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Models of justice evoked in published scientific studies of plastic pollution

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Abstract

An exponentially growing body of international research engages with plastic pollution using different ideas on the right ways to frame, research, and intervene in the problem. The premise of this study is that all scientists work with understandings of what is right and wrong and why that is (models of justice) in their research, even when it is not explicitly stated, reflected upon, or a conscious part of the discussion. We surveyed 755 published articles on marine debris and plastic chemical additives and found that all evoked at least one model of justice, and often more. The most routinely used models included: developmental justice, distributive justice, and procedural justice. More rarely, we found appeals to environment-first justice and Indigenous sovereignty. While occasionally these multiple models worked synergistically, more often they conflicted. Our findings ground a call for fellow researchers to use a more intentional and systematic approach to evoking models of justice in our work. Our goal is to offer descriptions and insights about models of justice that are already being deployed to increase the sophistication of the ethical and normative orientations of our research and our fields, both in plastic pollution sciences and beyond.

Key words: plastic pollution, models of justice, value-based science, endocrine disrupting compounds, chemical pollution, plastic additives

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Introduction

Plastic pollution is an environmental issue on a global scale, and thousands of scientific articles, careers, and projects have been dedicated to the issue. Yet scientists engage with the issue of plastic pollution through different orientations to the underlying problem. This project came about because the authors, two of whom are plastic pollution scientists, began to notice small but important value-based statements in peer-reviewed articles in our fields. These articles contained denotations (direct references) and connotations (implied suggestions) of justice (ideas of what is good and right) that were pervasive in empirical, scientific studies of plastic pollution. Additionally, there were different and even competing concepts of justice often used in the same article.

This is not unusual: various public, government, community, and scientific communities have been calling for justice-oriented approaches to plastic pollution for some time (e.g., Cowger 2020; Walker 2020a; ClientEarth 2021; UNEP 2021; Youth Environment Assembly 2022; Scientists 2022). This paper is premised on the idea that all scientists work with models of justice in their research, even when it is not explicitly stated, reflected upon, or a conscious part of the research design (O'Brien 1993; Sismondo 2011; Haraway 2013). Our goal is to describe these models of justice and how they

are being used so that we, as researchers, can be more deliberate and sophisticated in how we use them.

There are multiple definitions and genealogies of justice– what we call models of justice (Clayton 2000; Gewirtz and Cribb 2002). Here, we use the phrase "models of justice" to recognize the way models can be understood as a best fit for compiled data that accounts for variation rather than a perfect descriptive definition (Morgan & Morrison 1999, p. 11). We identify examples that best fit different models of justice and use these examples to flesh out the nuances and subtleties of each model. Thus, the scope of our work is to provide descriptions and insights primarily for analytic and communication purposes to show the specificities, nuances, similarities, and incommensurabilities around ideas of justice that are present in published scientific research on plastic pollution, rather than provide an exhaustive typology or sort studies definitively. We provide descriptions and insights into what many of us are already doing intuitively.

Most texts we analyse use multiple models of justice, and models of justice themselves overlap and are interrelated (Clayton 2000, p. 463; Gewirtz and Cribb 2002, p. 503). However, we also found frequent use of conflicting models of justice that had mutually exclusive ideas of what is good and right within the same article. For example, if injustice is understood as plastic chemical harms being disproportionately borne by women, as it is within a distributive model of justice (Meeker et al. 2009; Lynn et al. 2017), then a call for more recycling in the conclusion (developmental justice) is a *mis*alignment because recycling *also* disproportionately negatively impacts women due to gendered norms that increase household and occupational exposure for women (Lynn et al. 2017) (see **Table 5**). An alignment of models of justice, we believe, would lead to more sophisticated frames and uses of scientific research. Our findings are organized such that each model of justice is described in turn before we discuss how these models conflict and alignment.

Methods

Positionality statements

It is well documented that social position influences knowledge production, from what types of research questions are considered critical to which forms of analysis are considered a best fit (Haraway 2013; Holmes 2020). In their review of the different models of justice used in environmental impact assessments, for example, Blue et al. (2021) "found that geographical differences appear to inform which dimension of environmental justice is privileged in English-speaking regions" and that "legal, institutional, and civil society contexts drive the focus of [Impact Assessment] scholarship on justice" (2021, pp. 7,6). They found that in the United States, distributive justice that focuses on fence-line communities of colour was more prevalent based on decades of grassroots activism, while in Scotland, procedural justice that focused on inclusion in decision making was more common, based on generations of regional exclusion from the ruling state (Blue et al. 2021; also see Holifield et al. 2009). Expertise, common sense, and internal bias are all based in researcher's positionality within existing cultural, social, geographic, and professional structures, and disclosing their particularities allows for more transparency and accountability (Harding 1995; Magaya and Fitchett 2022; Wijekoon and Peter 2022).

Based on these insights, we will introduce ourselves as authors, our stakes in this research, and our intersecting areas of expertise.

Max Liboiron (they/them) is a Michif interdisciplinary scholar who specializes in anti-colonial methodologies in natural and social sciences and has been researching plastic pollution for over a decade. Their scientific work most closely aligns with Indigenous sovereignty models of justice outlined

in this paper (e.g., Liboiron et al. 2021), though it also crosses into procedural and distributive justice in many instances (e.g., Liboiron et al. 2017).

Rui Liu (she/her) is a diasporic Chinese settler based in Toronto, Canada and a social science researcher in the Civic Laboratory for Environmental Action Research (CLEAR), a plastic pollution lab. Her research interests centre around Asian North American racialization in relation to settler colonialism and capitalism, and the theories of change that underlie different forms of knowledge production. One of her political commitments concerns how settlers academics can better align their work with Indigenous sovereignty models of justice.

Elise Earles (they/them) is a white settler based in Toronto, Canada. Currently a law student, they are formerly researcher in CLEAR. Their emerging research interests centre critical criminological approaches to issues of health and environmental law. They view anti-colonial research as central to increasing access to justice and are committed to aligning their work with Indigenous sovereignty goals.

Imari Walker (she/her) is a Black American scholar based in North Carolina, USA whose environmental engineering doctoral research focused on plastic pollution and the release and transformation of polymer-associated chemicals in the environment. She currently works as a research chemist identifying unknown chemicals in environmental and biological matrices. One of her commitments is to advance an environmental justice (EJ) framework within plastic pollution science research through providing informative science videos on YouTube (e.g., Walker 2020b).

Scoping review

We conducted a scoping review of published literature, which identifies common trends and gaps in professional discussions rather than aiming to capture all literature exhaustively or assess the quality of publications (Arksey and O'Malley 2005; Levac et al. 2010 in Blue et al. 2021). To identify relevant literature that already dealt with justice issues in some way, we developed an English-language search string in consultation with University of Toronto's Human Biology and Women and Gender Studies librarian Aneta Kwak. The string identified key terms for locating records along two dimensions: implicit and explicit proxies for justice, and implicit and explicit proxies for plastic pollution. We selected the databases SCOPUS and Web of Science Core Collection in alignment with our study's focus on scientific literature rather than social science and humanities literature. See Appendix A for the full search string. We applied our search string to record titles, abstracts, and keywords first for articles published between 1957 and 2021, which brought back 755 results in SCOPUS (called the S1 corpus).

Network analysis

We conducted a keyword network analysis by linking author-created keywords from articles in the S1 corpus to analyse the key connections across texts where a justice term appeared in the keywords, title, or abstract (n = 755). To map relationships between articles, we used ScienceScape network creation (Sciences-Po Medialab n.d.) and Gephi (0.9.2), with a focus on the *betweenness centrality* of keywords. This measure maps degrees of relation, or influence on flow, rather than merely how often a keyword is used, where the fewer articles a term has to pass through in the network to connect to every other keyword gives the keyword a higher ranking. In short, keywords with high betweenness centrality serve as bridges within the network (Puzis et al. 2007). Betweenness centrality is calculated in Gephi by taking every pair of texts in the network and counting how many times a keyword can interrupt the shortest path (geodesic distance) between two keywords in any pair of texts in the network (Gephi 0.9.2). To complement the network analysis of keywords, we also used SCOPUS' internal

Table 1. Frequency of author keywords in the SCOPUS corpus (n = 755) for keywords appearing 10 or more times.

Author keyword	Number of papers it appears in
Phthalates	37
Bisphenol A	31
Biomonitoring	16
Children	16
Recycling	15
Endocrine disruptors	13
Pregnancy	13
Circular economy	12
Environmental justice	12
Marine debris	12
Microplastics	12
Occupational exposure	11
Plastic pollution	11
Polyurethane	11
Marine litter	10
Plastic waste	10
Urine	10

keyword rankings feature to identify which author-created keywords were used most often within the S1 corpus (**Table 1**, below).

Discourse analysis

Upon initial review of the S1 corpus, it was clear that many articles did not discuss justice terms overtly even when they appeared in author-created keywords, titles, or abstracts. To identify which articles were engaging in discussion of justice more deeply, we narrowed our results by searching in record titles and keywords only (not abstracts) and made slight modifications to the search string to fine-tune the precision of the results (e.g., narrowing "rights" to "human rights"). Narrowing our search fields and terms brought back 157 results for SCOPUS and 106 results for Web of Science. Importing our results into Covidence 1.0 removed 34 duplicates, which left 229 unique records. Articles that discussed justice, plastics, or polymer-associated chemicals only in passing were then removed, resulting in 213 articles (corpus available here: (corpus zotero.org/groups/4676015/s22_corpus). These articles were read in full until saturation of themes was reached (meaning no new models of justice, uses of the models, or combinations of models were observed). This resulted in 55 articles subjected to close reading (corpus available here zotero.org/groups/4676912/close_read_corpus/library).

Models of justice were identified using grounded theory, meaning that each model of justice and its terms evolved from the data itself rather than starting with a list of models of justice and then organizing articles into them (Lai and To 2015; Urquhart 2012). Close readings of full texts were used to analyse how different models of justice co-existed within a professional argument. During close

reading, we found references to new research texts, mostly grey literature, that were missed through the SCOPUS review because they are not peer reviewed. These texts were also subjected to close reading. For final analysis, we read widely in social science and legal studies on theories of justice to frame interpretation and align our study with the field of justice studies.

Findings

Network analysis of keywords

The network analysis of keywords of 755 articles (S1) that explicitly used a justice-oriented term in their keywords, title, or abstract allowed us to visualize the professional conversation on justice in the field. Greater size and darkness of keyword nodes reflect the greater influence of the keyword (its centrality to other keywords). This does not necessarily mean they are mentioned more, though this is often the case, but that they appear together with other terms the most often. This is a measure for how *influential* they are in terms of cohering and organizing other terms. The distance of nodes from one another indicates how often they appear together in the same text: the closer they are, the more often they appear together. For the unfiltered version, see Appendix B.

The most central keyword in the S1 corpus is a distributive justice-oriented term: occupational health, a term used to describe how and whether certain types of workers are more likely to be exposed to harm due to their job, and (or) how often they suffer the consequences of that exposure. In traditional EJ literature in the social sciences, distributive justice refers to the uneven distribution of burden and benefit, including the need to recognize key differences that lead to inequitable distribution (Schlosberg 2007). It is a core model of justice within published scientific studies of plastic pollution.

After occupational health, justice-oriented keywords have very little betweenness centrality in the corpus, and instead descriptive keywords related to plastics such as phthalates, microplastics, plastics, marine litter, recycling, and bisphenol A link the professional conversation together. We interpret this to mean that even when articles that feature justice terms in their keywords, title, and abstract, the professional conversation is not cohering around such terms so much as around types of plastic pollution.

Finally, the network analysis allows us to look at the distance between clusters to see which conversations are occurring together, and which are occurring independently. Studies in plastic additives are more represented in the corpus, as they are more likely to use justice-oriented terms in their writing. Distributive justice terms such as socio-economic class, children, adolescents, and pregnancy organize this nexus.

Justice terms such as ethics and EJ are *closer* to conversations about chemical additives and *farther* from the conversations about marine plastics, marine litter, and plastic pollution as a term itself. One way to interpret this split is that the plastic chemical conversation and the aquatic plastics conversation have different dominant models of justice: distributive (about uneven harms) and developmental (about industry solutions), respectively.

When we turn to the bare frequency of keywords, we see that the number of times a keyword is used is not the same as its influence (betweenness centrality). While "occupational health" and "occupational exposure" are the most *central* keywords, they are mentioned in only 9 and 11 papers, respectively (total: 20). More common keywords are phthalates (37 papers), which also has the second highest centrality, and BPA (31). This aligns with the keyword network analysis in that types of plastic pollution organize the corpus more than models of justice. However, "children" (16 papers) and "pregnancy" (13 paper), while not central terms, are the fourth and seventh most common keywords, respectively and, like occupational health, are ways to talk about distributive justice and the uneven

impact of plastic additives on different groups. Likewise, "recycling" and "circular economy" appearing in 15 and 12 papers, respectively, are linked to developmental justice. Even with these clusters, however, there is little cohesion in the corpus as a whole, since these figures are based on 755 articles, so even the highest count at 37 papers accounts for only 5% of the corpus.

Models of justice

While network and keyword analyses can tell us about overall trends of prevalence and relationality in the corpus, we also wished to see how different models of justice are being described, understood, and used. A close reading of 55 texts allowed a qualitative analysis describing key models of justice themselves. Though they are often used together and overlap, we will first consider each model individually, ordering them in terms of prevalence in the literature. **Table 2** provides a summary of each.

Developmental justice

"Developmental justice" is a term we devised specifically for trends we saw in this project, as it is not a term used in the wider EJ literature but is the most prevalent model emerging from our analysis. The developmental model of justice understands production and growth as inherently good, natural, and (or) the best place for intervention. This model of justice was evoked in several ways, outlined in turn.

