor attributed this to corruption within the municipal body in the awarding of contracts.) The trash would get dispersed by winds or rain in the meantime, and the sweepers (typically women of the Dalit, that is the most marginalized, castes)—would be blamed. To avoid this, the sweepers would set the piles ablaze every week or so. Often, the doctor explained, the gathered trash would not be collected (nor set alight) for more than 4–5 days. When the trash piles built up near his hospital and started smelling, he would ask a nurse to set a match to them. Ninety percent of the time, he said, the piles would catch fire without an accelerant; otherwise, they would use “rockel” (kerosene). In Tangerang, Indonesia, we similarly heard garbage collectors—who, as part of the informal economy, sell waste with scrap value—complain that local government officers charged them illegal fees to take the remaining

wastes to the dumping ground; they practiced open burning to escape or reduce these fees.

Such frictions were also implicated in large-scale fires at dumping grounds in India. Many countries in the Global South, such as India, rely on dumping grounds—rather than scientifically managed landfills—to house wastes; around 93% to 66% of the municipal solid waste in LMICs is deposited in dump sites (Sharma and Jain 2020). In 2016, a fire raged at Mumbai's Deonar dumping ground—the city's largest dumping ground—for a week (Earth Observatory 2016; Pinto 2016). Although that conflagration was novel in its scale and duration, it was not an isolated incident. Fires at dumping grounds are common, and Deonar regularly experiences them. Spontaneous fires can result from highly flammable landfill gases, which are the byproducts of the degradation of organic wastes, interacting with flammable plastic wastes in places with high ambient temperatures. However, several interlocutors in Mumbai, especially those working in the environmental or social justice spaces, suggested that fires at the Deonar dumping ground are often set intentionally, as tactics in turf wars between gangs involved in the scrap trade or to allow valuable metal scrap to surface from garbage heaps. These suggestions were echoed in the media coverage of such fires (e.g., Sinha 2018).

Fires at dumping grounds can also be set intentionally to reduce waste volumes. In Zambia, we heard of constant burning at the Chunga dumpsite outside the city of Lusaka. "The fire at the landfill [dumpsite] has been burning for years, and it is rekindled every time the wind blows... That fire never burns out even during the rainy season," an interlocutor complained. Similarly, in Indonesia, we were told that the owners of three private dumping grounds burned wastes daily. Burning took place in the afternoons and evenings, after wastes had dried in the sun. Such burning helped prevent garbage piles toppling over, hardened the soil on uneven land, and reduced the amount of waste in the dumping grounds. In the Philippines, prior to the passage of the Clean Air Act, dumping grounds all over the country were constantly burning. Low awareness regarding the prohibition against burning meant that interlocutors expressed sentiments such as, "If I don't burn my trash, they will just put it in the dumping ground," implying that it would be burned anyway. This was not unique to the Philippines; we heard several community members say that wastes would be burned at dumpsites anyway. In the absence of alternatives to burning in order to deal with ever-increasing volumes of waste at dumping grounds, interlocutors saw small-scale burning as a more convenient, cheaper option. As we elaborate later, they also saw it as safer than the large-scale burning that occurred at dumping grounds.

5. Focus on aesthetics of place

The lack of affordable, frequent, and effective waste collection and disposal was complemented by an emphasis on aesthetics and cleanliness in encouraging the burning of mixed wastes. In our sites in Indonesia, open burning was associated with mosque or community cleaning activities, usually conducted on Fridays. Friday, as a holy day, was considered auspicious for cleaning. Community members would take turns to clean their streets, waterways, and public facilities, with the wastes burned thereafter. These findings are in line with a study by Phelan et al. (2020) in a coastal community in Indonesia, which noted that village-level clean ups resulted in increased plastic burning. Anthropologist Lukas Forte (personal communication, 2021) also observed open burning on the island of Sumbawa as a part of clean-up events.

Similarly, in Dakshin Kanara, India, wastes, mostly plastic packaging, were dumped by travelers along roadsides or rail tracks. When these wastes accumulated to the point of becoming an eyesore, they were periodically gathered up and set on fire by various community groups. Such activities occurred as part of routine clean-up activities.

Clean-up activities that focused on public spaces and culminated in burning were especially pronounced in tourist destinations. Tourism is vital to the economy of many LMICs, and litter undermines the tourist

industry's efforts to market destinations (Williams et al., 2016). Plastic litter generated by both high consumption tourism and g/local marine flows (in the case of beaches) is a constant challenge (Hayati et al., 2020). In the popular tourist destinations that we observed in South and Southeast Asia, piles of mostly plastic litter in tourist spaces were typically raked up and burned early each morning by restaurant/hotel managers and local vendors to maintain a pristine "front stage" image. Meanwhile, spaces frequented more by locals than tourists were left littered (see also Kerber and Kramm 2021 for similar observations in Vietnam).

6. Policies targeting plastic pollution

Policies and interventions that are ostensibly aimed at tackling plastic pollution were also revealed to inadvertently encourage open burning. For example, the state of Maharashtra, India, put in place a single-use plastic ban in 2018. Our ethnographic study in a residential complex located on the outskirts of a town in the state found that the local governing body, the *gram panchayat*, refused to collect Styrofoam. Styrofoam is a type of polystyrene, known locally as thermocol. Thermocol had been included under the single-use plastic ban in Maharashtra. However, it was still entering the complex as it was being used for packing, especially for goods bought online or shipped in from outside the state. With no way of disposing of the polystyrene, residents were forced to burn it at the peripheries of the complex. The ban, aimed at the reduction of plastic pollution, led to another form of pollution—the open burning of polystyrene, which produces the toxic styrene gas.

