


RESEARCH ARTICLE

Careful handling of marine plastic litter: Technology assessment and care

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22

Abstract • Waste is a core concern of today's societies. A prominent example is marine plastic litter, which has devastating impacts on ocean ecosystems. But: How can technology assessment (TA) support a careful handling of plastic waste in the sea? And what can care concepts contribute to the practice of TA in this context? In this article, I show that care concepts can help understand the complexity of waste management as well as the environments involved, regulation processes, and technical innovations. Moreover, care concepts could benefit TA practice by sensitizing it not only to cultural, regional, and global concerns, but also to the distribution of responsibility and marginalization processes.

Sorgsamer Umgang mit marinem Plastikmüll: Technikfolgenabschätzung und Fürsorge

Zusammenfassung • Abfall ist ein zentrales Problem der heutigen Gesellschaft. Ein prominentes Beispiel ist der Plastikmüll in den Meeren, der verheerende Auswirkungen auf die Ökosysteme der Ozeane hat. Aber: Wie kann Technikfolgenabschätzung (TA) einen sorgsamen Umgang mit Plastikmüll im Meer unterstützen? Und was können Fürsorge-Konzepte dabei zur TA-Praxis beitragen? In diesem Artikel zeige ich, dass Konzepte der Fürsorge helfen können, die Komplexität der Abfallproblematik sowie die damit verbundenen Umwelten, Regulierungsprozesse und technischen Innovationen zu verstehen. Darüber hinaus könnten diese Konzepte nützlich für die TA-Praxis sein, indem sie sie für kulturelle, regionale und globale Belange, aber auch für die Verteilung von Verantwortung und Marginalisierungsprozesse sensibilisieren.

Keywords • global TA, care, plastic waste, marine litter

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Introduction

Waste is a core concern in today's societies. One example for waste is waste in the ocean. The marine area has gained prominence lately as part of the UN Ocean Decade which started in 2021. Marine waste, also called marine litter or marine debris, consists of variously sized objects, such as ropes, bottles, cans, fish nets and plastic and microplastic particles, the latter representing a substantial fraction of marine waste. Marine litter floats and drifts around – seemingly endlessly as it is submerged and diluted within the vastness of the deep oceans – before it ends up in the deep sea or on the shorelines. Thus, marine litter is not confined to one area but dispersed throughout the oceans on earth, creating a global problem. At the same time, marine litter is not always necessarily visible to humans as a substantial amount resides in spaces largely inaccessible to human intervention, such as the deep sea. In this article, I highlight marine plastic litter, a material which has undoubtedly risen to some fame in the last decade and argue, that care can serve as a tool in technology assessment (TA) practice to reflect on the complexity of global environmental problems. Here is why:

Estimations claim that the global human-made mass of plastic exceeds the living biomass by double (Elhacham et al. 2020). These and other estimations (report from World Economic Forum et al. 2016) have brought plastic into a questionable limelight of attention and characterized it as remnant of socio-technical innovation. Plastic objects are produced as part of a promising innovation and are part of a variety of infrastructures and related practices, from household items to mobility technologies. At the same time, plastic objects often end up on landfills, in rivers and last but not least, in the sea. Once in water or deep in soil, plastic is hard if not impossible to trace or recycle. For example, as soon as plastic litter enters the marine environment, it interacts with the marine ecosystem and marine life. It is often ingested by

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marine life or entangled with it, for example when ropes or packages lead to physical harm or when small plastic particles exert ecotoxicological effects due to leaching its components. Based on this, leading marine scientists have framed marine plastic litter as a core global environmental problem (Napper et al. 2021; Bergmann et al. 2015). Similarly, societal stakeholders, non-governmental organizations, policy makers and citizen groups identified marine plastic litter as highly problematic. This problematization has led to political incentives and to a plethora of technological innovations focused on cleaning the ocean, rivers and streams. ‘Horizon’, the European Union’s Research and Innovation Magazine featured some technological innovations in 2022, among them cleaning robots for picking up waste on the shorelines, cleaning technologies for big and small plastic objects or mobile application for the detection of litter (Willmer 2022). But although technical innovations for combating marine litter are assessed (Bellou et al. 2021), it still needs to be figured out which solutions might work best and for whom and where, who are the societal stakeholders that care about marine plastic litter and how this can be done in a global manner.