Naturalization of development

Within studies, models of developmental justice often appear in the introductory or concluding paragraphs when the article discusses but does not evaluate the rise of plastic production over time. For example, "Plastics have become increasingly dominant in the consumer marketplace since their commercial development in the 1930s and 1940s" or "Our waste will continue to grow with increased population and increased per capita consumption associated with economic growth" (Jambeck et al. 2015, p. 768, 770). In some cases, the naturalization of industrial activities is explicit: "Plastic waste generation is an inevitable product of human activities" (Kumar et al. 2018, p. 781). When such statements are left without evaluation, we cannot tell if the authors are for or against developmental justice – the right of industry to produce and grow. However, when industrial phenomena are framed as "a given" or inevitable activity in the natural order of the world, they become naturalized, meaning that they are made to seem normal and unremarkable, and thus much less available to debate or change (Bijker 1997).

Table 2. Models of justice and their definitions.

Model of Justice	Definition
Developmental justice	The primary good is right of industry and economic systems to endure, grow, and flourish (develop) without significant interruption or hardship
Distributive justice	Investigates the uneven harms of plastic pollution, particularly for workers (occupational health), women, children and fetuses (reproductive health), and race and socio-economic class (fence-line communities)
Procedural justice	Refers to more equitable processes for laws, regulations, treaties, and other decision making forums or techniques
Environment-first justice	Argues that flora and fauna should not be harmed, regardless of whether harm to them impacts humans or the wider ecosystem, or whether threshold levels of pollutants are within regulated allowable levels
Indigenous sovereignty	Upholds Indigenous peoples' rights to govern their lands, waters, foods, and lives

Developmental models turn plastic pollution into a downstream issue: the production of plastics is left untouched in favour of locating justice issues and interventions in the pollution itself, after production has occurred, which allows production to continue (Crang et al. 2013). This tends to be most strongly articulated in concluding sections that include recommendations such as recycling (15 papers) or circular economy (12 papers), terms that have low betweenness centrality so do not organize the conversation, but are sprinkled throughout the corpus. Other recommendations for solving plastic pollution through development include plastic credits (e.g., Hardman 2021), "life cycle consideration" (Soares et al. 2020, p. 7), education about consumption (Dalu et al. 2020, p. 2), changes in design including the circular economy (Zota et al. 2014, p. 239) and ingestion by microbes or mushrooms (Guo et al. 2020, p. 8; Caruso 2015, p. 1).

There is mixed evidence that actions based in developmental justice create change, particularly at scale (e.g., MacBride 2013; MacBride 2019; Gregson et al. 2015). Yet since plastics only come from industry sources, interventions into industry have the potential (though never the guarantee) to mitigate plastic pollution. Though we agree with other researchers that harm reduction rather than significant changes to the system is the most likely mode of change in a developmental approach to justice (Mah 2021, p. 111). For example, among the general U.S. population's exposure to different phthalates, Zota et al. (2014) found that "reductions in DEP [diethyl phthalate] exposures have been the most pronounced, possibly because of changes in the formulation or use of personal care products, which are an important source of exposure to DEP" (p. 239). In the case of DEP, a phthalate, NGO advocacy, industry change, and regulation often moved hand in hand (e.g., Canada Minister of Health 2016). As such, development provides an important but limited model of justice, particularly when it is aligned with procedural justice linked to regulations and law.

Stability of industry

A few texts, mainly on aquatic plastic pollution, used a development justice model to frame plastic pollution as a source of harm to economic stability or growth. For example, the United Nations Environmental Programme reports that, "in Thailand, where plastic waste import increased by 1,000 percent since the Chinese ban on plastic waste imports in 2018, shrimp farms have especially taken an economic hit from plastic pollution" (2021: 42, see also Jang et al. 2014; Laglbauer et al. 2014; Shim et al. 2018). Further examples are summarized in **Table 3**.

In another example, Beaumont et al. (2019, p. 194) argue that articulating harm to industry is a crucial mechanism for change: "Drawing on previous experiences of global pollutants (Van den Bergh and Botzen, 2015), we propose that the calculation of the economic costs per tonne of marine plastic is fundamental in future global negotiations to change the way plastics are designed, produced, used, reused and reprocessed. [. . .] While explicitly recognising the limitations of the economic cost

Table 3. Examples of types of economic harm caused by plastic pollution.

Type of economic harm	Citation
Damage to fishing and aquaculture industries by reducing fishery species	Beaumont et al. (2019, p. 190)
Damage to shipping vessels via entanglement and snaring	Mofijur et al. (2021, p. 12)
Damage to the tourism industry via reduction in aesthetic value of shorelines	Abalansa et al. (2020, p. 10)
Damage to the agricultural industry, power generation industry, and transportation industry when plastics clog waterways	Mofijur et al. (2021, p. 13)
Loss of "ecosystem services" (the value that ecosystems contribute to the economy or human wellbeing by absorbing chemicals, among other activities)	Fisher, Turner and Morling (2009, p. 645)

estimate presented here, we propose this as a foundation on which a Social Cost of Marine Plastic could be calculated". Here, as is common in the corpus, authors describe a developmental theory of change as crucial yet limited.

Critiques of the development model

Notably, some texts – almost always grey literature summarizing primary research or NGO-authored primary research reports – offer an explicit critique of the developmental justice model and its use by plastics industries in particular. For example, a report by the United Nations Environmental Programme noted that,

> "the pandemic has been viewed as an opportunity to drive consumption of single-use plastics. For instance, during the early weeks of the pandemic in March 2020, the U.S. Department of Health and Human Services received a letter from the Plastics Industry Association requesting a public announcement from the Department praising promoting the health and safety benefits of single-use plastics and speaking out against bans of single-use plastic materials. The letter was sent a week after a peer-reviewed study was published demonstrating that the novel COVID-19 virus could survive on plastic surfaces for up to 72 hours, compared to up to 24 hours on cardboard surfaces" (UNEP 2021, pp. 7–8. See also, Schlegel 2020)

A smaller number of texts critique developmental justice methodologically. For example, *Plastics Exposed* (2019) by the Global Alliance for Incinerator Alternatives (GAIA) uses brand audits to indicate which companies produce shoreline plastic waste. They write that this research method is designed to "unmask how the industry has passed on the blame for the waste they produce to the consumers of their products, and the responsibility for clean-up of their packaging to governments" and to "reinforce the need for corporations to accept liability for the full life-cycle impacts of their products and the packaging in which their products are sold" (GAIA 2019, p. 6). This method is increasingly used in peer-reviewed shoreline studies as well (e.g., Okuku et al. 2021; Aragaw 2021). Other implicit methodological critiques of production include biomonitoring and epidemiological studies of chemical additives to plastics (e.g., Autian 1973, pp. 5–6; Zota et al. 2014; Rillig et al. 2021) and occupational health studies broadly.

Development model in science

We saw the model of developmental justice applied to science itself. These were most often calls for more data, more studies, more refined scientific standards or methods paired with the often explicit argument that more science and more data will lead to change. For example, it is frequently recommended "to undertake further research [...] to enable the efficient development of future policy and regulation" (Beaumont et al. 2019, 194) or that further "Investigations [...] will also enable prioritizing resources and to focus and steer conservation measures" (Thiel et al. 2018, p. 13). The theory of change implicit in this use of the developmental model is that more data or information is able to lead to change, whether by influencing publics, policy makers, or industry. Although this theory of change is common in knowledge-producing professions such as science and journalism (Callison and Young 2019; Singh et al. 2021), Singh et al. (2021) argue that more science does "not inherently lead to sustainable outcomes" but may in fact contribute to "unsustainable and inequitable development", since powerful actors have long-used science to exploit the ocean and other environments (2021, p. 2). They emphasize that solution-oriented research based on evaluation and testing of existing efforts to make concrete change, rather than more basic science aimed at understanding ecosystems are "more effective in contributing to policy goals" (2021, p. 2). While this paper focuses mainly on models of justice, it is important to recognize that different models of justice (what is most important and right) are aligned with different theories of change (how systems change or shift).

Distributive justices

Distributive models of justice are well-defined in traditional EJ literature. They might be considered a suite of approaches that focus on the systematic, inequitable distribution of harms, burdens, benefits, and liabilities across populations differentiated by race, indigeneity, geography, occupation, socio-economic class, gender, age, and other social stratifications (Whyte 2017, p. 116; Pulido 2017, p. 2; UNEP 2021, p. 13). In the plastic pollution literature, we identified several reoccurring ways that these *differences* or *social locations* were understood and used.

Upstream and downstream approaches

There are different approaches to understanding where the differential distribution of plastic pollution harms comes from and thus where interventions might best occur. We frame these approaches as "upstream" or "downstream" because they locate responsibilities for harm variably along the value chain, from oil and gas extraction (upstream) to consumer choice (downstream), and variably between systems that produce unevenness such as racism (upstream) to symptoms of those systems such as racialization (downstream). Upstream approaches are closer to how distributive justice is understood in the EJ literature outside of the sciences, where harm is a result of complex and interlocking systematic oppressions and their material effects. Alternatively, downstream articulations of distributive justice locate the problem in waste disposal practices and consumer behaviour, often naturalizing both the production of plastics (pro-developmental justice) *and* the unevenness of its effects (distributive justice).

Within EJ literature, there are two main types of distributive justice: one that focuses on distributing benefits and burdens more equally so certain groups are not consistently overburdened with harms while others consistently gain the benefits, and another that seeks to guarantee protection from environmental degradation of any kind for all people (Clayton 2000; Blue et al. 2021). EJ professional Mike Ewall states that the two strains "represent the fundamental difference between the concepts of 'poison people equally' and 'stop poisoning people, period'" (Ewall 2012, p. 4). We find these two strains in our corpus. Upstream distributive justice mainly aims to decrease overall plastic or chemical production and even occasionally challenges the structural oppression that leads to social stratification to begin with. Downstream distributive justice focuses on evening out or mitigating the harm experienced by certain populations, such as through appeals to public education.

Global and fence-line geographies of injustice (upstream)

For decades, fence-line distributive justice has been the classic framing used to address the inequitable distribution of harms associated with chemical production and pollution (Bullard 2018). It emerged as a way to show how industrial production facilities, mines, pipelines, and landfills – and the pollution they produced – tend to be sited near low income, racialized, and Indigenous communities. A classic example is the 1987 report, *Toxic wastes and race in the United States: A national report on the racial and socio-economic characteristics of communities with hazard waste sites,* which found that three of every five (60%) Black and Hispanic Americans and approximately half (50%) of all Asian, Pacific Islander, and Native Americans lived in communities with uncontrolled toxic waste sites (Chavis and Lee 1987). The report showed that race was the most significant variable – greater than socio-economic status – in the siting of hazardous waste facilities in the United States (see also Tishman Environment and Design Center 2019; UNEP 2021). Because of this focus on production, fence-line distributive justice is often aligned with critiques of developmental justice.

A key characteristic of fence-line distributive justice is its use of a structural analysis that attributes harm to discriminatory *systems* rather than irresponsible *individuals* or events (Bullard 2018). In other words, fence-line distributive justice distinguishes between race and racism, class and

Table 4. Examples of types of uneven distributions of harm described through fence-line distributive justice.

Type of economic harm	Citation
Exposure through siting of plastic and plasticizer manufacturing	UNEP (2021, p. 18); Hoffman et al. (2011, p. 55); Nelson et al. (2012)
Exposure through siting of plastic waste sorting or recycling facilities	Petrlik et al. (2021)
Loading of plastic waste onto specific shorelines	Cowger (2020)
Discriminatory zoning practices, infrastructural funding, and divisions of labour that go into creating underserved and unhealthy neighbourhood environments	Ruiz et al. (2018, p. 201); Nelson et al. (2012, p. 11)
Exposure through lower quality and higher toxicity consumer products rather than *industries* in low income and racialized neighbourhoods	N'dri et al. (2015, p. 19); Belova et al. (2013)

capitalism, and gender and patriarchy in its diagnoses of the problem. Instead of framing the condition of *being* Black or poor as risk factors for certain exposures or forms of harm – which essentializes difference and locates responsibility in the individual – traditional fence-line distributive justice emphasizes the systems of exploitation (e.g., racism and capitalism) that create and distribute risks in inequitable and predictable ways (Pulido 2017). For instance, the report *U.S. Municipal Solid Waste Incinerators* discusses how the siting of plastic incinerators in poor and racialized communities "is not a coincidence but rather it is a product of historic residential, racial segregation and expulsive zoning laws that allowed whiter, wealthier communities to exclude industrial uses and people of colour from their boundaries" (2019, p. 13). Table 4 outlines examples of this type of harm in the corpus.

Related to fence-line distributive justice, we identified a specific upstream articulation of global geographies of injustice in articles that discussed relationships between the Global North to the Global South (a useful but imperfect categorization for looking at distribution [Dirlik 2007, 15]). According to a UNEP plastics report, "the increasing disconnection of economic benefits and ecological costs of the global economy has created opportunities for exploitation by more powerful actors from the Global North, while also complicating the attribution of liability" (2021, 14). GAIA's report *Discarded: Communities on the Frontlines of the Global Plastic Crisis* (2019) emphasizes how waste exports from wealthy countries overwhelm the infrastructures of, and offload an array of environmental and health problems to, lower-income countries in Southeast Asia. In their article on global plastic and climate governance, Stoett and Vince underscore that it would be constructive to consider the historic plastic footprints of European and North American countries where industrial processes and large-scale plastics production were first innovated, rather than just contemporary snapshots (2019, 350). This framing of distributive justice illuminates the globalization of the fence-line by highlighting not only the concentration of global plastic disposal in the communities of developing, coastal, and island nations but also the upstream culpabilities of overdeveloped Global North governments and industries. Although there are many articles in our corpus that investigated global distributions and sources of plastic pollution and might have aligned with this model of justice, we found arguments of global fence-line distributive justice mainly in grey literature, social science, and journalistic sources (GAIA 2019; Petrlik et al. 2021), despite many articles that investigated global distributions and sources of plastic pollutions that had findings that would have aligned with this model.