Global, governmental, and media messages highlight plastic litter as a problem, and this has meant that other dimensions of plastic pollution get elided. Most policies and interventions aimed at plastic pollution focus on the aesthetic dimension, that is, on plastic litter (Pathak 2023). Sensitization to plastic litter also ends up, in many cases, favoring burning (Aarti Latkar and Gauri Pathak elaborate upon this in a forthcoming publication). In India, campaigns such as the Clean India Mission—a national program aimed at waste management and the cleaning of India's public spaces—have sensitized the public to litter and visible waste. Under the Mission, local governance bodies are incentivized to reduce the volumes of waste going to dumping grounds (by increasing recycling and composting); we heard that municipal officials and employees were therefore engaging in open burning. In Arunachal Pradesh, India, we similarly observed a guide for a trekking group gather the plastics he encountered on a trail and set them alight. When asked, he said he had been inspired by the Clean India Mission.

In Citayam, Indonesia, we found that the local government had put up signs warning residents not to throw plastic trash into the Ciliwung river. Though households were plied by garbage collectors provided by the local government, the dumping ground that received wastes was over capacity. Moreover, garbage collectors would not handle litter dumped by passersby on roadsides. As a result, the community built small-scale kilns (*tungku sampah*) to burn household and community waste; one kiln was located near the river. Here again, an intervention aimed at keeping the river free of plastic wastes led to the burning of those wastes instead; the river was still being polluted but just in a different way.

7. Assessments of risks and harms

In the earlier paragraphs, we laid out the constraints faced by communities and individuals in disposing of their plastic wastes. Against this highly constrained waste management landscape, residents individually and collectively make assessments regarding the harms posed by the alternatives available to them. In some cases, these assessments are based on a lack of awareness regarding the dangers posed by the emissions and ash resulting from the burning of plastics. Thus, although the smoke and smell from burning were seen by our interlocutors as bothersome, the practice was not viewed as especially toxic. In the

Philippines, *siga* is the practice of morning and/or afternoon yard cleaning within the country; swept up leaves and litter are burned. Burning is thought to not only be an effective way of dealing with yard waste but also to serve as natural fumigation—the smoke keeps mosquitos and other pests away. The smoke is also likened to carbon, which plants are thought to need. Accustomed to burning yard waste, residents, particularly of rural areas, saw no harm in adding household wastes, including plastics, to the mix. In Indonesia, we heard from community members that the ashes from burning wastes—even plastic wastes—were thought to make plants grow better and used as fertilizer.

In India, the burning of agricultural stubble is common, and interlocutors recounted similar practices in rural fields to deal with littered plastics. Discarded plastic bags are used to ward off birds, and plastic wastes are often carried into fields by winds or rain and accumulate there. After the harvest, farmers set fire to the stubble, and littered plastics get burned as well. Cultural notions of fire as purificatory mean that such burning is seen as relatively harmless. In Hinduism, fire is “an agency of destruction leading to possible rebirth” (Rosin 2000: 395). Thus, not only fire but also the ashes it leaves behind are considered both purified and purifying (Rosin 2000: 362). Fire is thought to remove elements from the cosmological food chain, preventing undigestible elements from entering ecologies. It therefore forms a seemingly ideal method of dealing with troublesome non-biodegradable wastes such as plastics. These attitudes to fire have also hampered a full appreciation among the public for the dangers of the inhalation of smoke from agricultural burning and indoor mud stoves.

We also encountered the use of small plastics as fire starters for household wood-fired *chul* (mud stoves) in Maharashtra. “*Patdishī pet dhartaya plastic mula* [It catches fire instantly because of the plastic],” an interlocutor in Kolhapur explained. The women who described such use were typically from lower-income groups; although they had gas connections that they used for everyday cooking, other chores, such as heating bathwater, relied on cheaper firewood. In the cities of Mumbai and Lucknow, we also observed workers on the night shift in the winters, especially night watchmen, light small bonfires by gathering dried leaves, twigs, and trash together. These bonfires included small plastic packaging wastes, which were not segregated out. In Ngwerere, Zambia, a school teacher described using plastic packets from small snacks (*jiggies*) as fire starters: “We collect them and use them to light cooking fires because they are quite flammable. The fire lights up quicker that way.” In Helen Kaunda, Zambia, they were used to light braziers in the community. Given the small quantities of plastics being burned, such burning was not deemed dangerous.

Across our field sites, even when the burning of mixed wastes was recognized as harmful, harms were evaluated through the sensorial. That is, the color of the smoke and the smell were seen as indicators of harm. Thus, when trash was burned in a pit at the very center of a housing complex in India, residents complained that they could see and smell the thick, acrid smoke within their homes. Trash burning was therefore moved to the peripheries of the complex, even though it was close to a river. In the Philippines, we were told that when the smoke produced by burning was dark and the burning pile emitted a strong odor, people kept away from it, whereas white smoke with a “natural” odor was considered safe.

Even sensory indices were seen to suggest more of a short-term bother than a long-term hazard. None of our interlocutors evidenced concern about the fact that the particulates and toxicants released by burning plastics can linger in the air for long periods, even after the smoke and smell have dissipated. This can be compared to perceptions of harm related to second-hand cigarette smoke—the smoke lingers in the air for several hours but is not considered dangerous when it can no longer be smelled (Padmawati et al., 2018). Moreover, frequent and long-term exposure to smells can lead to olfactory adaptations, rendering certain smells less perceptible. In Indonesia, interlocutors who burned their waste stated that none of their family members had experienced respiratory problems; some coughing was deemed a brief,

“natural consequence” of smoke exposure. Community kilns were thought to be safe as they directed smoke upwards, away from people. Similarly, in Zambia, open burning was generally carried out when neighbors were asleep to avoid people’s exposure to smoke:

There is no harm in burning the plastics because we do it at night and early in the morning while people are still sleeping...We wait for people to sleep before we burn the plastic and leaves.