cepts are capable of attending to marginalized places, spaces and voices (Puig de la Bellacasa 2010, 2011, 2015) and allow to think about “everything that we do to maintain, continue and repair ‘our world’ so that we can live in it as well as possible” (Tronto 1993, p. 103). Attending to care is insofar relevant, as the ocean is currently featured as carbon storage space crucial for humankind and its survival. This scenario is however only possible with an ocean that is not constantly polluted and in danger but an ocean that is resilient. New technological innovations, global alliances and policy measures for a less polluted ocean will need to be reflected on by TA scholars in the future.

Conceptualizations of care

Care represents a core concern in many social science disciplines. Prominent scholars, such as Mol (2008), Moser and Pols (Mol et al. 2010) and Puig de la Bellacasa (2010; 2011), have brought the notion of ‘care’ into the center of interest in different communities, among them Science and Technology Studies, a scientific

Leading marine scientists have framed marine plastic litter as a core global environmental problem.

All these contexts make marine litter an important case for TA practice and its focus on political decision-making processes, enabling a broad societal discourse on technical innovation and their effects, among them for example through participatory processes including different societal stakeholder groups (Grunwald 2002). This is even more so for TA practice that explicitly discusses human-made problems on a global scale (Böschchen et al. 2021; Hennen et al. 2023). The global dimension of marine plastic litter also resembles other waste debates, among them in TA practice and its concern with nuclear waste (Töpfer and Ufer 2019; Hansson 2022), concerns that involve various stakeholders dealing with environmental concerns. The global character of marine litter, its different forms and formats and its presence in different ecosystems such as the ocean surface or the deep sea, as well as its different sources, however create a conceptual challenge, that I suggest can be tackled with the concept of care. I ask:

How can technology assessment scholars care for marine plastic litter and what can care concepts add to technology assessment practices?

I highlight care as my conceptual take for the enrichment of TA practices by thinking along the complexity of marine plastic litter, efforts for its regulation and socio-technical innovations for its removal. Specifically, I argue that a focus on care can be particularly fruitful for TA practice that focusses on global environmental problems such as marine plastic litter. Care con-

community on whose work I largely draw on. A prime example of work on care and its conceptual impact is that of Puig de la Bellacasa who demands an understanding of care that allows to see “how things would be different if they generated care” (2011, p. 96). In calling for a speculative commitment for “situated and positioned visions of what a liveable and caring world could be” (2011, p. 96), she calls for engagement beyond normative interventions and awareness for oppressed and neglected experiences that create oppositional positions. Thereby, Puig de la Bellacasa aims to unpack relationships along a focus on marginalized and excluded voices, in order to “not only (to) expose or reveal invisible labors of care, but also to generate care” (2011, p. 94). In this sense, care not only allows to analyze care practices but also unpacks who engages in care practices, who is left out or marginalized. Applied to the case of marine litter, the concept of care can open up what often stays hidden, such as the occurrence of marine litter in different spaces, the deep sea or the ocean surface, spaces that need different interventions and regulations. Moreover, marine litter comes in different shapes and sizes while representing a fundamental global phenomenon. Hence, a focus on care can not only monitor who is affected but also who cares and how. This speculative commitment could then re-orient research on and technological innovations to combat marine litter as it could unpack the complexity of marine litter.