The global or fence-line distributive models of justice become complicit in mis-attributing disproportionate responsibility to more disempowered Global South agencies. An example of this misattribution can be found in Jambeck et al. (2015) article, which argues that 83% of marine plastic debris is generated by 20 countries, most of which are developing countries. Jambeck et al. go on to frame the global plastic pollution problem as an issue of developing countries' waste "mismanagement" (2015, 770). GAIA (2015) and Liboiron (2021) specifically critique this article's misdiagnosis of injustice for overlooking the ways in which historical and contemporary processes of colonialism and imperialism craft such data, narratives, and waste flows to begin with. Thus, global economies of both plastic production and waste export complicate where upstream and downstream occur, as well as provide challenges for the use of global data.

Occupational health (mixture of upstream and downstream)

Occupational health is the most central keyword in our corpus (**Fig. 2**). This field has an implicit framing of distributive justice in that it focuses on exposure to harm for mainly blue-collar workers and looks upstream in terms of investigating whether/when industry is the source. These studies emphasize the disproportionate disease burdens borne by workers through exposure to polymer-associated chemicals and particulates in specific industries and informal sectors, including synthetic textile manufacturing, plastics manufacturing, construction, waste picking, and beauty care work (Huang et al. 2011; Wright and Kelly 2017; Fucic et al. 2018; UNEP 2021; Varshavsky et al. 2020).

In its most upstream articulation, occupational distributive justice in the literature considered inequitable occupational distributions of harm in the workplace in relation to the racialized, gendered, and classed nature of labour divisions, particularly in the production of plastics and plastic additives (e.g., DeMatteo et al. 2012). These studies often found that women, Indigenous peoples, racialized, and working-class people tend to face higher occupational exposures due to the kinds of jobs available or assigned to them not only in production and manufacturing but also in blue collar service and waste disposable industries (N'dri et al 2015, p. 16; Varshavsky et al. 2020; UNEP 2021). In their pilot study on Vietnamese American nail salon workers, for example, Varshavsky et al. found that Vietnamese nail salon workers in California – most of whom are low-income women – are disproportionately exposed to phthalates in comparison to the general population (2020, p. 10).

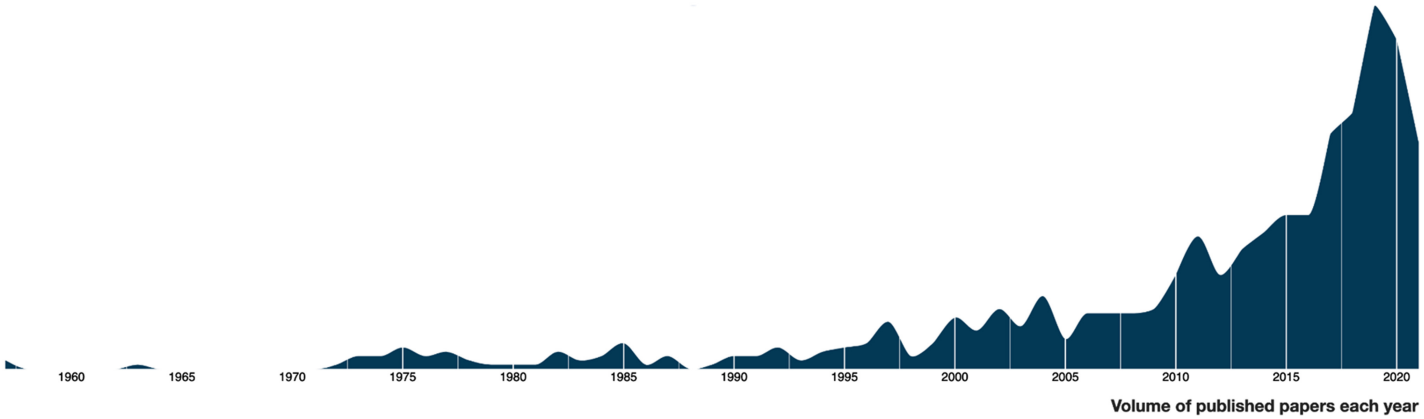

Fig. 1. The number of English-language published papers in the bibliographic database SCOPUS that include terms in the title, keywords, or abstract that relate to both plastic pollution and a wide range of justice-oriented terms (see list of keywords in Appendix 1).

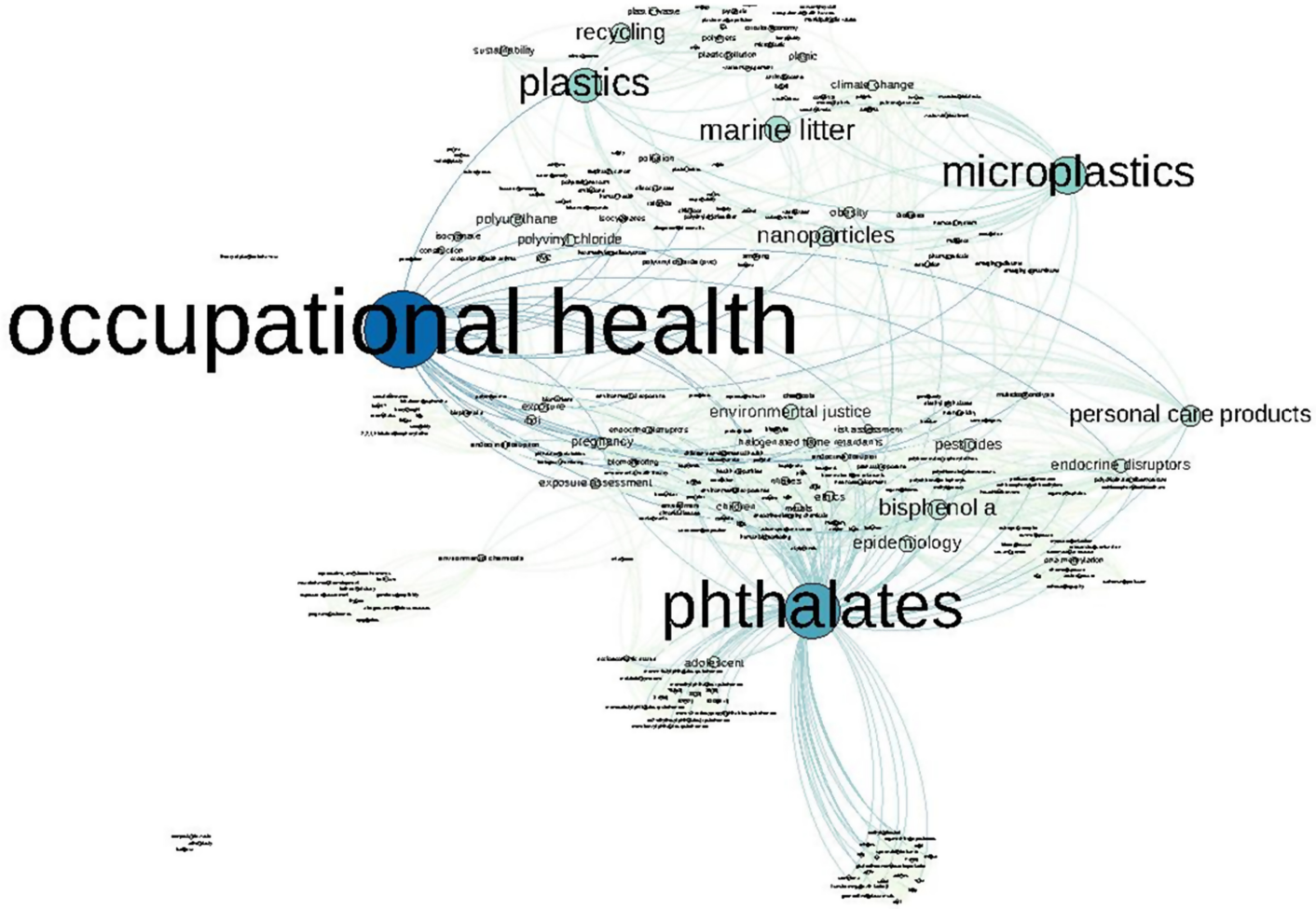

Fig. 2. Network analysis of keywords in articles that included both justice-oriented terms and plastic research terms. 755 articles are included in the original network, while this visualization is refined so that only keywords with 10 or more connections in the corpus are included. Larger size of text and darker colour of notes indicate greater centrality of the keyword. Distances between nodes indicate the degree of common use within the corpus–tiny bundles that are unconnected (lower left) are single papers with no keyword connections to any other papers, while more central and closer nodes share keywords across papers.

However, some studies straddle upstream and downstream approaches. Although these studies concede that exposure is linked to occupation, they forward a developmental model of justice by advocating for downstream solutions: more rigorous occupational health surveillance via personal biomonitoring tracking systems, educating workers and doctors, conducting more research, providing better protective gear to workers, and improving workplace safety practices (Fucic et al. 2018, p. 5; Varshavsky et al. 2020, p. 12). That is, these studies do not align the problem (distributive) with the solution (developmental), which allows distributive injustice to continue, even if mitigate).

Naturalizing difference (downstream)

There is high agreement in the literature that there are strong race, class, sex, gender, and age disparities in terms of which populations carry the highest risks and burdens of plastic pollution (for a summary, see Bergman et al. 2013, as well as Adeyi and Babalola 2019; Belova et al. 2013; Nelson et al. 2012). In all cases, these studies use cultural categories of difference to identify uneven

harms. At the same time, rather than pointing upstream to issues of racism, classism, sexism, ageism, colonialism, capitalism, and other systems that organize populations through differential privilege and oppression, they almost always direct their attention downstream, either to consumption behaviour and choices or innate biology. For example, in nearly all cases, the analysis of racialized disparities stops at ethnic differences and expresses uncertainty as to why such differences occur in product consumption and thus chemical exposure (e.g., Kobrosly et al. 2012, 15). This lack of explanation and conflation of race and racism leaves room for potential blame of exposure on racialized individuals for using certain consumer products. When researchers use racialized categories for comparison but do not take into account that plastic packaging is often related to affordability, cultural practices, and the types of stores that surround communities of colour, they collapse racism into race or ethnicity. By decontextualizing distributive injustice into categories of difference rather than systems of differentiation, studies can mis-align a distributive model of justice with developmental justice.

This trend is compounded when disproportionate burdens of plastic pollution along lines of race, sex, gender, and age are attributed to biology. For instance, multiple sources attributed the larger plastic toxicity burdens borne by women to "particular biological vulnerabilities" (DeMatteo et al. 2012, p. 428), "women's specific biology" (UNEP 2021, p. 19), or to their use of certain consumer products (Arbuckle et al. 2015, 283), rather than to patriarchal social arrangements that constrict women to occupations of increased exposure like the household labour or informal waste picking (Lynn et al. 2017). That is, the problem is located in women rather than sexism, which risks legitimizing uneven harms (Moore et al. 2003). Like the trend in occupational health, many of these studies turn to the scientific development model and call for more research or enhanced biomonitoring of "vulnerable" populations (Arbuckle et al. 2015, p. 281; Kobrosly et al. 2012, p. 16), accruing resources to those least impacted (white collar researchers). This is another example of misalignment of models of justice within a single text (see **Table 5**).

Research bias and distribution of harms (upstream)

The final type of distributive justice turns its attention (as we did above) to uneven power relations in scientific research, joining a wider multidisciplinary trend (e.g., Carter et al. 2021; Liboiron 2021; Mervins 2022; Robertson and Hairston 2022). A number of articles tacitly pointed upstream towards university institutions, funding agencies, and dominant research cultures as the sources of inequitable distributions of scientific attention, studies, personnel, and resources, and the negative impacts of this maldistribution. In their review paper on women workers' chemical exposures in the plastics industry for example, DeMatteo et al. assert gendered biases in occupational health research. They argue that when occupation is considered without also considering gender, they find that the most impacted workers – women – are missed (2012, p. 440). In our literature review, there were only a few studies, DeMatteo et al (2012) among them, that considered the unique *intersection* of two or more markers of difference (Crenshaw 2017). While many studies considered multiple markers, they used a one-at-a-time approach.

Because this finding has direct ramifications for research design and methodology, we highlight two articles that take an intersectional approach using geography and either socio-economic status or indigeneity to analyse research biases and gaps. Blettler et al. (2018) argue that not only are freshwater environments massively understudied in plastic pollution research compared to marine environments, but that existing research on freshwater pollution does not even address the most polluted rivers. They argue that these research biases are produced through socio-economic differences between developing and developed countries (2018, 422. Also see Melvin et al. 2021 for a similar argument around plastics research in icy regions). Likewise, Liboiron et al. (2021) found that 100% of research leads who studied surface water plastics in Inuit homelands were not Inuit and were not from Inuit

Table 5. Common pairings of incommensurate models of justice within the same published article. The first four are discussed in detail below, while others are discussed in the text above.