Given the use of the sensorial to assess harm, the volume of plastics getting burned was key to perceptions of and action against harm. Across field sites, people expressed concern about open burning at large dumping grounds. A Zambian interlocutor stated about fires at the dumping ground, “The problem is that the plastics that are burned produce fumes which might be responsible for some health problems some people have in this area...I know of a friend who has been complaining of chest pains for over two years now and he lives opposite the landfill.” In Indonesia, interlocutors differentiated between smaller scale waste burning, which they saw as acceptable, and burning at dumping grounds, which they opposed. Fires at dumping grounds were considered harmful because they produced a haze and brought “strange” and “strong” chemical odors. Similarly, in India, whereas the small-scale burning of plastics was tolerated, the fires at the Deonar dumping ground, which involved many more plastics, thicker smoke, and a longer duration, elicited complaints from city residents. Such an assessment of harm encouraged small-scale burning as it was seen as less problematic than (often inevitable) burning at dumping grounds which are over capacity. Nonetheless, studies suggest that small-scale burning is more harmful than large-scale burning because people are exposed more closely and more frequently to the emissions (Ajay et al., 2022).

Against this backdrop, interlocutors spoke of the perceived harms of letting wastes fester, which was the outcome of not burning those wastes. In Telangana, India, an interlocutor setting aflame a heap of mixed waste at a temporary dumpsite explained that he did so to eliminate the stench and to prevent seepage of leachate into the groundwater and his neighboring field. He also believed burning would prevent the spread of germs and infections from the garbage. In Zambia, concerns about menstrual blood being used in witchcraft led to used menstrual pads being burned in secret. The piling of ripe diapers between waste collection was meanwhile thought to be unhygienic and used diapers were therefore burned.

Concerns regarding hygiene and contagion are particularly salient when it comes to the disposal of medical waste: incineration is thought to be best practice by many healthcare professionals because of a belief that this effectively kills pathogens (e.g., Gupta et al., 2009; Mbongwe, Mmerekhi, and Magashula 2008). In Dhule, India, however, our medical interlocutor expressed reservations regarding the fate of the medical waste that was collected, purportedly for incineration, from his facilities. Medical waste collected for incineration in Dhule had been found, he told us, to be openly burned—and the collection fees illegally pocketed—a few years prior.

However, it was not just the health risks that troubled interlocutors—aesthetics was a major focus, in all four countries. As an interlocutor in Ngwerere, Zambia, explained, “When I seriously come to think of it, burning plastics causes air pollution. However, we are often faced with a situation where we have to choose between unsightly surroundings or burning the plastic waste.” In fact, as described, we found that sensitization to plastic litter and waste—as a result of global and local campaigns and policies raising awareness about plastic pollution and the cleanliness of public spaces—led to community members conducting clean-up drives and burning wastes. Visible litter was not just a threat to tourism but also left the sense of a place not being tended to which distressed community members. Without alternative ways to manage wastes, open burning was considered a more benign option.

Finally, it is worth highlighting two aspects related to the enforcement of regulations against open burning. For one, public awareness of

policies against open burning was relatively low across all our field sites. People were not always aware of specific restrictions, even if they had vaguely heard about them. Secondly, there were pragmatic and social relational reasons that policies were not stringently enforced. In Indonesia, for example, some residents who did not burn their trash were concerned about the smoke or worried that it would worsen family members' respiratory disorders. However, they were reluctant to complain for reasons related to social risk. They wished to avoid conflict that might disrupt social relations. Social relations were also implicated in community members' reluctance to complain about open burning at dump sites; people did not want conflict with the kin of those managing the sites. Furthermore, in contexts in which open burning occurs because of a lack of feasible alternatives for waste management—or because of a lack of money to pay for waste collection services—enforcing policies, especially among low-income community members, is not viable. It would likely result in community outrage and political ramifications. Concerns about social relations and the micro-politics of community life in villages and towns make enforcing policies against open burning problematic. Thus, residents in Panay, the Philippines, told us that the rules related to open burning were “negotiable” and added that “*walang pangil ang batas* (the law has no teeth).” Enforcement consisted of, at best, token gestures.

8. Toward harm reduction

In the face of these local constraints and concerns—and their rendering of policies against open burning largely unenforceable—what can be done to reduce the harms of the burning of plastic wastes? First, two notes of caution. For one, we must recognize that the open burning of wastes is an act of care. It is undertaken to reduce unsightliness and risks of contagion and infection. Practices of open burning mark off spaces as *places*—as the sites of community attention, concern, and effort. In fact, throughout our fieldwork, we found that spaces where wastes were left to accumulate were a “no-man’s land”—zones of abandonment and apathy. Any measures to tackle the harms of open burning must recognize the labor and local capacities required by the practice, and interventions must leverage—rather than devalue—these capacities.