Next to this conceptual sensitivity, Murphy (2015, p. 721) characterizes care along four main meanings: “[F]irst, it refers to the state of being emotionally attached to or fond of something;

second, it means to provide for, look after, protect, sustain, and be responsible for something; third, it indicates attention and concern, to be careful, watchful, meticulous, and cautious; while its fourth meaning [...] is to be troubled, worried, sorrowed, uneasy, and unsettled.” Taking up Murphy’s characterization of care, I have previously developed the notion *environmental care* (Schönbauer 2024), a concept that allows to understand care for environmental changes on individual and collective level based on the premises of emotional attachment, responsibility, attention and concern as well as the worries and uneasiness that environmental harm invokes for those studying them and those affected by it. In this sense, care can provide a speculative commitment for affectedness, for relationships with an empirical concern, for researcher responsibility and attentiveness towards a global phenomenon and its complex ramifications.

Marine plastic litter as a concern for TA

Since marine plastic litter is a global problem that cannot be confined in place nor time, its global character resonates with recent calls from TA scholars, namely that TA practice concerned with environmental problems needs a global agenda. Bösch and colleagues (2021) identify the need to account for the global dimensions and complexity of global human-made problems as a core challenge for TA practice. Hennen and colleagues (2023)

and its occurrence in different shapes and sizes, but it can also help to understand the difficulties of regulatory processes in the marine area. In the following, I will attend to some aspects of marine plastic litter that showcase its complexity and how it can be understood with care.

Marine plastic litter: a complexity

Marine plastic litter often resides in spaces that are not immediately accessible for humans. Objects dis- and re-appear from the global ecosystem and travel in time and space with an inherent there-but-not-there quality. A prominent example for marine plastic litter is the Great Pacific Garbage patch, a huge accumulation of marine litter in the Pacific. It is a space that is out of reach for most humans while full of marine life and plastic objects. De Wolff (2014) has for example shown how marine life uses plastic objects as habitat in the open sea. Fish and other animals find shelter in these objects and small plastic objects travel with them. At the same time, plastic litter has toxic and harmful effects on this ocean sphere. Based on the entangled nature of marine plastic litter and marine life, Bergmann (2019) has argued that care is a crucial concept to think with. Care can mean to relieve the ocean ecosystem from an anthropogenic marker when removing plastic litter. Yet, care can also result in marine life being denied an infrastructure that it got used to. Thinking with care then means to focus on the relationships that marine plastic litter creates with marine life.

Care can provide a speculative commitment for affectedness.

also argue that the inherent global characters of many current problems call for international connection to reflect on technological innovations. The need for international connection that TA scholars argue for, is tangible for example in political regulation processes for marine plastic litter. The identification of marine areas in need of protection already happened in 1974, when the United Nations Environment Programme (UNEP) has launched a Regional Seas Programme in order to protect marine and coastal environments. This programme brought together various stakeholders and also addressed marine litter. Later on in 2022, UNEP adopted a resolution to develop a legally binding mechanism to stop plastic pollution, the so-called ‘Plastics Treaty’, a resolution which was considered a break-through for the future of the ocean (UNEP 2022).

Connected to the need for global alliances in global TA, Hahn and Ladikas (2021) call for new conceptual and methodological approaches that assist the need for “urgent global coordination” and “identify, assess, discuss and regulate the impacts (e.g. societal, environmental, ethical or legal)” of technological innovation (Hennen et al. 2023, p. 5). I argue that care can serve as a tool in TA practice to reflect the complexity of global environmental problems. Care can for example help to make sense of marine plastic litter specificities, such as its inaccessibility in some areas

Connected to care for marine life and litter entanglements, care can also open up affectedness. Thinking along marine plastic litter with care needs to take into account human and more-than human entities, both being affected differently by plastic objects. If taking into account marine life and its entanglement with marine plastic litter as well as environments out of human-inhabited worlds, care can mean to focus on affectedness beyond human-centered interpretations (Lindén and Lydahl 2021), an important reframing for environmental problems. Thereby, TA scholars can attend to emotional attachment, protection and responsibility, attention and concern, but also take into account who is being troubled and worried by the presence of marine plastic litter. This shift in focus could serve TA practitioners to attend to the complexity of affected marine life, to the relations being made. Marine plastic litter then results as a complexity rather than isolated problem.