Pairing	Issue	Citation
Pro-developmental justice and anti-developmental justice	Where both the problem and the solution to the problem are in increased or expanded industrial production	Huysman et al. (2017); Fucic et al. (2018); DeMatteo et al. (2012)
Upstream distributive justice and downstream distributive justice	Upstream/traditional distributive justice shows the sources of uneven harm stem from systems of power and oppression, but downstream versions argue sources are harm stem from the bodies, habits, or choices of the harmed	Trasande et al. (2013); Kobrosly et al. (2012); DeMatteo et al. (2012); UNEP (2021); Arbuckle et al. (2015)
Indigenous sovereignty and pro-developmental justice	Indigenous sovereignty is based on Indigenous nation's right to govern their lands and pro-developmental justice is based on those lands being used for more industrial production or scientific production	Implicit in most developmental justice arguments
Indigenous sovereignty and the absence of distributive justice	Indigenous sovereignty is based on the idea that Indigenous nations and people have unique relationships to land. When researchers posit blame or change to "humankind", these differences (and others central to distributive justice) are erased.	Hartley et al. (2018); Soares et al. (2020)
Pro-developmental justice and distributive justice	A trend in the literature was the analysis of pro-developmental models in the Global North contributed to Distributional Justice problems in Global South	GAIA (2021); GAIA (2019); Stoett and Vince (2019); Dayaram (2019); Yeung (2019), Petrlik et al. (2021)
Pro-developmental justice and distributive justice	In many occupational health studies, it was found that workplaces caused uneven exposure risks to workers, but solutions concentrated on maintaining workplaces (rather than worker's bodies) and (or) increasing resources to science	Fucic et al. (2018); Varshavsky et al. (2020); Arbuckle et al. (2015); Kobrosly et al. (2012)
Procedural justice with developmental justice	When scientists and other researchers argue for their own increased presence (developmental) in decision making to speak on behalf of those most impacted, but those most impacted are not part of decision making	Coffin et al. 2021; critique in GAIA 2015

homelands "despite the existence and excellence of Inuit researchers" (2021: 21–22). Liboiron et al. posit that this results "in an overall regional skew of knowledge" (2021: 23) divergent from local research needs (also see Inuit Tapiriit Kanatami 2018).

Procedural justices

Procedural justice focuses on equitable access to decision-making processes, political representation, and bargaining powers in the development and enforcement of laws, regulations, policies, and other legally binding instruments (US EPA 2015; UNEP 2021, p. 13; Whyte 2017, p. 117; Clayton 2000, p. 461). It typically recommends increasing the consultation and participation of marginalized communities in polity decision making as the solution to environmental inequities. We found that this traditional definition of procedural justice is rarely articulated in scientific plastic pollution literature. Even in the considerable literature on occupational health, rarely do recommendations focus on worker participation in the development of health and safety policies or measures. Even when articles call for broadening participation, they argue for inclusion of "researchers, citizens, industry representatives, and commercial monitoring laboratories" (Coffin et al. 2021, p. e3000932) rather than those most impacted by exposure or harm.

However, we identified two interrelated examples of procedural justice that do appear regularly in the literature: expert appeals to policy in general and critiques of weak governance structures in particular. Both are usually aligned with distributive and anti-developmental justices.

Scientific appeals to policy

Rather than advocating for better decision-making representation of marginalized or often-harmed groups, it was exceedingly common for researchers to make recommendations on behalf of these groups. Many advocated for scientists to be better represented in plastics governance so they could better represent harmed groups. Yet grey literature originating in social movements critiqued this model, arguing that scientists often speak over and obfuscate marginalized populations' own priorities and knowledge in direct contravention of traditional ideas of procedural justice (GAIA 2015).

Critiques of weak governance systems

Another model of procedural justice in the corpus makes more explicit critiques of governance structures, infrastructure, and power. Direct criticism of weak governance systems, such as how insufficient regulations and enforcements create asymmetrical risks and harms, appeared in several articles (e.g., Njeru 2006). For instance, Korfali et al.'s (2013) study on phthalates in children's toys on the Lebanese market criticizes the Lebanese Standards Institution for failing to set appropriate national criteria for levels of toxic chemicals (2013, p. 380). In the North American context, scientists have critiqued current dose-based regulatory conventions for failing to capture the low dose toxicities of endocrine disrupting chemicals (EDCs) (Charboneau and Koger 2008; DeMatteo et al. 2012). For example, Charboneau and Koger's paper on the connection between EDCs and developmental disabilities condemns the affinity between government and industry, and the US EPA's reliance on chemical manufacturers' data (2007, p. 125). Social science research such as Njeru's critiques of how economic instruments and anti-littering campaigns in Nairobi, Kenya individualize systemic issues of colonialism and capitalism is also part of this model of procedural (2006, p.1047). While critiques such as these do not always posit methods for achieving procedural justice, they do articulate areas of procedural injustice to be addressed.

Environment-first justices

Although "EJ" appears as a keyword in 1.5% of articles, the fifth most common occurrence in our heterogenous corpus, in most cases, these articles articulated an *anthropocentric* model of justice, meaning they focus on humans and even used developmental justice models. To deal with the conflation of terms, we use the phrase "environment-first justice" to refer to a suite of justices that centre nature, animals, land, ecosystems, or other non-humans over humans as primary rightsholders or stakeholders deserving justice (e.g., Healey and Pepper 2021; Sunstein and Nussbaum 2004; Nash 1989).

In the reviewed published scientific literature on plastic pollution, we find no *explicit* references to this model of justice, but many *implicit* statements and study designs that posit the inherent goodness or importance of nature, animals, and (or) ecosystems and frame harm to them or interruption of their habitats or bodies is wrong or unjust. This most often manifests as a passing introductory statement that plastics cause harm to animals and (or) ecosystems, even when the study is not about animals or ecosystems. For example, Mofijur et al. (2021, p. 2) provide a paragraph on "the death and injury of aquatic birds, fish, mammals, and reptiles", and the "suffocation of the ocean floor" in a paper that is primarily about the sources and socio-economic impacts of marine microplastics. Others refer to plastics as "intrusions on natural ecosystems" (Stoett and Vince 2019, p. 345) or provide other statements that centre the environment.

A subtle but pervasive evocation of environment-first models of justice is the way studies are designed. Thousands of studies focus on the impacts of plastics on animals even when that animal is not directly relevant to humans as a biological model, health indicator, or as part of the human food web (e.g., Lin et al. 2020). Bläsing and Amelung's (2018) summary of how microplastics negatively impact the reproduction, growth, and mortality of earthworms has been used by the United Nations

Environmental Programme to argue that microplastics in soil are in contravention of the United Nations' Sustainable Development Goal (SDGS) #15: life on land (UNEP 2021, p. 20).

For environment-first justice, we include only studies that do not foreground humans. This means that assessments of risks to ecosystems services or harm to animals that are understood as harm to human well-being, etc. are excluded because they remain anthropocentric (e.g., Beaumont et al. 2019; Silva et al. 2018, p. 153; Khan et al. 2019, p. 33054).

Environment-first models of justice and tensions in science

Due to the frequency of environment-first statements in science, researchers have investigated the pervasiveness of implicit critiques of animal or ecosystem harm in studies that do not investigate such harms. Rochman et al. (2016) found that 27% of claims of harm in scientific articles are what they call "perceived" (stated without scientific evidence) rather than "demonstrated" (through the findings of the paper) and that many perceived impacts are articulated at the ecological level (rather than organelle, individual, or species levels). That is, scientists are making claims that plastics have negative impacts on ecosystems when those claims are not scientifically proven within the study. Our interpretation of Rochman et al.'s findings is that nearly a third of scientists in the study (n = 366) are expressing an environment-first orientation regardless of their research questions or methods (2016, p. 306).

In an interview, conservation scientist and plastic pollution researcher Alex Bond has said that, "As a scientist, you have to take a step back and almost detach yourself from the situation. But as a human being, when I cut open a dead bird and see bottle caps, tetra-pack lids and balloon clips gushing out of the stomach, it just breaks my heart. You think, 'God, there's no way that this has not severely affected this bird.' But that's a different thing than the scientific weight of evidence" (Bond and Liboiron 2018). Rochman et al. and Bond illuminate the same tension, that scientists who forward an environment-first model of justice often do so without toxicological or other scientific measures of harm in contradiction to scientific models of evidence that do require such measures.

There is a small but overt conversation in the scientific literature on plastic pollution that *science* is a potential cause of harm to animals, nature, and (or) ecosystems. Some scientists actively develop non-invasive methods to research plastic ingestion without the need to kill or even disturb animals, such as using ematics (pharmaceutical agents that induce regurgitation) and lavage (pumping the stomach with water) (Bond and Lavers 2013), visual identification of plastics in bird's nests (Grant et al. 2021), boluses (Bond et al. 2021), and scat (Donohue et al. 2019). Some, though not all, of the articles cite animal welfare as the reason behind researcher's choice to develop or use non-lethal methods.

Indigenous sovereignty

Indigenous models of justice are based on responsibilities to land, broadly defined, and "the worldviews, philosophies, and knowledges of Indigenous peoples [are] central tenets in defining Indigenous environmental justice concepts" (McGregor 2018: 10). Kyle Whyte writes that for Indigenous peoples, "Environmental injustice can be seen as occurring when these systems of responsibilities are interfered with or erased by another society in ways that are too rapid for Indigenous peoples to adapt to without facing significant harms that they would not ordinarily have faced" (Whyte 2016). These models of justice are different than including Indigenous peoples in distributive justice models, which is based on an ethic of inclusion into the settler state (Gilo-Whitaker 2019; Coulthard 2014; McGregor 2014). They also differ from environment-first justice, where considerations of animals and ecosystems are not based in responsibility to them as articulated through Indigenous nations, law, cosmologies, and governance. As such, these models of justice cannot be led by non-Indigenous peoples, though it can certainly be respected and followed by all scientists regardless of their origins.

Though versions of these models of justice have existed since time immemorial (Borrows 2010), only one peer-reviewed *scientific* article in the corpus truly used this model, which had an Indigenous lead author (Liboiron et al. 2021). Other sources outside the scientific corpus include those in the social sciences and humanities (Njeru 2006; Altman 2021; Shadaan and Murphy 2020; Liboiron 2021), magazine articles and blog posts written by two Indigenous scientists (Ngata 2018; Liboiron 2018; Ngata and Liboiron 2020), and an NGO campaign (GAIA 2021). While other scientific publications do address connections between Indigenous peoples and plastic pollution, they consistently forwarded non-Indigenous models of justice (e.g., UNEP 2021; Perovich et al. 2018, p. 8). We will cover two core topics in these articles: plastics as a colonial injustice and the role of colonialism in plastic pollution research. We describe Indigenous models of justice with detail despite their rarity because non-Indigenous readers may not be familiar with them.

Plastic pollution as colonial injustice

Most sources articulated plastic pollution as a colonial *in*justice, arguing that plastic and "EDCs are materially a form of colonial environmental violence" (Shadaan and Murphy 2020, p 1) and that plastic waste management is part of an ongoing "struggle to overcome the inequalities of colonialism" (Njeru 2006, p. 1056). In a special issue on plastic pollution in *Science,* historian Rebecca Altman makes the case that bio-based plastics were not only "extracted under colonial regimes" but also were core drivers of Indigenous dispossession and sites of resistance (2021, p. 48). GAIA's #StopWasteColonialism Campaign is based on "the effects of waste colonialism in the African continent. … Where our resources are returned to us, in the form of waste and cheap products made from toxic recycled materials. Where plastic waste has infiltrated its way into our land, oceans and physical bodies, severing our cultural connections with the earth and violating our rights to a clean and healthy environment" (GAIA 2021). Other sources argued that plastic pollution is a form of colonial injustice because it interrupts Indigenous food sovereignty and Indigenous relationships to fish and other aquatic life (Ngata 2018; Ngata and Liboiron 2020).

Colonialism in plastic pollution research

One scientific study on marine plastics called for "reconciliation science", where "existing and ongoing Indigenous research relations should never be divided from scientific study and reporting" and should be characterized by "respecting Indigenous sovereignty" (Liboiron et al. 2021: pp. 2, 11). This text outlines how access to Indigenous land by non-Indigenous scientists, even when that access is for benevolent or well-intentioned environmental science, perpetuates non-Indigenous entitled access to Indigenous land (Liboiron 2021). The authors provide examples from existing plastic pollution research where researchers do not or may not seek consent, permissions, or permits for conducting plastic pollution research on Indigenous lands. They note that "of the 18 peer reviewed articles collected in our systematic literature review where Indigenous permits were required… five (28%) mentioned whether a permit from an Inuit Nunangat [Inuit homelands] research center was obtained" while more mentioned permits from settler Canadian government agencies even though both are required (2021, p. 8).