Second, we must recognize that the problem of open burning is not a problem of unhygienic or ignorant citizens in the Global South. Open burning is not unique to the Global South. Even the plastic wastes that are burned in these regions are implicated in global flows of plastics, for example, through plastics carried by ocean currents and deposited onto distant seashores or plastic wastes dumped in LMICs under the guise of recycling. The open burning of plastics is symptomatic of communities overburdened with the wastes of a global “cannibal” capitalist economy (Fraser 2022) that revolves around ever-increasing consumption regardless of its ecological costs. Burdening these communities further, by raising awareness regarding the harms of burning without providing locally viable alternatives for waste disposal, will not only prove fruitless but is also grossly unfair. Many anti-litter campaigns, for example, emphasize the removal of litter as normative behavior but fall short of providing effective, convenient means for disposing of this litter. Indeed, as we have shown, such campaigns end up encouraging open burning.

Ultimately, then, addressing the harms of the open burning of plastic wastes will require interventions at the level of not just disposal—the creation of affordable, reliable, and effective trash collection and end-stage processing alternatives that build upon local capacities—but also at the level of production, through a reduction in the manufacturing and consumption of plastics, a turn toward greater reuse, the use of less toxic plastic additives, and the phasing out of forms of packaging (e.g., multi-layer packaging and multi-polymer packaging) and plastics (e.g., polycarbonate) that cannot be easily recycled. This may sound utopian and unpragmatic. It will undoubtedly take several decades to make such a shift. As we work toward these larger goals, what steps can we take in the meantime for harm reduction? One place to begin is to focus on those

plastics that are most toxic when burned.

When burned, some plastics are less harmful than other types that yield emissions and residues linked to severe environmental and human health problems; see Table 1 (Alabi et al., 2019; Lebek et al., 2005; McKenna and Hull 2016; Morikawa and Yanai 1989; Sovová et al., 2008; U.S. Environmental Protection Agency 2011; Valavanidis et al., 2008; Velis and Cook 2021; Verma et al., 2016; Wakefield 2010; Wheatley et al., 1993). The burning of Styrofoam (polystyrene) or polyvinyl chloride (PVC), is, for example, extremely dangerous—such plastics release especially toxic styrene gas, dioxins, or chlorinated furans when ignited. Interactions between these plastics and other wastes can also lead to toxic emissions mixes.

Recognizing the reality that these plastics and packaging types will likely end up being burned, we recommend 1) reductions in the use of these plastics and packaging types wherever possible, incentivized through higher taxation and caps on production, 2) local campaigns raising awareness about the toxicity of the ash left behind by open burning to prevent use of this ash as fertilizer, and 3) extended producer responsibility (EPR) schemes that task manufacturers with collecting and safely—and under regular monitoring—recycling or disposing of the post-consumer wastes that result.

Policies related to EPR were introduced in India in 2016, but they have been criticized for being vague and unclear on several counts,

Table 1
Examples of toxicants released upon the open burning of various plastics.

Type of Plastic	Common Forms	Toxicants Released Upon Burning	Health Effects
Polyethylene Terephthalate (PET or PETE)	Drink bottles, cosmetic packaging, water bottles	Methane, ethane, ethyne, formaldehyde, carbon dioxide, carbon monoxide, polycyclic aromatic hydrocarbons	Mild to moderate respiratory irritation, carcinogenic and mutagenic effects
High-Density Polyethylene (HDPE)	Shampoo bottles, grocery bags, flower pots, cereal box liners	Olefins, paraffin, aldehydes, and light hydrocarbons, carbon monoxide, polycyclic aromatic hydrocarbons	Mild to moderate respiratory irritation, carcinogenic and mutagenic effects
Polyvinyl Chloride (PVC or Vinyl)	Drainpipes, blister packs, toys, bottles, and jugs	Carbon monoxide, dioxins, chlorinated furans, hydrogen chloride, polycyclic aromatic hydrocarbons	Cancer, birth defects, respiratory tract disorders, etc.
Low-Density Polyethylene (LDPE)	Assorted beverage and food, frozen food, frozen juice, and milk packaging	Olefins, paraffin, aldehydes, and light hydrocarbons, carbon monoxide, polycyclic aromatic hydrocarbons	Mild to moderate respiratory irritation, carcinogenic and mutagenic effects
Polypropylene (PP)	Medicine, yogurt, condiments, other food and beverage packaging	Naphthalene, methylnaphthalene, biphenyl, fluorene, phenanthrene, methylphenanthrene, anthracene, pyrene, and benzo[a] fluorene, polycyclic aromatic hydrocarbons	Mild to moderate respiratory irritation, carcinogenic and mutagenic effects
Polystyrene (PS or Styrofoam)	Foam cups, meat trays, egg cartons, plastic forks and spoons, packaging filler	Styrene gas, acrolein, hydrogen cyanide, polycyclic aromatic hydrocarbons	Cancer, neurotoxicity, eye and mucous membrane damage, narcosis, and death in high doses
Polyurethane (PU)	Curtains, wood finishes, sealants, adhesives	Carbon monoxide, hydrogen cyanide, phosgene	Death in high doses

including who is to be held financially liable (the plastic resin manufacturer, the packaging maker, or the brand owner) and to whom they would be answerable (local or national pollution control boards). The role of the informal economy and waste pickers within such schemes was also not entirely clear (Pani and Pathak 2021). Since then, EPR policy has undergone several refinements, and the latest set of amendments has set down targets and timelines for the collection of volumes of types of plastic wastes and the reuse of recycled materials. Nevertheless, implementation remains problematic, and third-party monitoring mechanisms have not been set in place (Shah 2022). We suggest that to be truly successful, EPR schemes will need to go beyond these measures and take advantage of local capacities by providing incentives, not just to waste pickers but also to community members, for the segregation and return of plastic wastes.