Connected to these sensibilities is the existence of marine plastic litter on different scales: small and big. Considerable proportions of marine plastic litter exist invisibly as microplastics (Thompson et al. 2004; Liboiron 2019; Bergmann 2021). While slowly breaking down to microscopic size, plastic residues of various origins become not only invisible, but also untraceable and descend to considerable oceanic depths. Meanwhile, big

plastic objects can potentially be removed from the ocean, although only in extremely costly undertakings (Galgani et al. 2010). An example for this is the Ocean Cleanup, an organization featuring a technological device invented by a team around Dutch entrepreneur Boyan Slat (The Ocean Cleanup 2024). This approach has been criticized by marine scientists based on the entanglement of marine life with marine waste and the lack of discrimination between individual plastic objects and those that are inhabited by marine life. While such technofixes contain the

took into account marginalized voices is the fifth session of the UN Environment Assembly (UNEA-5.2) which took place in March 2022. UNEA-5.2 was historic insofar as it was the first step towards creating a binding agreement for the regulation of plastic waste – including the marine area. Later in 2022, a multi-stakeholder forum was being implemented, including scientists, finance sector representatives, civil society groups, indigenous people and youth representatives. This also resonates with the written resolution published in March 2022 stating the impor-

*Thinking with care then means to focus on the relationships
that marine plastic litter creates with marine life.*

illusion of re-gained purity, they come at profound costs when not including a more than human reflexivity. Thereby, marine plastic litter also challenges Western concepts of pollution, specifically those of repair and purity (Shotwell 2016; Liboiron 2016) and demands different forms of technological innovation beyond human-centered imaginations on an environmental problem.

These sensibilities connect to arguments in global TA that urge TA practice to move beyond traditional Western concepts. For one, Ely and colleagues (2011, p. 21) state, that TA has to become more “transnational, networked, virtual and flexible” in order to stay attentive to global environmental problems and that Western concepts do not necessarily fit into every cultural and regional context. On the other hand, Hahn and Ladikas (2021) similarly formulate a main challenge for global TA: to dedicate work to national as well as global contexts and regional concerns. One example when thinking with care along marine plastic litter is the attention towards differing cultural practices. For example, plastic waste can land on shorelines and be considered aesthetically distortive, thereby becoming part of purification measures such as beach cleanups. At the same time, plastic containers can be used with extreme care, such as in household practices, when they are repurposed to contain food sources and thereby creating socio-material configurations and novel relational possibilities (Dey and Michael 2021). Thinking with care can open up a reflection on plastic objects in relation to powerful asymmetrical relationships, those created by international commodity chains and international and national waste infrastructures. Thinking with care also allows to reflect on marine plastic litter and its different forms, formats and inhabited environments and thereby highlight the relations plastic objects build before entering the ocean, when landing on the shorelines, or when residing in inaccessible oceanic depths.

Marine plastic litter and regulation

Connected to marine plastic litter and its complexities, TA practitioners and care scholars argue, that marginalized voices and communities often stay invisible but might be affected most, such as by residues of waste. An example for an event which

tance to recognize “workers in informal and cooperative settings to the collecting, sorting and recycling of plastics in many countries” (UNEP 2022, p. 3), such as waste pickers, island communities and fisheries. The involvement of marginalized voices is symbolic for how waste resembles a global matter yet needs to be reflected along regional and cultural contexts. For example, it is crucial to highlight the different contexts of affected communities. Fishers working on the shorelines are economically dependent on their profession and the well-being of fish habitat, while waste pickers are exposed to toxic chemicals when caring for inland recycling infrastructures, often informal ones (Schlitz 2020). And island communities are particularly vulnerable to marine plastic litter (Lachmann et al. 2017) as they are challenged with its ecological effects, are dependent on coastal tourism or limited in their prevention strategies. Hence, emotional attachments vary as well as measures for protection, responsibility distributions and how the different communities are troubled and by what.