The same study found that all research on plastic pollution on surface water and in ice in Inuit Nunangat was led by non-Inuit researchers, resulting in all research on plastics stemming from the research interests and skills of white, settler, Western-trained scientists (Liboiron et al. 2021, pp. 8-9). These trends are in direct contravention of both the United Nations Declaration of the Rights of Indigenous Peoples (UNDRIP) that outlines Indigenous peoples' right to self-determination in any aspect of knowledge or policy concerning their lands (United Nations 2008) and the Inuit Tapiriit Kanatami's (ITK's) National Inuit Strategy on Research (NISR), which seeks to change the norm wherein "the primary beneficiaries of Inuit Nunangat research continue to be [non-Inuit] researchers themselves, in the form of access to funding, data and information, research outcomes,

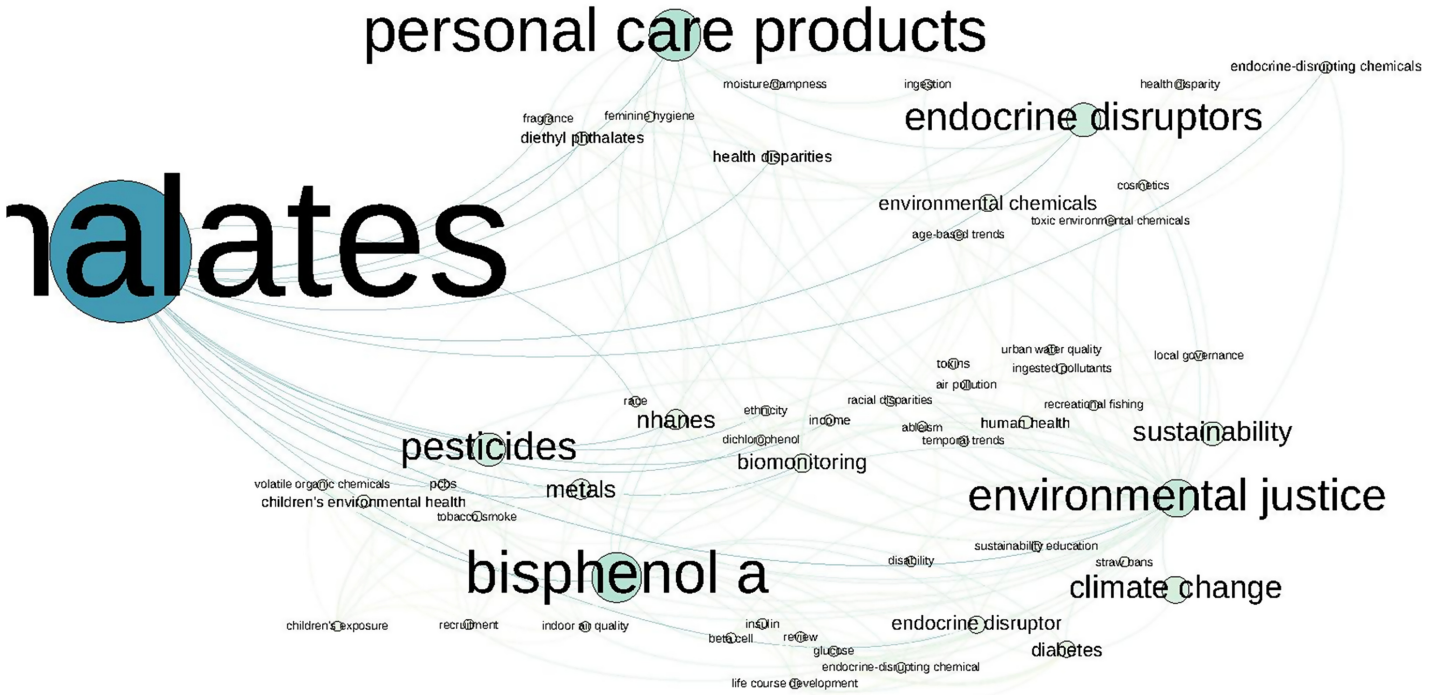

Fig. 3. Ego network for environmental justice. This network only includes keywords linked directly (one degree of separation) to other papers that use the term "environmental justice" as a keyword. Larger size of text and darker colour of notes indicate greater centrality of the keyword. Distances between nodes indicate the degree to which the keywords appear in the same papers.

and career advancement" (ITK 2018, p. 5). Outside of Indigenous lands, the same finding is reflected between freshwater plastic pollution research conducted in the global north versus global south with the majority of research "performed in Europe and North America (67%)" and 69% in developed countries compared to developing ones (Blettler et al. 2018, pp. 418, 420). While this paper critiques power relations of dominant science institutions and colonial geographies, it did not examine whether the few studies in developing nations were conducted by "parachute" researchers from developed nations or by local researchers.

Models against Indigenous Sovereignty

We also saw a consistent trend in published literature that implicitly worked *against* the Indigenous Sovereignty models of justice: many peer-reviewed articles claimed to be the first to know about plastic pollution in Indigenous lands, even when they also acknowledged Indigenous people were part of the research who lived in the area and thus knew about plastics (e.g., Laglbauer et al. 2014; Lusher et al. 2015; Mallory et al. 2021; Huntington et al. 2020; Pinzone et al. 2021). In almost all cases, these Indigenous co-researchers were not named or listed as authors. Attribution experts Anderson and Christen write that, "Firsting [stating that a researcher is the first to do or know something] is a linguistic act that supports and makes possible the physical act of taking: it is, fundamentally, an act of settler-colonial attribution. Firsting names something in order to erase what was before it—eliding both a previous existence and continued presence. Firsting, then, is a mechanism that supports a colonial property paradigm of possession through taking, naming, and attributing" (Anderson and Christen 2019, p. 121; see also O'Brien 2010). As such, taking up Indigenous Sovereignty models of justice in science would require changing cultural norms in the field, including but not limited to

claims of novel knowledge in Indigenous homelands and attributing Indigenous knowledge from hunters, fishers, guides, and associations to non-Indigenous authors (see ITK 2018 for more).

Alignment and contradiction between models

Of the articles that were read in their entirety, Fig. 4 shows which models of justice appeared the most often. While the single models of distributive justice (23%, often occupational health studies), developmental justice (13%), and procedural justice (3%) existed, more than half of the articles had more than one model of justice and these combinations varied considerably. Within these cases, sometimes the models were well aligned and built on one another, but just as often they contradicted one another. In this final section, we look at some of the key alignments and contradictions. This is not an exhaustive inventory, but an effort to describe some of the key relations between models for researchers to consider moving forward.

Alignments

Distributive and procedural

In the classic EJ literature, distributive justice problems (uneven harms and benefits) are often addressed with procedural justice solutions (structural changes such as policy or participation by those harmed in governance generally) (e.g., Chavis and Lee 1987, p. xv; UNEP 2021, 13; Whyte

Fig. 4. Prevalence of combinations of models of justice used in individual articles that were close read (n = 56). Darker colours and larger sizes show higher sums of occurrence. Dist = Distributive. Dev = Developmental. Proc = Procedural. Envt = Environment-first. Indig = Indigenous Sovereignty.

2017, p. 116). We found the same trend in our corpus: 20% of our closely read documents used these two models in combination exclusively, and another 18% included a third model (**Fig. 4**). These combinations most often occurred when identification of structural discrimination in the findings was accompanied by calls for stricter policies, laws, regulation, and oversight in the conclusion of the study (e.g., Ruiz et al. 2018; DeMatteo et al. 2012, p. 440; Varshavsky et al. 2020, p. 2).

However, most of these papers do not invoke procedural justice in its traditional definition, which emphasizes fairness in political representation and decision-making powers for different groups. That is, although upstream models of distributive justice critique weak governance structures and make expert appeals to policy makers for new policies or treaties (e.g., Charboneau and Koger 2008, N'Dri et al. 2015; Korfali et al. 2013), rarely do they directly address the need for more working-class, Global South, racial minority, women, gender minority, and Indigenous representation in politics, research, or grassroots advocacy work (exceptions include GAIA 2019, p. 40; Liboiron et al. 2021)

Multiple alignments within one text

There are some instances where multiple models – three or more – are aligned in the same work. This trend is confined almost exclusively to justice-oriented research groups and grey literature. For instance, GAIA's plastic pollution research is fairly unique in that their work encompasses nearly the full range of models of justice outlined here, including distributive justice by showing how plastics uniquely harm certain groups of people (e.g., Southeast Asian countries in the global waste trade, GAIA 2019), procedural justice in the demand to have waste pickers and other key rightsholders participate in decision making (GAIA 2019, p. 40), critiques of developmental justice in recommendations that foreground the need to reduce the production of plastics and hold companies accountable (e.g., Liamzon et al. 2020), and implicit invocations of environment-first justice (Liamzon et al. 2020, p. 6). GAIA clearly aligns these various models of justice together *against* developmental justice by showing how industry growth, profit, and waste practices are at the root of these injustices.

Contradictions

Contradictions between models of justice were more common and more diverse than alignments within our corpus. Often one section of an article, such as introductions, would have an opposing model of justice and contradictory values compared to another section of the text, such as findings or conclusions. The following analyses between or within select models of justice are not an exhaustive list, but it does highlight a few of the most frequently encountered tensions between models of justice. **Table 5** provides a summary.

The dominance of developmental justice

A common form of contradiction occurred in papers that paired developmental justice with nearly any other form of justice. These papers would often use a non-development model of justice in the introduction or design of the article and later recommend solutions that aligned with developmental justice. For example, Huysman et al. (2017, p. 46) gesture to oil extraction as the root of plastic waste when they write that, "The production of plastics consumes yearly 4 to 8 % of the global crude oil extraction". This is an argument against developmental justice. But they then advocate for a circular economy where plastics are brought into waste-to-energy structures, which leaves the issue of extraction and production untouched. Similarly, Fucic et al. (2018) frame the production of endocrine disruptors as the core problem in how construction industries lead to increased occupational and regional exposure to endocrine disruptors: "In Europe, 20% of plastics production is used in the construction sector … However, there is no knowledge of the possible interaction of plastic materials with building materials, which may cause biological effects (synergistic and/or additive effects), and consequently no occupational safety protocols for work with such complex mixtures containing

ED" (Fucic et al. 2018, p. 3). However, rather than proposing decreases in the production of endocrine disruptors, they recommend enhanced occupational surveillance by biomonitoring workers as the way to reduce exposure (see also DeMatteo et al. 2012, p. 440 for a similar argument that recommends substitution or re-engineering rather than biomonitoring). In all cases, both the root of the problem and the solution lie in the development models. The dominance of developmental justice in the framing of the problem of plastic pollution leads to solutionism, or the idea that all solutionism, or the idea that complex social, cultural, environmental, and economic problems have a technical fix (Rittel and Webber 1973).

From the perspective of justice movements and theories of change, placing both the problem and the solution within the same paradigm "means that only the most narrow of parameters of change are possible and allowable… *For the master's tools will never dismantle the master's house*. They may allow us to temporarily beat him at his own game, but they will never enable us to bring about genuine change" (Lorde 2012 [1979], pp. 111–112, emphasis in original). This is one reason that understanding models of justice can be useful to scientists and users of science: the intervention into the problem must address the injustices specific to the problem, rather than reach for incompatible solutions such as recycling, avoidance, or behaviour change that do not address the problem specifically (Rittel and Weber 1973; Liboiron 2014).

Distributive justice vs developmental justice

Though 8% of papers used distributive and developmental justice models together, in its most upstream forms, distributive justice is antithetical to developmental justice. Distributional justice models distinguish between the unequal responsibilities for and vulnerabilities to plastic pollution. That is, distributive justice shows us that consumers are not as responsible for plastic pollution, environmental harm, and individual harm compared to production, extraction, and corporations (e.g., GAIA 2019; Ruiz et al. 2018, p. 201), and that low-income groups in the Global South are not as responsible as peoples in the Global North (e.g., Petrlik et al. 2021, Stoett and Vince 2019). Developmental justice, on the other hand, supports the role of industry and economies in producing more of these products and effluents, which in turn accrue harms and benefits unevenly, and thus perpetuate distributive injustice. In other words, they erase the systems that cause unevenness by focusing on and naturalizing the symptoms of those systems instead.

We found a striking contradiction in the corpus in how particular developmental interpretations of "downstream" distributive justice were used to naturalize uneven harm. Most of these were studies of the impacts of plastic additives on different ethnic, racial, socio-economic, gender, and other groups, and they worked to locate the unevenness within those being harmed rather than the production of harmful chemicals. For example, Trasande et al.'s (2013) project on uneven phthalate levels in children from different ethnicities and races explains this correlation by speculating that that this correlation emerges from different consumer purchasing habits and genetic and epigenetic differences among the children's families rather than the excessive production of polymer associated chemicals, siting decisions, systemic poverty and (or) racism, or corporate negligence (2013, p. 505). In this way, studies that use a distributive justice framework can fail to observe any of the tenants of distribute justice itself.

Indigenous sovereignty vs developmental justice

Some forms of justice are so antithetical to one another that the use of one can implicitly argue against other forms of justice even if they are not overtly discussed. One case is the relationship between developmental justice and Indigenous sovereignty. Indigenous sovereignty explicitly challenges developmental justice by highlighting the negative impacts of industrial extraction, waste, and growth on Indigenous or local peoples. For example, GAIA's #StopWasteColonialism Campaign challenges

"the effects of waste colonialism in the African continent.... Where our resources [extracted from colonial states/industries] are returned to us, in the form of waste and cheap products made from toxic recycled materials. Where plastic waste has infiltrated its way into our land, oceans and physical bodies, severing our cultural connections with the earth and violating our rights to a clean and healthy environment... We demand that the health and wellbeing of our communities be prioritized over profit" (GAIA 2021).

The Indigenous sovereignty model also challenges narratives about the relationships between plastics and "humankind" as a category, which requires a complete absence of distributive justice that turns all people into one equally accountable category (Liboiron and Lepawsky 2022b). Many scientific studies make claims such as, "Human behaviour is the sole source of marine litter, and changing perceptions and behaviour is key to tackling litter escaping into the natural environment" (Hartley et al. 2018, p. 945) or that "Humans are involved in plastic pollution and micro(nano)plastic presence in the environment in different dimensions of the problem: they caused it, can help address it, and may suffer from its impact" (Soares et al. 2020, p. 9). In these arguments, a particular type of human comes to stand in for all of humankind: a polluting, ignorant, usually affluent human in need of education. Yet none of these narratives account for the people represented by GAIA's work, nor Indigenous peoples and their conservation efforts. Industrial and economic processes premised on constant growth and disposability are relatively new and come from specific cultures (Meikle 1995; Strasser 1999; D'Ailsa et al. 2014). Arguments about "humans" or "the" economy are "universalizing project[s], [that] serve to re-invisibilize the power of Eurocentric narratives, again re-placing them as the neutral and global perspective" (Davis and Todd 2017, p. 762). "Humankind" or "people" and their relationship to plastic, then, are "not precise enough terms for many Indigenous peoples, because they sound like all humans are implicated in and affected by colonialism, capitalism and industrialization in the same ways" (Whyte 2017, p. 159). Thus, when scientists use arguments that foreground humans, people in general, or consumers as a general category, they are also arguing against both Indigenous sovereignty and distributive justice models.