In India, we encountered an environmental initiative termed *Safai Bank* (<https://safaiabank.org>) that can serve as an example. As part of this initiative, students were asked to collect their multi-layer packaging wastes for use as fuel stock (co-processing) in cement kilns. Burning in cement kilns can be problematic in India as a result of the inadequate regulation of emissions, but what we wish to foreground here is the leveraging of students for waste management. Student volunteers were provided with certificates and other rewards for their efforts. EPR initiatives based on local capacities, such as this one, would require an easily identifiable label on these types of packaging and plastics combined with campaigns to create awareness about these labels and about the EPR schemes.

9. Conclusion

In this article, we have focused on community and household practices related to the open burning of plastics despite existing laws and policies meant to discourage those practices. At a time when global and regional actors are increasingly committed to developing greater accountability through a global plastics treaty, ethnographic research can provide insights into the limits of policy-based interventions. This is especially the case in contexts where waste management is largely carried out through informal networks that routinely escape governance attempts and in a world where wastes, plastic and otherwise, are increasingly exported from wealthy countries to be disposed of, recycled, or processed in LMICs.

Given the increased attention in policymaking to limiting plastic pollution, as anthropologists of science and technology, we draw attention to the ways that legal categorizing, in this case, distinguishing between plastics in and out of place or waste that is properly or mismanaged, may help to conceal the larger problems of exponential increases in plastic production and distribution, global flows of plastic waste into marginalized communities, and the limits of plastics' recyclability. The implementation and oversight of policies and laws requires the resources, capacity, infrastructure, and political will to do so. In practice, our research has shown that governments may find it difficult to implement policies banning single-use plastics or the open burning of (plastic) waste for a variety of reasons. They may also encounter widespread resistance when they try to enforce said policies, from interests ranging from multinational companies to waste pickers.

We have suggested that while big shifts toward plastic control are debated, put into practice, and assessed, some initial steps may be taken in the name of harm reduction. These steps revolve around recognizing the realities of open burning and focusing on those plastics and packaging types that are the most dangerous to burn. Our embracing of a harm reduction strategy, as a first step in tackling open burning, is pragmatic. We hope it will curb the most toxic aspects of the problem and lead to public demand for and support of better plastic control policies that make sense in place. Our reason for this strategy can perhaps best be summed up in one Zambian interlocutor's statement, which was echoed across field sites: "We burn a lot of plastics because we are not sure which ones are harmful." Such statements reference a

desire to know more and a willingness to mitigate harms.

CRediT authorship contribution statement

Gauri Pathak: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing - original draft, Writing - review & editing. **Mark Nichter:** Conceptualization, Formal analysis, Investigation, Methodology, Writing - original draft. **Anita Hardon:** Conceptualization, Formal analysis, Funding acquisition, Methodology, Writing - review & editing. **Eileen Moyer:** Conceptualization, Formal analysis, Funding acquisition, Methodology, Writing - review & editing. **Aarti Latkar:** Investigation, Writing - original draft, Writing - review & editing. **Joseph Simbaya:** Investigation, Writing - original draft. **Diana Pakasi:** Investigation, Writing - original draft. **Efenita Taqueban:** Investigation, Writing - original draft. **Jessica Love:** Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data used is based on fieldnotes and ethnographic data; further details will be published in individual country reports.

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References

- Abrahms-Kavunenko, S., 2021. Toward an anthropology of plastics. *J. Mater. Cult.* (published online ahead of print, 17 December). <https://doi.org/10.1177/13591835211066808>.
- Adetona, O., et al., 2020. An exploratory evaluation of the potential pulmonary, neurological and other health effects of chronic exposure to emissions from municipal solid waste fires at a large dumpsite in Olusosun, Lagos, Nigeria. *Environ. Sci. Pollut. Res.* 27 (24), 30885–30892. <https://doi.org/10.1007/s11356-020-09701-4>.