Along these differences, the negotiation processes of UNEA-5.2 offers insights into the challenge to include societal stakeholders along their different aims. For example, Melanie Bergmann, a German marine scientist, attended the fourth meeting in Ottawa in spring 2024. She narrated the difficulty of including the whole life cycle of plastics, such as derivatives and chemicals, into regulation practice and the importance yet marginalization of voices from scientific communities (Bergmann n.d.). Hence, not only affected communities but also those researching the impact of marine plastic litter are challenged for their expertise being heard. This is also based on the different key motivations to tackle plastic pollution dependent on agenda prioritizations from societal stakeholders, posing challenges for the development of a binding instrument (Knoblauch and Mederake 2024). Hence, there is no unified interpretation of care for marine plastic litter yet. Related to this struggle, TA scholars argue that different forms of expertise need to be accounted, that different stakeholders and social groups need to be included and that reflexivity needs to be effectively integrated in TA processes (Ladikas and Stamm 2023). A focus on care can add to this

reflexivity and help understand whose voice (and research) is marginalized and which stakeholders remain absent from environmental regulation processes.

Another dimension often left aside is the affective dimension. As “attentive experimentation” (Mol et al. 2010, p. 13), care opens up a feminist standpoint of sociotechnical issues, as they demand a particular “thinkpolitics” (Puig de la Bellacasa 2011, p. 94) that includes a socio-political diagnosis of the affective dimension. Highlighting the affective dimension means to focus on an “affectively charged sensibility characterized by worry, attentiveness, and thoughtfulness” (Martin et al. 2015, p. 629). This sensibility can then mean to engage closely with neglected toxins and invisible chemical residues leaching from plastic litter as proposed by the scientists, or including voices of non-governmental organizations and communities of local fisheries with differing worries. It also means to take into account and relate regional, national and international concerns and foster future meetings and regulation practices that include various societal stakeholders, showcase their expertise, but also their (varying) environmental concerns.

Conclusion

I have started by asking: How can TA scholars care for marine plastic litter and what can care concepts add to TA practices? I argue, that marine plastic litter demands a notion of care that takes into account different voices, spaces, times, governance regimes, policies, regional, national and international contexts. Marine plastic litter also demands a sensitivity to its appearance in different forms, formats and spaces, its large inaccessibility and invisibility but also its omnipresence, characteristics that make regulation processes and just technological innovations difficult.

I have shown that thinking with care on this matter allows to understand the complexities of an environmental problem, such as more-than human relationships, the re-definition of pollution in the omnipresence of plastic objects, and affectedness in and marginalization of social groups. A focus on care is thus important to understand technological innovations that promise to tackle marine plastic litter, in order to see whom they help, whose voices and concerns they leave out. This could for example mean to challenge current plastic production processes and demand policies for just and effective cleaning technologies (Bergmann et al. 2023) or to think about alternative product innovation and to rethink commodity chains. Thinking with care is also important regarding regulation practices and affected communities and to reflect on the potential selective attention that regulation processes bring with. I argue, that integrating care as conceptual tool responds to the call for conceptual enrichment in TA practice of how we can best attend to the socio-technical challenges of future times (Böschen and Dewald 2018). An *environmental care* for marine plastic litter could open up “the complexities of caring in turbulent times with regards to po-

tential catastrophic events lingering in the future and cases of destruction or variable harm that reside in the past and present” (Schönbauer 2024, p. 18). Reflecting with care and focusing on *environmental care* could assist TA practitioners by helping to sensitize TA practice towards emotional attachment, responsibility, attention and concern and environmental uneasiness, core characteristics of care that open up “neglected experiences that create oppositional standpoints” (Puig de la Bellacasa 2011, p. 96).

It seems imperative for global environmental problems to be reflected along care concepts and analyze negotiation processes, marginalized and present actors, but also the distributed responsibilities, affectedness and worries that they bring with. This is all the more important in view of the global nature of marine plastic litter and the debates on environmental justice at global, international, national and regional level.

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