Conclusion

The most common models of justice identified in the corpus are developmental justice (the right of industry to grow and produce) and distributive justice (the inequitable distributions of harms). The second most common models were procedural justice (the right of various groups to be involved in decision making as well as the need for strong legal, policy, and regulatory frameworks), and environment-first justice (which prioritizes the rights of animals and environments), while rare, Indigenous sovereignty models of justice (where Indigenous peoples have the right to govern their lands) were potently and overtly described in the corpus.

The models of justice identified here are just those that were evident (latently or overtly) in our reviewed plastic pollution scientific corpus. It does not include an exhaustive overview of all models of justice since many are missing, including abolitionist justice, disability justice, or anti-racism, for example. Nor does it account for models of justice that are more common outside of English-language regions since our search was only in English. This does not mean that scientists are unaware of or do not practice within other models of justice, but that they are not found in the pages of scientific papers we reviewed. Indeed, we know full well that scientists often downplay, soft pitch, or code switch justice frameworks in their scientific research to fall within professional norms that often divide justice from science, and that they may publish or practice justice work overly in other professional spaces (e.g., Junco 2022).

At the same time, *every* article in the corpus mobilized at least one concept of "goods sought and bads fought" (Liboiron and Lepawsky 2022a). Such ideas do not arise from scientific findings themselves,

but from social and cultural realms in which science is funded, created, and used (Sismondo 2011). Science can tell us the abundance of plastics in a body of water or the levels of endocrine disrupting compounds in a blood stream, but it cannot tell us whether those numbers or that presence is good or bad (Vogel 2009; Vogel 2013, Manfield 2012). Science and values are not separate. Scientist Mary O'Brien writes about how "once you are a scientist . . . you take a political side. There are infinite questions that you could ask about the universe, but . . . you must choose to ask only certain questions. Asking certain questions means not asking other questions, and this decision has implications for society, for the environment, and for the future. The decision to ask any question, therefore, is necessarily a value-laden, social, political decision as well as a scientific decision" (1993, p. 706; Pine and Liboiron 2015). Indeed, many environmental scientists go into environmental science precisely because they wish to impact the world for good.

This study is designed to support scientists and other researchers in making these decisions by demonstrating which models of justice are already being used, drawing out the nuances of their use and relationships to one another. As scientists, it is likely that we will want to be informed and active decision makers around the models of justice being mobilized in our collaborations and in our fields.

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Author contributions

ML, RL, EE, and IW-F conceived and designed the study. ML, RL, EE, and IW-F performed the experiments/collected the data. ML, RL, EE, and IW-F analyzed and interpreted the data. ML and IW-F contributed resources. ML, RL, and IW-F drafted or revised the manuscript.

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CRediT statement

ML (lead author): Conceptualization, methodology, formal analysis, investigation, resources, mentorship, writing, editing, visualization, organization, funding acquisition, and emotional labour. RL: Conceptualization, methodology, formal analysis, investigation, data curation, writing, editing, organization, and emotional labour. EE: Conceptualization, methodology, formal analysis, and emotional labour. IW (anchor author): Conceptualization, methodology, formal analysis, investigation, mentorship, editing, and emotional labour.

Competing interest statement

The authors declare there are no competing interests.

Data availability statement

Data generated or analysed during this study are available from the third party site Zotero and links are provided within the published article.

References

Abalansa S, El Mahrad B, Vondolia GK, Icely J, and Newton A. 2020. The marine plastic litter issue: A social-economic analysis. Sustainability (Switzerland) 12(20): 1–27. DOI: 10.3390/su12208677

Adeyi AA, and Babalola BA. 2019. Bisphenol-A (BPA) in Foods Commonly Consumed in Southwest Nigeria and Its Human Health Risk. Scientific Reports 9(1). DOI: 10.1038/s41598-019-53790-2

Altman R. 2021. The myth of historical bio-based plastics. Science, 373(6550): 47–49. PMID: 34210874

Anderson J, and Christen K. 2019. Decolonizing attribution: Traditions of exclusion. Journal of Radical Librarianship, 5: 113–152.

Aragaw TA. 2021. The macro-debris pollution in the shorelines of Lake Tana: First report on abundance, assessment, constituents, and potential sources. Science of The Total Environment 797: 149235. PMID: 34346355 DOI: 10.1016/j.scitotenv.2021.149235

Arbuckle TE, Marro L, Davis K, Fisher M, Ayotte P, Bélanger P, et al. 2015. Exposure to Free and Conjugated Forms of Bisphenol a and Triclosan among Pregnant Women in the MIREC Cohort. Environmental Health Perspectives, 123(4): 277–284. DOI: 10.1289/ehp.1408187

Arksey H, and O'Malley L. 2005. Scoping studies: Towards a methodological framework. International Journal of Social Research Methodology, 8(1): 19–32. DOI: 10.1080/1364557032000119616

Autian J. 1973. Toxicity and health threats of phthalate esters: Review of the literature. Environmental Health Perspectives 4: 3–26. PMID: 4578674 DOI: 10.1289/ehp.73043

Beaumont NJ, Aanesen M, Austen MC, Börger T, Clark JR, Cole M, et al. 2019. Global ecological, social and economic impacts of marine plastic. Marine Pollution Bulletin 142: 189–195. PMID: 31232294 DOI: 10.1016/j.marpolbul.2019.03.022

Belova A, Greco SL, Riederer AM, Olsho LEW, and Corrales MA. 2013. A Method to Screen U.S. Environmental Biomonitoring Data for Race/Ethnicity and Income-Related Disparity. Environmental Health 12(December): 114. DOI: 10.1186/1476-069X-12-114

Bergman A, Heindel JJ, Jobling S, Kidd K, and Zoeller TR. 2013. State of the Science of Endocrine Disrupting Chemicals 2012: Summary for Decision-Makers. World Health Organization. [online]: Available from extranet.who.int/iris/restricted/handle/10665/78102

Bijker WE. 1997. Of Bicycles, Bakelites, and Bulbs: Toward a Theory of Sociotechnical Change. MIT press.

Bläsing M, and Amelung W. 2018. Plastics in soil: Analytical methods and possible sources. Science of The Total Environment 612: 422–435. PMID: 28863373 DOI: 10.1016/j.scitotenv.2017.08.086

Blettler MCM, Abrial E, Khan FR, Sivri N, and Espinola LA. 2018. Freshwater plastic pollution: Recognizing research biases and identifying knowledge gaps. Water Research, 143: 416–424. PMID: 29986250 DOI: 10.1016/j.watres.2018.06.015

Blue G, Bronson K, and Lajoie-O'Malley A. 2021. Beyond distribution and participation: A scoping review to advance a comprehensive environmental justice framework for impact assessment. Environmental Impact Assessment Review, 90: 106607.

Bond AL, Hutton I, and Lavers JL. 2021. Plastics in regurgitated flesh-footed shearwater (*Ardenna Carneipes*) boluses as a monitoring tool. Marine Pollution Bulletin, 168: 112428. PMID: 33940375

Bond AL, and Lavers JL. 2013. Effectiveness of emetics to study plastic ingestion by leach's storm-petrels (*Oceanodroma Leucorhoa*). Marine Pollution Bulletin, 70(1): 171–175. DOI: 10.1016/j.marpolbul.2013.02.030

Bond A, and Liboiron M. 2018. Science with heart. *Discard Studies*. [online]: Available from discardstudies.com/2018/12/03/science-with-heart/.

Borrows J. 2010. Canada's indigenous constitution. University of Toronto Press.

Bullard RD. 2018. Dumping in dixie: Race, class, and environmental quality. Routledge.

Callison C, and Young LM. 2019. Reckoning: Journalism's limits and possibilities. Oxford University Press.

Canada Minister of Health. 2016. Consolidated federal laws of Canada, phthalates regulations. [online]: Available from laws-lois.justice.gc.ca/eng/regulations/SOR-2016-188/page-1.html.

Carter TL, Jennings LL, Yamina Pressler AC, Gallo AAB, Erika Marín-Spiotta CS, Ghezzehei T, et al. 2021. Towards diverse representation and inclusion in soil science in the United States. Soil Science Society of America Journal 85(4): 963–974.

Caruso G. 2015. Plastic Degrading Microorganisms as a Tool for Bioremediation of Plastic Contamination in Aquatic Environments. Journal of Pollution Effects & Control, 3(3). DOI: 10.4172/2375-4397.1000e112

Charboneau JP, and Koger SM. 2008. Plastics, pesticides and PBDEs: Endocrine disruption and developmental disabilities. Journal of Developmental and Physical Disabilities 20(2):115–128. DOI: 10.1007/s10882-007-9083-3

Chavis B, and Lee C. 1987. United church of Christ commission on racial justice. Toxic Wastes and Race in the United States. A National Report on the Racial and Socio-Economic Characteristics of Communities with Hazardous Waste Sites. 451 p.

Clayton S. 2000. New ways of thinking about environmentalism: Models of justice in the environmental debate. Journal of Social Issues 56(3): 459–474. DOI: 10.1111/0022-4537.00178

ClientEarth. 2021. Court win: Game over for plastics lobby in BPA human health impacts case | clientEarth. [online]: Available from clientearth.org/latest/press-office/press/court-win-game-over-for-plastics-lobby-in-bpa-human-health-impacts-case/.

Coffin S, Wyer H, and Leapman JC. 2021. Addressing the Environmental and Health Impacts of Microplastics Requires Open Collaboration between Diverse Sectors. PLoS Biology, 19(3): e3000932.

Coulthard GS. 2014. Red skin, white masks: Rejecting the colonial politics of recognition. Minnesota, Minneapolis.

Cowger W. 2020. Environmental justice and litter. DOI: 10.17605/OSF.IO/3XTBV

Crang M, Alex Hughes NG, Norris L, and Ahamed F. 2013. Rethinking governance and value in commodity chains through global recycling networks. Transactions of the Institute of British Geographers 38(1): 12–24. DOI: 10.1111/j.1475-5661.2012.00515.x

Crenshaw Kimberlé. 2017. On intersectionality: Essential writings. New Press, New York.

D'Alisa G, Demaria F, and Kallis G. 2014. Degrowth: A Vocabulary for a New Era. Routledge.

Dalu MTB, Cuthbert RN, Muhali H, Chari LD, Manyani A, Masunungure C et al. 2020. Is awareness on plastic pollution being raised in schools? Understanding perceptions of primary and secondary school educators. Sustainability (Switzerland), 12(17): 6775. DOI: 10.3390/SU12176775

Davis H, and Todd Z. 2017. On the importance of a date, or, decolonizing the anthropocene. ACME: An International Journal for Critical Geographies 16(4): 761–780.

DeMatteo R, Keith MM, Brophy JT, Anne Wordsworth AE. Watterson MB, Anne Rochon Ford MG, et al. 2012. Chemical exposures of women workers in the plastics industry with particular reference to breast cancer and reproductive hazards. New Solutions: A Journal of Environmental and Occupational Health Policy: NS, 22(4): 427–448. PMID: 23207955 DOI: 10.2190/NS.22.4.d

Dirlik A. 2007. Global south: Predicament and promise. The Global South 1(1): 12–23.

Donohue MJ, Julie Masura TG, Rolf Ream JD Baker KF, and Lerner DT. 2019. Evaluating exposure of northern fur seals, *Callorhinus ursinus*, to microplastic pollution through fecal analysis. Marine Pollution Bulletin, 138:213–221. PMID: 30660265 DOI: 10.1016/j.marpolbul.2018.11.036

Ewall M. 2012. Legal tools for environmental equity vs.environmental justice. Sustainable Development Law & Policy 13(1): 4–13.

Fisher B, Turner RK, and Morling P. 2009. Defining and classifying ecosystem services for decision making. Ecological Economics 68(3): 643–653. DOI: 10.1016/j.ecolecon.2008.09.014

Fucic A, Galea KS, Radu Corneliu Duca MEY, Nadine Frery LG, Thorhallur Ingi Halldorsson II, Sophie Ndaw ER, et al. 2018. Potential health risk of endocrine disruptors in construction sector and plastics industry: A new paradigm in occupational health. International Journal of Environmental Research and Public Health 15(6): 1229. PMID: 29891786 DOI: 10.3390/ijerph15061229

GAIA. 2015. Open letter to ocean conservancy regarding the report 'Stemming the Tide.'

GAIA. 2019. Plastics exposed: How waste assessments and brand audits are helping Philippine cities fight plastic pollution. Philippines: Quezon City.

GAIA. 2021. "Stop waste colonialism." *Global Alliance for Incinerator Alternatives*. [online]: Available from no-burn.org/stop-waste-colonialism/.

Gewirtz S, and Cribb A. 2002. Plural conceptions of social justice: Implications for policy sociology. Journal of Education Policy 17(5): 499–509. DOI: 10.1080/02680930210158285

Gilio-Whitaker D. 2019. As long as grass grows: The indigenous fight for environmental justice, from colonization to standing rock. Beacon Press.