- Ajay, S.V., et al., 2022. Assessment of dioxin-like POP's emissions and human exposure risk from open burning of municipal solid wastes in streets and dumpyard fire breakouts. *Exposure Health* 14 (3), 763–778. <https://doi.org/10.1007/s12403-021-00450-4>.
- Alabi, O.A., et al., 2019. Public and environmental health effects of plastic wastes disposal: a review. *J. Toxicol. Risk Assess.* 5 (021), 1–13. <https://doi.org/10.23937/2572-4061.1510021>.
- Alaimo, S., 2010. *Bodily natures: science, environment, and the material self*. Indiana University Press, Bloomington.
- Ayleru, O.O., et al., 2020. Challenges of plastic waste generation and management in sub-Saharan Africa: a review. *Waste Manage.* 110, 24–42. <https://doi.org/10.1016/j.wasman.2020.04.017>.
- Azulay, D., et al., 2019. Plastic & health: the hidden costs of a plastic planet, Center for International Environmental Law, Geneva. Available at: <https://www.ciel.org/reports/plastic-health-the-hidden-costs-of-a-plastic-planet-february-2019/>, (accessed 12 December 2022).
- Balcom, P., Cabrera, J.M., Carey, V.P., 2021. Extended exergy sustainability analysis comparing environmental impacts of disposal methods for waste plastic roof tiles in Uganda. *Dev. Eng.* 6, 100068. <https://doi.org/10.1016/j.deveng.2021.100068>.
- Chaudhary, P., et al., 2021. Underreporting and open burning – the two largest challenges for sustainable waste management in India. *Resour. Conserv. Recycl.* 175, 105865. <https://doi.org/10.1016/j.resconrec.2021.105865>.
- Checker, M., 2007. "But I know it's true": environmental risk assessment, justice, and anthropology. *Hum. Org.* 66 (2), 112–124. <https://doi.org/10.17730/humo.66.2.1582262175731728>.
- Christian, T.J., et al., 2010. Trace gas and particle emissions from domestic and industrial biofuel use and garbage burning in central Mexico. *Atmos. Chem. Phys.* 10 (2), 565–584. <https://doi.org/10.5194/acp-10-565-2010>.
- Cieslik, E., Pabianka, M.J., 2021. Preservation of geochemical markers during co-combustion of hard coal and various domestic waste materials. *Sci. Total Environ.* 768, 144638. <https://doi.org/10.1016/j.scitotenv.2020.144638>.
- Doherty, J., 2022. *Waste worlds: inhabiting Kampala's infrastructures of disposability*. University of California Press, Berkeley.
- Earth Observatory, 2016. *Fire burns in Mumbai landfill*. NASA Earth Observatory.
- Ferronato, N., Torretta, V., 2019. Waste mismanagement in developing countries: a review of global issues. *Int. J. Environ. Res. Public Health* 16 (6), 1060. <https://doi.org/10.3390/ijerph16061060>.
- Fraser, N., 2022. *Cannibal capitalism: how our system is devouring democracy, care, and the planet and what we can do about it*. Verso Books, London.
- Geissler, P.W., Prince, R.J., 2020. "Toxic worldings": introduction to toxic flows. *Anthropol. Today* 36 (6), 3–4. <https://doi.org/10.1111/1467-8322.12615>.
- Government Republic of Zambia, 2018. *Solid Waste Regulation and Management Act, 2018: Act No. 20 of 2018*. Available at: [moz-extension://ff229ead-058e-6b49-94dd-4a91d929eecb/enhanced-reader.html?openApp&pdf=https%3A%2F%2Fwww.parliament.gov.zm%2Fsites%2Fdefault%2Ffiles%2Fdocuments%2Ffacts%2Fthe%2520Solid%2520Waste%2520Regulation%2520and%2520Management%2520Act%2520C%25202018.pdf](https://www.parliament.gov.zm%2Fsites%2Fdefault%2Ffiles%2Fdocuments%2Ffacts%2Fthe%2520Solid%2520Waste%2520Regulation%2520and%2520Management%2520Act%2520C%25202018.pdf), (accessed 12 December 2022).
- Groh, K.J., et al., 2019. Overview of known plastic packaging-associated chemicals and their hazards. *Sci. Total Environ.* 651 (Pt 2), 3253–3268. <https://doi.org/10.1016/j.scitotenv.2018.10.015>.
- Gupta, S., et al., 2009. Rules and management of biomedical waste at Vivekananda Polyclinic: a case study. *Waste Manage.* 29 (2), 812–819. <https://doi.org/10.1016/j.wasman.2008.06.009>.
- Hardon, A., 2021. *Chemical youth: navigating uncertainty in search of the good life*. Palgrave Macmillan Cham (Critical Studies in Risk and Uncertainty) <https://doi.org/10.1007/978-3-030-57081-1>.
- Hardon, A., et al., forthcoming. The leakiness of plastics—connecting the dots. *Engaging Sci. Technol. Soc.*
- Hawkins, G., 2012. The performativity of food packaging: market devices, waste crisis and recycling. *Sociol. Rev.* 60 (2 suppl), 66–83. <https://doi.org/10.1111/1467-954X.12038>.
- Hawkins, G., 2018. The skin of commerce: governing through plastic food packaging. *J. Cult. Econ.* 11 (5), 386–403. <https://doi.org/10.1080/17530350.2018.1463864>.
- Hayati, Y., et al., 2020. Magnitudes and tourist perception of marine debris on small tourism island: assessment of Tidung Island, Jakarta, Indonesia. *Mar. Pollut. Bull.* 158, 111393. <https://doi.org/10.1016/j.marpolbul.2020.111393>.
- Hoffer, A., et al., 2020. Emission factors for PM₁₀ and polycyclic aromatic hydrocarbons (PAHs) from illegal burning of different types of municipal waste in households. *Atmos. Chem. Phys.* 20 (24), 16135–16144. <https://doi.org/10.5194/acp-20-16135-2020>.
- Irianti, S., Prasetyoputra, P., 2019. Open burning of household solid waste and child respiratory health: evidence from Indonesia. *Jurnal Ekologi Kesehatan* 17 (3), 123–134. <https://doi.org/10.22435/jek.17.3.996.123-134>.
- Kerber, H., Kramm, J., 2021. On- and offstage: Encountering entangled waste-tourism relations on the Vietnamese Island of Phu Quoc. *Geogr. J.* 187 (2), 98–109. <https://doi.org/10.1111/geoj.12376>.
- Kováts, N., et al., 2022. Ecotoxic emissions generated by illegal burning of household waste. *Chemosphere* 298, 134263. <https://doi.org/10.1016/j.chemosphere.2022.134263>.
- Lebek, K., Hull, T.R., Price, D., 2005. Products of rigid PVC burning under various fire conditions. *ACS Sympos. Ser.* 922, 334–347. <https://doi.org/10.1021/bk-2006-0922.ch026>.
- Lee, R., 2020. A lattice of chemicalized kinship: toxicant reckoning in a depressive-reparative mode. *Catalyst: Feminism, Theor. Technosci.* 6 (1). <https://doi.org/10.28968/cft.v6i1.33904>.