Grant ML, O'Hanlon NJ, Lavers JL, Masden EA, James NA, and Bond AL. 2021. A standardised method for estimating the level of visible debris in bird nests. Marine Pollution Bulletin, 172: 112889. PMID: 34454385 DOI: 10.1016/j.marpolbul.2021.112889

Gregson N, Crang M, Fuller S, and Holmes H. 2015. Interrogating the Circular Economy: The Moral Economy of Resource Recovery in the EU. Economy and Society, 44(2): 218–243. DOI: 10.1080/03085147.2015.1013353

Guo J-J, Xian-Pei Huang LX, Yi-Ze Wang Y-WL, Hui Li Q-YC, Mo HC, and Wong M-H. 2020. Source, migration and toxicology of microplastics in soil. Environment International, 137: 105263. PMID: 32087481 DOI: 10.1016/j.envint.2019.105263

Haraway DJ. 2013. Primate visions: Gender, race, and nature in the world of modern science. Routledge.

Harding S. 1995. 'Strong Objectivity': A Response to the New Objectivity Question. Synthese, 104(3): 331–349. DOI: 10.1007/BF01064504

Hardman S. 2021. "How Do Plastic Credits Work?" *Plastic Collective*. [online]: Available from plasticcollective.co/how-do-plastic-credits-work/.

Hartley BL, Pahl S, Veiga J, Vlachogianni T, Vasconcelos L, Maes T, et al. 2018. Exploring public views on marine litter in Europe: Perceived causes, consequences and pathways to change. Marine Pollution Bulletin, 133: 945–55. PMID: 29910143 DOI: 10.1016/j.marpolbul.2018.05.061

Healey R, and Pepper A. 2021. Interspecies justice: Agency, self-determination, and assent." Philosophical Studies, 178(4): 1223–1243. DOI: 10.1007/s11098-020-01472-5

Hoffman K, Webster TF, Bartell SM, Weisskopf MG, Fletcher T, and Vieira MV. 2011. "Private drinking water wells as a source of exposure to perfluorooctanoic acid (PFOA) in communities surrounding a fluoropolymer production facility. Environmental Health Perspectives, 119(1): 92–97. PMID: 20920951

Holifield R, Porter M, and Walker G. 2009. Spaces of environmental justice: Frameworks for critical engagement. Antipode 41(4): 591–612.

Holmes AGD. 2020. Researcher positionality–A consideration of its influence and place in qualitative research–A new researcher guide. Shanlax International Journal of Education, 8(4): 1–10.

Huang L-P, Lee C-C, Hsu P-C, and Shih TS. 2011. The Association between Semen Quality in Workers and the Concentration of Di(2-Ethylhexyl) Phthalate in Polyvinyl Chloride Pellet Plant Air. Fertil. Steril, 96(1): 90–94. DOI: 10.1016/j.fertnstert.2011.04.093

Huntington A, Corcoran PL, Liisa Jantunen CT, Sarah BernsteinStern GA, and Rochman CM. 2020. A first assessment of microplastics and other anthropogenic particles in Hudson Bay and the surrounding eastern Canadian Arctic waters of Nunavut. Facets, 5(1): 432–454.

Huysman S, De Schaepmeester J, Ragaert K, Dewulf J, and De Meester S. 2017. "Performance indicators for a circular economy: A case study on post-industrial plastic waste." Resources, Conservation and Recycling 120: 46–54. DOI: 10.1016/j.resconrec.2017.01.013

ITK. 2018. National Inuit Strategy on Research. Inuit Tapiriit Kanatami

Jambeck JR, Roland Geyer CW, Siegler TR, Miriam Perryman AA, Narayan R, and Lavender Law K. 2015. Plastic waste inputs from land into the ocean. Science 347(6223): 768–771. PMID: 25678662 DOI: 10.1126/science.1260352

Jang YC, Hong S, Lee J, Lee MJ, and Shim WJ. 2014. Estimation of lost tourism revenue in Geoje island from the 2011 marine debris pollution event in South Korea. Marine Pollution Bulletin, 81(1): 49–54. PMID: 24635983 DOI: 10.1016/j.marpolbul.2014.02.021

Junco CD 2022. "A Weighty Footnote." *Inside Higher Ed*. [online]: Available from insidehighered.com/views/2022/04/05/raise-racist-scientific-history-science-papers-opinion.

Khan F, Ahmed W, and Najmi A. 2019. Understanding Consumers' Behavior Intentions towards Dealing with the Plastic Waste: Perspective of a Developing Country. Resources, Conservation and Recycling 142: 49–58. DOI: 10.1016/j.resconrec.2018.11.020

Kobrosly RW, Parlett LE, Stahlhut RW, Barrett ES, and Swan SH. 2012. Socioeconomic Factors and Phthalate Metabolite Concentrations among United States Women of Reproductive Age. Environmental Research, 115(May): 11–17. DOI: 10.1016/j.envres.2012.03.008

Korfali SI, Sabra R, Jurdi M, and Taleb RI. 2013. Assessment of toxic metals and phthalates in children's toys and clays. Archives of Environmental Contamination and Toxicology, 65(3): 368–381. PMID: 23780492 DOI: 10.1007/s00244-013-9925-1

Kumar A, Samadder SR, Kumar N, and Singh C. 2018. Estimation of the generation rate of different types of plastic wastes and possible revenue recovery from informal recycling. Waste Management, 79: 781–790. PMID: 30343811 DOI: 10.1016/j.wasman.2018.08.045

Laglbauer BJL, Melo Franco-Santos R, Miguel Andreu-Cazenave LB, Maria Papadatou AP, Grego M, and Deprez T. 2014. Macrodebris and Microplastics from Beaches in Slovenia. Marine Pollution Bulletin, 89(1–2): 356–366. PMID: 25440193 DOI: 10.1016/j.marpolbul.2014.09.036

Lai LSL, and To MW. 2015. Content analysis of social media: A grounded theory approach. Journal of Electronic Commerce Research, 16(2): 138.

Levac D, Colquhoun H, and O'Brien KK. 2010. Scoping studies: Advancing the methodology. Implementation Science, 5(1): 69. DOI: 10.1186/1748-5908-5-69

Liamzon C, Benosa S, Aliño M, and Baconguis B. 2020. Sachet Economy: Big Problems in Small Packets. Global Alliance for Incinerator Alternatives, Quezon City, Philippines.

Liboiron M. 2014. Solutions to waste and the problem of scalar mismatches. *Discard Studies*. [online]: Available from discardstudies.com/2014/02/10/solutions-to-waste-and-the-problem-of-scalar-mismatches/.

Liboiron M. 2018. How plastic is a function of colonialism. *Teen Vogue*.

Liboiron M. 2021. Pollution is colonialism. Duke University Press.

Liboiron M, Justine Ammendolia KW, Alex Zahara HB, Jessica Melvin CM, Dawe N, Wells E et al. 2017. Equity in author order: A feminist laboratory's approach. Catalyst: Feminism, Theory, Technoscience, 3(2):1–17. DOI: 10.28968/cftt.v3i2.28850

Liboiron M, Alex Zahara KH, Christina Crespo BMN, Vonda Wareham-Hayes EE, Muise C, Jane Walzak M et al. 2021. Abundance and types of plastic pollution in surface waters in the eastern arctic (Inuit Nunangat) and the case for reconciliation science. Science of The Total Environment, 782: 146809. DOI: 10.1016/j.scitotenv.2021.146809

Liboiron M, and Lepawsky J. 2022a. Discard studies: Wasting, systems, and power. MIT Press, Cambridge, MA.

Liboiron M, and Lepawsky J. 2022b. There's no such thing as we: A theory of difference. *In* Discard studies: Wasting, systems, and power. MIT Press, Cambridge, MA. pp. 97–124

Lin D, Guangrong Yang PD, Shenhua Qian LZ, Yang Y, and Fanin N. 2020. Microplastics negatively affect soil fauna but stimulate microbial activity: Insights from a Field-Based microplastic addition experiment. Proceedings of the Royal Society B: Biological Sciences, 287(1934): 20201268. DOI: 10.1098/rspb.2020.1268

Lorde A. 2012. The master's tools will never dismantle the master's house. *In* Sister outsider: Essays and speeches. Crossing Press, Berkeley, CA. pp. 110–114.

Lusher AL, Tirelli V, O'Connor I, and Officer R. 2015. Microplastics in arctic polar waters: the first reported values of particles in surface and sub-surface samples. Scientific Reports 5(1): 1–9.

Lynn H, Rech S, and Samwel M. 2017. Plastics, gender and the environment. Women Engage for a Common Future and the United Nations.

MacBride S. 2013. Recycling reconsidered: The present failure and future promise of environmental action in the United States. MIT Press.

MacBride S. 2019. Does recycling actually conserve or preserve things?" *Discard Studies*. [online]: Available from discardstudies.com/2019/02/11/12755/.

Magaya S, and Fitchett JM. 2022. Approaching Positionality in Research on Indigenous Knowledge Systems. *In* Indigenous Knowledge and Climate Governance: A Sub-Saharan African Perspective. *Edited by* EE Ebhuoma and L Leonard, Springer International Publishing. pp. 81–93. DOI: 10.1007/978-3-030-99411-2_7

Mah A. 2021. Future-Proofing capitalism: The paradox of the circular economy for plastics. Global Environmental Politics, 21(2): 121–142. DOI: 10.1162/glep_a_00594

Mallory ML, Julia Baak CG, Mallory OE, Manley B, Swan C, and Provencher JF. 2021. Anthropogenic litter in marine waters and coastlines of arctic Canada and West Greenland. Science of The Total Environment, 783: 146971. PMID: 33865122 DOI: 10.1016/j.scitotenv.2021.146971

Manfield B. 2012. Environmental health as biosecurity: 'seafood choices,' risk, and the pregnant woman as threshold. Annals of the Association of American Geographers 102(5): 969–976. DOI: 10.1080/00045608.2012.657496

McGregor D. 2018. Mino-Mnaamodzawin: Achieving indigenous environmental justice in Canada. Environment and Society, 9(1): 7–24. DOI: 10.3167/ares.2018.090102

McGregor D. 2014. Traditional knowledge and water governance: The ethic of responsibility. AlterNative: An International Journal of Indigenous Peoples 10(5): 493–507. DOI: 10.1177/117718011401000505

Meeker JD, Sathyanarayana S, and Swan SH. 2009. Phthalates and other additives in plastics: Human exposure and associated health outcomes. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526): 2097–2113. DOI: 10.1098/rstb.2008.0268

Meikle JL. 1995. American plastic: A cultural history. Rutgers University Press, New Brunswick, NJ.

Melvin J, Madeline Bury JA, Mather C, and Liboiron M. 2021. Critical gaps in shoreline plastics pollution research. Frontiers in Marine Science, 8: 689108. DOI: 10.3389/fmars.2021.689108

Mervins J. 2022. How a culture of white privilege discourages black students from becoming physicists. Science, 375(6584).

Mofijur M, Ahmed SF, Rahman SMA, Arafat Siddiki SY, Islam ABMS, Shahabuddin M. et al. 2021. Source, distribution and emerging threat of micro- and nanoplastics to marine organism and human health: socio-economic impact and management strategies. Environmental Research, 195: 110857. PMID: 33581088 DOI: 10.1016/j.envres.2021.110857

Moore DS, Kosek J, and Pandian A. 2003. Race, Nature, and the Politics of Difference. Duke University Press.

Morgan MS, and Morrison M. 1999. Models as Mediators. Cambridge University Press Cambridge.

N'Dri LA, White-Newsome JL, Corbin-Mark CD, and Shepard PM. 2015. The invisible threat: Bisphenol-A and phthalates in environmental justice communities. Environmental Justice, 8(1): 15–19. DOI: 10.1089/env.2014.0015

Nash Roderick Frazier. 1989. The rights of nature: A history of environmental ethics. Univ of Wisconsin press.

Nelson JW, Madeleine KS Hatch EE, and Webster Thomas F. 2012. Social disparities in exposures to bisphenol A and polyfluoroalkyl chemicals: A cross-sectional study within NHANES 2003-2006. Environmental Health, 11: 10. PMID: 22394520 DOI: 10.1186/1476-069X-11-10

Ngata T. 2018. "An unconquerable tide." *Tina Ngata: Dismantling Frameworks of Domination, Rematriating Ways of Being.* [online]: Available from tinangata.com/2018/02/18/2494/.

Ngata T, and Liboiron M. 2020. Māori Plastic pollution expertise and action in aotearoa. *CLEAR*. [online]: Available from civiclaboratory.nl/2020/07/13/maori-plastic-pollution-expertise-and-action-in-aotearoa/.

Njeru J. 2006. The urban political ecology of plastic bag waste problem in Nairobi, Kenya. Geoforum, 37(6): 1046–1058. DOI: 10.1016/j.geoforum.2006.03.003

O'Brien MH. 1993. Being a scientist means taking sides. BioScience, 43(10): 706–708.

O'Brien JM. 2010. Firsting and Lasting: Writing Indians out of Existence in New England. University of Minnesota Press, Minneapolis, MN.

Okuku EO, Linet Kiteresi GO, Kenneth Otieno JO, Maurine MK, Catherine M, Mbuche M, et al. 2021. Temporal trends of marine litter in a tropical recreational beach: A case study of Mkomani beach, Kenya. Marine Pollution Bulletin 167: 112273. PMID: 33774485

Perovich LJ, Ohayon JL, Cousins EM, Morello-Frosch R, Brown P, Adamkiewicz G, et al. 2018. Reporting to parents on children's exposures to asthma triggers in low-income and public housing,

an interview-based case study of ethics, environmental literacy, individual action, and public health benefits. Environmental Health, 17(1): 48. PMID: 29784007 DOI: 10.1186/s12940-018-0395-9

Petrlik J, Lee Bell BB, Møller M, Jopkova M, and Brabcova K. 2021. Plastic waste poisoning food and threatening communities in Africa, Asia, Central & Eastern Europe and Latin America. International pollutants elimination network (IPEN).

Pine KH, and Liboiron M. 2015. The politics of measurement and action. *In* Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. ACM. pp. 3147–3156

Pinzone M, Nordøy SE, Gauthier E, Cédric M, Das K, and Collard F. 2021. First record of plastic debris in the stomach of a hooded seal pup from the Greenland Sea. Marine Pollution Bulletin, 167: 112350. PMID: 33865037

Pulido L. 2017. Geographies of race and ethnicity ii: Environmental racism, racial capitalism and state-sanctioned violence. Progress in Human Geography 41(4): 524–533. DOI: 10.1177/0309132516646495

Puzis R, Elovici Y, and Dolev S. 2007. Fast algorithm for successive computation of group betweenness centrality. Physical Review E, 76(5): 056709. DOI: 10.1103/PhysRevE.76.056709

Rittel HWJ and Webber MM. 1973. Dilemmas in a general theory of planning. Policy Sciences, 4(2): 155–169. DOI: 10.1007/BF01405730

Robertson AD, and Hairston TW. 2022. Observing whiteness in introductory physics: A case study. Physical Review Physics Education Research, 18(1): 010119. DOI: 10.1103/PhysRevPhysEducRes.18.010119

Rochman CM, Browne AM, Underwood AJ, Van Franeker JA, Thompson RC, and Amaral-Zettler LA. 2016. The ecological impacts of marine debris: Unraveling the demonstrated evidence from what is perceived. Ecology, 97(2): 302–312. PMID: 27145606

Ruiz D, Becerra M, Jagai JS, Ard K, and Sargis RM. 2018. Disparities in environmental exposures to endocrine-disrupting chemicals and diabetes risk in vulnerable populations. Diabetes Care, 41(1): 193–205. PMID: 29142003 DOI: 10.2337/dc16-2765

Schlegel Ivy. 2020. How the plastic industry is exploiting anxiety about COVID-19. *Greenpeace USA*. [online]: Available from greenpeace.org/usa/how-the-plastic-industry-is-exploiting-anxiety-about-covid-19/

Schlosberg David. 2007. Defining environmental justice: Theories, movements, and nature. OUP Oxford.

Sciences-Po Medialab. n.d. Sciencescape. [online]: Available from medialab.github.io/sciencescape/.

Scientists. 2022. Scientists' declaration on the need for governance of plastics throughout their lifecycles.

Shadaan R, and Murphy M. 2020. EDC's as Industrial Chemicals and Settler Colonial Structures. Catalyst: Feminism, Theory, Technoscience, 6(1).

Shim WJ, Hee Hong S, and Eo S. 2018. Marine Microplastics: Abundance, Distribution, and Composition. *In* Microplastic Contamination in Aquatic Environments. Elsevier. pp. 1–26.

Silva MLD, Castro RO, Sales AS, and Araújo FVD. 2018. Marine debris on beaches of arraial do cabo, RJ, Brazil: An important coastal tourist destination. Marine Pollution Bulletin, 130: 153–158. PMID: 29866541 DOI: 10.1016/j.marpolbul.2018.03.026

Singh GG, Harden-Davies AM, Allison EH, Cisneros-Montemayor AM, Swartz W, Crosman KM, et al. 2021. Opinion: Will understanding the ocean lead to 'the Ocean We Want'? Proceedings of the National Academy of Sciences, 118(5): e2100205118.

Sismondo S. 2011. An introduction to science and technology studies. John Wiley & Sons.

Soares J, Miguel I, Venâncio C, Lopes I, and Oliveira M. 2020. Perspectives on micro(Nano)plastics in the marine environment: Biological and societal considerations. Water (Switzerland), 12(11): 1–16. DOI: 10.3390/w12113208

Stoett P, and Vince J. 2019. The plastic-climate nexus linking science, policy, and justice. *Edited by* P. G. Harris. Cambridge Univ Press, Cambridge

Strasser S. 1999. Waste and want: A social history of trash. Metropolitan Books, New York, NY.

Sunstein C, and Nussbaum MC. 2004. Animal Rights: Current Debates and New Directions. Oxford University Press, Oxford; New York.

Thiel M, Luna-Jorquera G, Álvarez-Varas R, Gallardo C, Hinojosa IA, Luna N, et al. 2018. "Impacts of marine plastic pollution from continental coasts to subtropical gyres—Fish, seabirds, and other vertebrates in the SE pacific. Frontiers in Marine Science 5: 238. DOI: 10.3389/fmars.2018.00238

Tishman Environment and Design Center. 2019. U.S. Municipal Solid Waste Incinerators: An Industry in Decline. The New School.

Trasande L, Attina TM, Sathyanarayana S, Spanier AJ, and Blustein J. 2013. Race/Ethnicity-specific associations of urinary phthalates with childhood body mass in a nationally representative sample. Environmental Health Perspectives, 121(4):501–506. PMID: 23428635 DOI: 10.1289/ehp.1205526

UNEP. 2021. NEGLECTED: Environmental Justice Impacts of Marine Litter and Plastic Pollution. United Nations Environment Programme, Nairobi, Kenya.

United Nations. 2008. United Nations Declaration of the Rights of Indigenous Peoples (UNDRIP). United Nations.

Urquhart C. 2012. Grounded Theory for Qualitative Research: A Practical Guide. Sage.

US EPA, OP. 2015. Learn About Environmental Justice. [online]: Available from epa.gov/environmentaljustice/learn-about-environmental-justice.

van den Bergh JCJM, and Botzen WJW. 2015. Monetary Valuation of the Social Cost of CO2 Emissions: A Critical Survey. Ecological Economics, 114: 33–46. DOI: 10.1016/j.ecolecon.2015.03.015

Varshavsky JR, Morello-Frosch R, Harwani S, Snider M, Petropoulou SSE, Park JS, et al. 2020. A Pilot Biomonitoring Study of Cumulative Phthalates Exposure among Vietnamese American Nail Salon Workers. International Journal of Environmental Research and Public Health 17(1): 325. PMID: 31906553 DOI: 10.3390/ijerph17010325

Vogel SA. 2009. The Politics of Plastics: The Making and Unmaking of Bisphenol a 'Safety.' American Journal of Public Health 99(S3):S559–S566. DOI: 10.2105/AJPH.2008.159228

Vogel SA. 2013. Is It Safe?: BPA and the struggle to define the safety of chemicals. University of California Press.

Walker I. 2020a. Is Anyone looking at microplastic exposure with an environmental justice focus? *Twitter*. [online]: Available from twitter.com/dr_imariwalker/status/1321906227677417479.

Walker I. 2020b. 10 Facts you need to know about microplastics. YouTube. [online]: Available from youtube.com/watch?v=UnrjR2ZWePQ

Whyte K. 2016. "Indigenous Experience, Environmental Justice and Settler Colonialism." *Environmental Justice and Settler Colonialism*.

Whyte K. 2017. The Recognition Paradigm of Environmental Injustice. *In* The Routledge Handbook of Environmental Justice. Routledge.

Wijekoon S, and Peter N. 2022. Examining Racial, Ethnic, and Cultural Diversity in Occupational Science Research: Perspectives of Persons of Color. Journal of Occupational Science 0(0): 1–20. DOI: 10.1080/14427591.2022.2119269

Wright SL, and Kelly FJ. 2017. Plastic and Human Health: A Micro Issue? Environmental Science and Technology 51(12): 6634–6647. DOI: 10.1021/acs.est.7b00423

Youth Environment Assembly. 2022. 2022. Summary report, 19–20 February 2022. United Nations Environmental Assembly, Nairobi, Kenya.

Zota AR, Calafat AM, and Woodruff TJ. 2014. Temporal trends in phthalate exposures: findings from the national health and nutrition examination survey, 2001–2010. Environmental Health Perspectives 122(3): 235–241. DOI: 10.1289/ehp.1306681

Appendix A: Search string

We used the following search string for both title, keywords, and abstract, as well as just title and keywords in identifying different published literature in the scoping review: Justice terms: (*justice* OR justness OR unjust OR fairness OR redress OR rights OR ethic* OR unethical OR reparation* OR *equit* OR equalit* OR inequalit* OR moral* OR immoral* OR racis* OR antiracis* OR "anti-racis*" OR reconciliation OR sovereignty OR decolonization OR colonialism OR decolonial OR anticolonial* OR neocolonial* OR socio-economic OR underserved OR violence OR "food desert" OR disabilit* OR ableis* OR classis* OR capitalis* OR misogyn* OR sexis* OR patriarch* OR "labor rights" OR "labour rights" OR "workers' rights" OR "worker rights" OR "worker safety" OR "occupational health" OR "pollution credits" OR "rights of nature")

AND

Plastic research terms: ("plastic* pollution" OR "micro plastic*" OR microplastic* OR "macro plastic*" OR macroplastic* OR "plastic microfiber*" OR "plastic debris" OR "plastic waste" OR "waste plastic*" OR "plastic emission*" OR "plastic production" OR "plastic producer*" OR "single-use plastic*" OR "plastic packaging" OR "plastic bag*" OR "plastic pellet*" OR "marine litter" OR "marine debris" OR "marine plastic*" OR "plastic and environment" OR bisphenol OR phthalate* OR "polyvinyl chloride" OR polyurethane OR "plastic* additive")

AND NOT

("rights reserved" OR "rights resented" OR catheter* OR ethicon)

Appendix B: Keyword network analysis

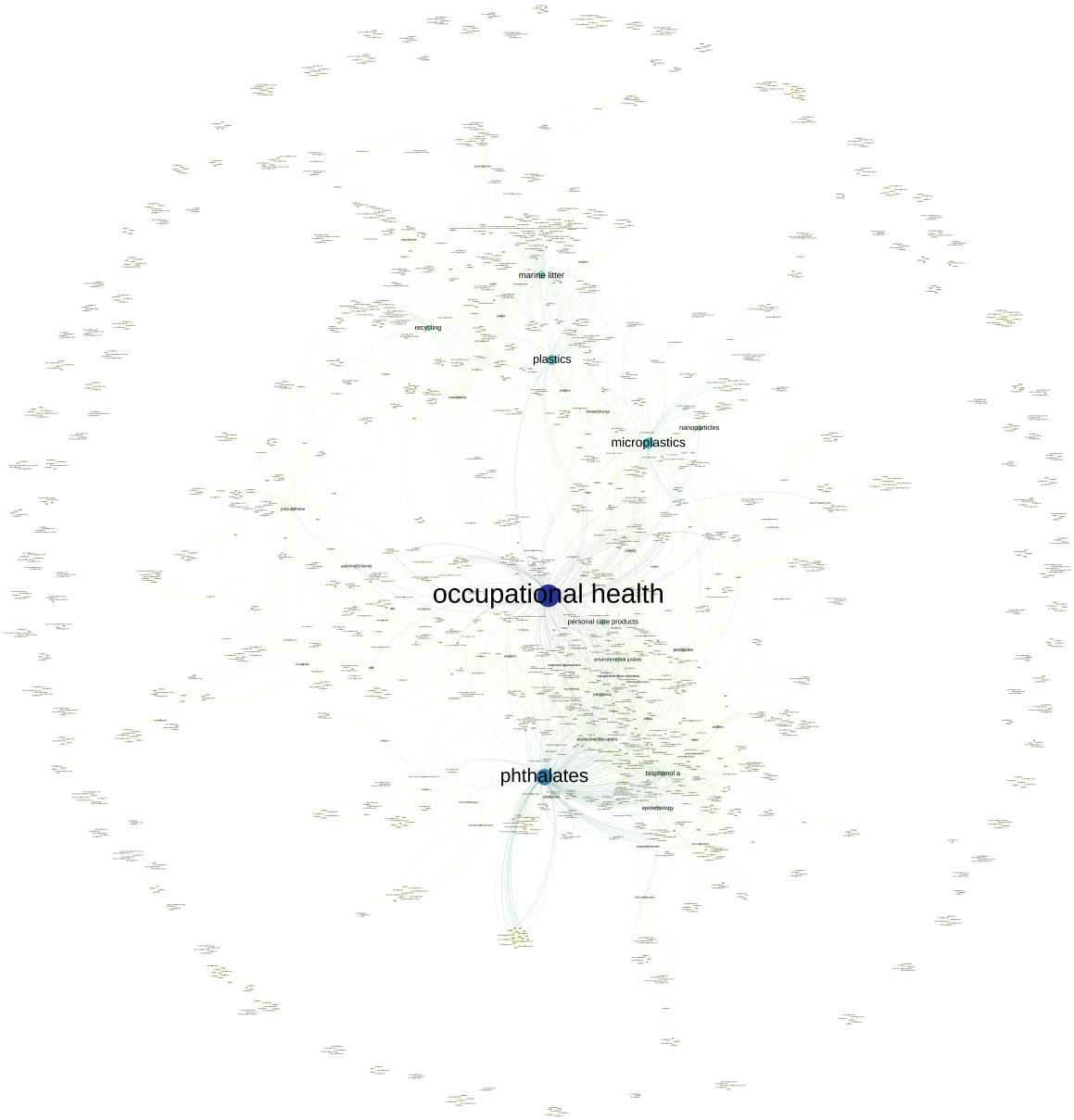

Fig. B1. This network analysis of keywords in articles that included both justice-oriented terms and plastic research terms. 755 articles are included in the original network without filtering, meaning that even entries with keywords that appear a single time and (or) are not linked to other keywords in the larger corpus are included. This allows us to see the lack of cohesion across the corpus. The small clusters around the periphery of the central cluster are keywords, often single articles that meet search criteria but do not link to any other articles via keywords. Larger size of text and darker colour of notes indicate greater centrality of the keyword. Distances between nodes indicate the degree of common use within the corpus–tiny bundles that are unconnected (lower left) are single papers with no keyword connections to any other papers, while more central and closer nodes share keywords across papers.