- Liboiron, M., Tironi, M., Calvillo, N., 2018. Toxic politics: acting in a permanently polluted world. *Soc. Stud. Sci.* 48 (3), 331–349. <https://doi.org/10.1177/0306312718783087>.
- Little, P.C., 2021. *Burning matters: life, labor, and e-waste pyropolitics in Ghana*. Oxford University Press, Oxford.
- Maasikmets, M., et al., 2016. Emissions from burning municipal solid waste and wood in domestic heaters, Atmospheric. *Pollut. Res.* 7 (3), 438–446. <https://doi.org/10.1016/j.apr.2015.10.021>.
- MacLeish, K., Wool, Z., 2018. 'US military burn pits and the politics of health', *Critical Care: Medical Anthropology Quarterly Blog*. Available at: <https://medanthroquarterly.org/critical-care/2018/08/us-military-burn-pits-and-the-politics-of-health/>, (accessed 22 December 2022).
- Marder, M., 2020. *Pyropolitics in the world ablaze*. Rowman and Littlefield Publishers, Lanham.
- Mbongwe, B., Mmereki, B.T., Magashula, A., 2008. Healthcare waste management: Current practices in selected healthcare facilities, Botswana. *Waste Manag.* 28 (1), 226–233. <https://doi.org/10.1016/j.wasman.2006.12.019>.
- McKenna, S.T., Hull, T.R., 2016. The fire toxicity of polyurethane foams. *Fire Sci. Rev.* 5 (1), 3. <https://doi.org/10.1186/s40038-016-0012-3>.
- Morikawa, T., Yanai, E., 1989. Toxic gases and smoke evolution from foam plastic building materials burning in fire environments. *J. Fire Sci.* 7 (2), 131–141. <https://doi.org/10.1177/073490418900700204>.
- Murphy, M., 2008. Chemical regimes of living. *Environ. Hist.* 13 (4), 695–703.
- Musariri, L., Moyer, E., 2022. Hunting treasure, gathering trash: politics and precarity in the plastic recycling industry. *Etnofoor* 34 (2), 49–66.
- Nading, A.M., 2020. Living in a toxic world. *Ann. Rev. Anthropol.* 49 (1), 209–224. <https://doi.org/10.1146/annurev-anthro-010220-074557>.
- Naidja, L., Ali-Khodja, H., Khadi, S., 2018. Sources and levels of particulate matter in North African and Sub-Saharan cities: a literature review. *Environ. Sci. Pollut. Res.* 25 (13), 12303–12328. <https://doi.org/10.1007/s11356-018-1715-x>.
- National Green Tribunal, 2013. *Order on Original Application 56 (The) and Original Application 57 (The)*, New Delhi.
- Paddock, R.C., 2019a. 'Indonesia lets plastic burning continue despite warning on toxins'. *The New York Times*. Available at: <https://www.nytimes.com/2019/12/19/world/asia/indonesia-dioxin-plastic-tofu.html>, (accessed 12 December 2022).
- Paddock, R.C., 2019b. 'To make this tofu, start by burning toxic plastic'. *The New York Times*. Available at: <https://www.nytimes.com/2019/11/14/world/asia/indonesia-tofu-dioxin-plastic.html>, (accessed 12 December 2022).
- Padmawati, R., et al., 2018. Establishing a community-based smoke-free homes movement in Indonesia. *Tob. Prev. Cessat.* 4 (November), 36. <https://doi.org/10.18332/tpc/99506>.
- Pani, S.K., Pathak, A.A., 2021. Managing plastic packaging waste in emerging economies: the case of EPR in India. *J. Environ. Manage.* 288, 112405. <https://doi.org/10.1016/j.jenvman.2021.112405>.
- Pathak, G., 2023. "Plastic Pollution" and Plastics as Pollution in Mumbai, India. *Ethnos* 88 (1), 167–186. <https://doi.org/10.1080/00141844.2020.1839116>.
- Pathak, G., Nichter, M., 2019. The anthropology of plastics: an agenda for local studies of a global matter of concern. *Med. Anthropol. Q.* 33 (3), 307–326. <https://doi.org/10.1111/maq.12514>.
- Pathak, G., Nichter, M., 2021a. Ecocommunicability, citizenship, and discourses on plastic control in India. *Geoforum* 125, 132–139. <https://doi.org/10.1016/j.geoforum.2021.04.027>.
- Pathak, G., Nichter, M., 2021b. 'Plastic pollution goes far beyond litter', *Somatosphere*. Available at: <http://somatosphere.net/2021/plastic-pollution.html/>, (accessed 22 December 2022).
- Percezl, J., 2021. Where is toxicity located? Side glances through fieldwork in a toxic place. *Anthropol. Today* 37 (4), 27–30. <https://doi.org/10.1111/1467-8322.12668>.
- Petriik, J., et al., 2019. Plastic waste flooding Indonesia leads to toxic chemical contamination of the food chain. Available at: www.ecoton.or.id, (accessed 12 December 2022).
- Phelan, A. (Any), et al., 2020. Ocean plastic crisis—mental models of plastic pollution from remote Indonesian coastal communities. *PLoS One* 15 (7), e0236149. <https://doi.org/10.1371/journal.pone.0236149>.
- Pinto, R., 2016. 'Toxic fumes from Deonar dumping ground fire choke locals', *The Times of India*. Available at: <https://timesofindia.indiatimes.com/city/mumbai/toxic-fumes-from-deonar-dumping-ground-fire-choke-locals/articleshow/51488734.cms>, (accessed 12 December 2022).
- Republic of Indonesia, 2008. *Waste Management Act, Number 18*, Republic of Indonesia.
- Republic of the Philippines, 1999. *An Act Providing for a Comprehensive Air Pollution Control Policy and for Other Purposes (Republic Act 8749)*, Republic of the Philippines.
- Republic of the Philippines, 2001. *An Act Providing for an Ecological Solid Waste Management Program, Creating the Necessary Institutional Mechanisms and Incentives, Declaring Certain Acts Prohibited and Providing Penalties, Appropriating Funds Therefor, and for Other Purposes (RA 9003)*, Republic of the Philippines. Available at: <https://www.officialgazette.gov.ph/2001/01/26/republic-act-no-9003-3-2001/>, (accessed 12 December 2022).
- Reyna-Bensusan, N., et al., 2019. Experimental measurements of black carbon emission factors to estimate the global impact of uncontrolled burning of waste. *Atmos. Environ.* 213, 629–639. <https://doi.org/10.1016/j.atmosenv.2019.06.047>.
- Reyna-Bensusan, N., Wilson, D.C., Smith, S.R., 2018. Uncontrolled burning of solid waste by households in Mexico is a significant contributor to climate change in the country. *Environ. Res.* 163, 280–288. <https://doi.org/10.1016/j.envres.2018.01.042>.
- Roberts, E.F.S., 2017. What gets inside: violent entanglements and toxic boundaries in Mexico City. *Cult. Anthropol.* 32 (4), 592–619. <https://doi.org/10.14506/ca32.4.07>.

- Rosin, R.T., 2000. Wind, traffic and dust: the recycling of wastes. *Contrib. Indian Sociol.* 34 (3), 361–408. <https://doi.org/10.1177/006996670003400302>.
- Shah, D., 2022. 'Why the plastic waste amendment rules 2022 is a paper tiger', *The Wire: Science*. Available at: <https://science.thewire.in/environment/plastic-waste-amendment-rules-2022-epr-certificates-paper-tiger/>, (accessed 27 December 2022).
- Sharma, K.D., Jain, S., 2020. Municipal solid waste generation, composition, and management: the global scenario. *Soc. Responsibility J.* 16 (6), 917–948. Available at: <https://EconPapers.repec.org/RePEc:eme:srjpps:srj-06-2019-0210>.
- Sinha, A., 2018. 'Garbage gangs of Deonar: the kingpins and their multi-crore trade', *The Quint World*. Available at: <https://www.thequint.com/explainers/garbage-business-in-deonar-dumping-ground-rag-pickers-businessmen-and-mafia>, (accessed 12 December 2022).
- Sovová, K., et al., 2008. A study of thermal decomposition and combustion products of disposable polyethylene terephthalate (PET) plastic using high resolution fourier transform infrared spectroscopy, selected ion flow tube mass spectrometry and gas chromatography mass spectrometry. *Mol. Phys.* 106 (9–10), 1205–1214. <https://doi.org/10.1080/00268970802077876>.
- Tangerang City, 2009. Waste Management Ordinance, Tangerang City Regulation, Number 3, Tangerang City.
- The Hans India, 2016. 'NGT orders implementation of waste management rules, bans open burning of waste', *The Hans India*. Available at: <https://www.thehansindia.com/posts/index/National/2016-12-23/NGT-Orders-implementation-of-waste-management-rules-bans-open-burning-of-waste/270104>, (accessed: 12 December 2022).
- U.S. Environmental Protection Agency, 2011. Black carbon research and future strategies: reducing emissions, improving human health, and taking action on climate change, U.S. Environmental Protection Agency, Washington. Available at: <http://www.epa.gov/research/sciencematters/august>, (accessed 12 December 2022).
- Valavanidis, A., et al., 2008. Persistent free radicals, heavy metals and PAHs generated in particulate soot emissions and residue ash from controlled combustion of common types of plastic. *J. Hazard. Mater.* 156 (1–3), 277–284. <https://doi.org/10.1016/j.jhazmat.2007.12.019>.
- Velis, C.A., Cook, E., 2021. Mismanagement of plastic waste through open burning with emphasis on the Global South: a systematic review of risks to occupational and public health. *Environ. Sci. Technol.* 55 (11), 7186–7207. <https://doi.org/10.1021/acs.est.0c08536>.
- Verma, R., et al., 2016. Toxic pollutants from plastic waste—a review. *Proc. Environ. Sci.* 35, 701–708. <https://doi.org/10.1016/j.proenv.2016.07.069>.
- Wakefield, J.C., 2010. A toxicological review of the products of combustion, Health Protection Agency, Centre for Radiation, Chemical and Environmental Hazards, Chemical Hazards and Poisons Division, Government of UK, Oxfordshire. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/458052/HPA-CHA-PD-004_for_website.pdf, (accessed July 21, 2022).
- Wheatley, L., Leventis, Y.A., Vouros, P., 1993. Exploratory study on the combustion and PAH emissions of selected municipal waste plastics. *Environ. Sci. Technol.* 27 (13), 2885–2895. <https://doi.org/10.1021/es00049a032>.
- Wiedinmyer, C., Yokelson, R.J., Gullett, B.K., 2014. Global emissions of trace gases, particulate matter, and hazardous air pollutants from open burning of domestic waste. *Environ. Sci. Technol.* 48 (16), 9523–9530. <https://doi.org/10.1021/es502250z>.
- Williams, A.T., et al., 2016. Litter impacts on scenery and tourism on the Colombian north Caribbean coast. *Tour. Manage.* 55, 209–224. <https://doi.org/10.1016/j.tourman.2016.02.008>.