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Clean-ups or clean-washing?

How plastic pollution clean-up technology can actually harm the environment and obstruct policy progress

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Introduction

Marine plastic pollution is perhaps the most visual and visceral manifestation of the plastics crisis the world is currently facing. Turtles attempting to feed on plastic bags, beaches choked with plastic, large charismatic species such as whales entangled in fishing gear – these images are horrifying and highlight the scale and impact of plastics streaming into the ocean.

While global understanding of both the challenges and solutions of plastic pollution has expanded beyond the 'marine litter' frame, the ocean remains a concerning sink for both the emissions from plastics throughout their lifecycle and, in particular, for mismanaged plastics that have escaped traditional waste management systems.

Clean-up approaches have increased along with public outcries about the rise in plastic pollution, from concerned communities cleaning their local beaches to bubble barriers and SeaBins. Plastic clean-ups have proliferated in response to the growing crisis. Such clean-ups may involve large-scale unsupervised methods of plastic collection that do not discriminate between aquatic life, plastic and organic matter. As a result, the rise of these plastic clean-up technologies has raised red flags in civil society and academia, with many arguing that these technologies can have unintended consequences and should be regulated under larger efforts to restore polluted ecosystems.

In order to address plastic pollution along the full lifecycle, governments from around the world are engaged in negotiations towards a new international legally binding instrument (ILBI) to "end plastic pollution".[1] Member States are tasked with agreeing a 'Global Plastics Treaty' that takes a comprehensive approach across the full lifecycle of plastics, with negotiations set to conclude by the end of 2024. The task at hand is huge, with many stakeholders advocating for particular positions or solutions.

The Zero Draft text for the treaty, produced by the Chair in advance of the third round of negotiations in November 2023 (INC-3), provides an opportunity to sift through a range of views and provide a clear path to tackling plastic pollution. It includes, among many elements, options for provisions to cap and phase down plastic production, encouraging reuse-based economies, redesigning the plastics we do use to make them less toxic and easier to recycle and the remediation of existing plastic pollution in the environment.

Developing countries, in particular the Least Developed Countries (LDCs) and Small Island Developing States (SIDS), are disproportionately affected by the plastic pollution crisis and, for many, remediation will be an important element of national action to end plastic pollution. While these countries are often not plastic producers or even necessarily large consumers, the impact of long-term, transboundary plastic pollution on their environments poses a disproportionate threat to community health, food security, tourism and local municipalities. For these reasons, a call for action to reduce production and consumption is often coupled with a request for support to manage existing pollution and for historic contributors to pick up the tab. For example, in its submission to the INC process, the Association of Small Island States (AOSIS) has highlighted that the ILBI must include "a high level of initial ambition for all stakeholders across the full life cycle of plastics, including remediation".[2]

This leaves negotiators with the task of ensuring that existing pollution is appropriately addressed in the new treaty, making certain they are responsive to the unique circumstances of SIDS and LDCs while establishing measures to verify that 'remediative actions' are conducted in an environmentally sound manner. While remediation can be interpreted broadly to include issues beyond marine plastic pollution, such as the remediation of legacy dumpsites and managing contamination of soils and crops from long-term exposure to plastics, this briefing focuses on the emerging field of ocean clean-up technologies as a high-profile player in the 'race to remediation' and grapples with the policy and financing implications that these technologies present to negotiators working on the plastics treaty.

Front cover: Plastic pollution washing up on a beach in Asia.
Below: Fish living in plastic bottle.

What are aquatic plastics clean-up devices?

Aquatic plastic clean-up devices or technologies are a type of large-scale and often unsupervised effort to remediate areas impacted by plastic pollution by collecting and removing plastics from riverine and marine environments.[3]
Such devices have proliferated significantly in the past decade in response to the pollution crisis and the continued over-production of plastics.

A review of clean-up devices identified 38 different technologies either in use, in pilot testing, not in use or otherwise status unknown, which could be broadly categorised into: large-scale booms, river booms, boats and wheels, detection aids, waterway litter traps, drones and robots, sand filters, air barriers, surface skimmers and vacuums.[4]

Other forms of marine plastic mitigation include those that focus on preventing plastic pollution from reaching aquatic ecosystems. These include leakage prevention, stormwater and wastewater filters, removal from wastewater, laundry balls and residual wastewater treatment.

Above: Volunteer collects plastic bottles on a beach.

What are the concerns surrounding clean-up technologies?

In order to develop policies on existing plastic pollution, particularly in the marine environment, it is important to understand the myriad concerns that surround plastic clean-up technologies.

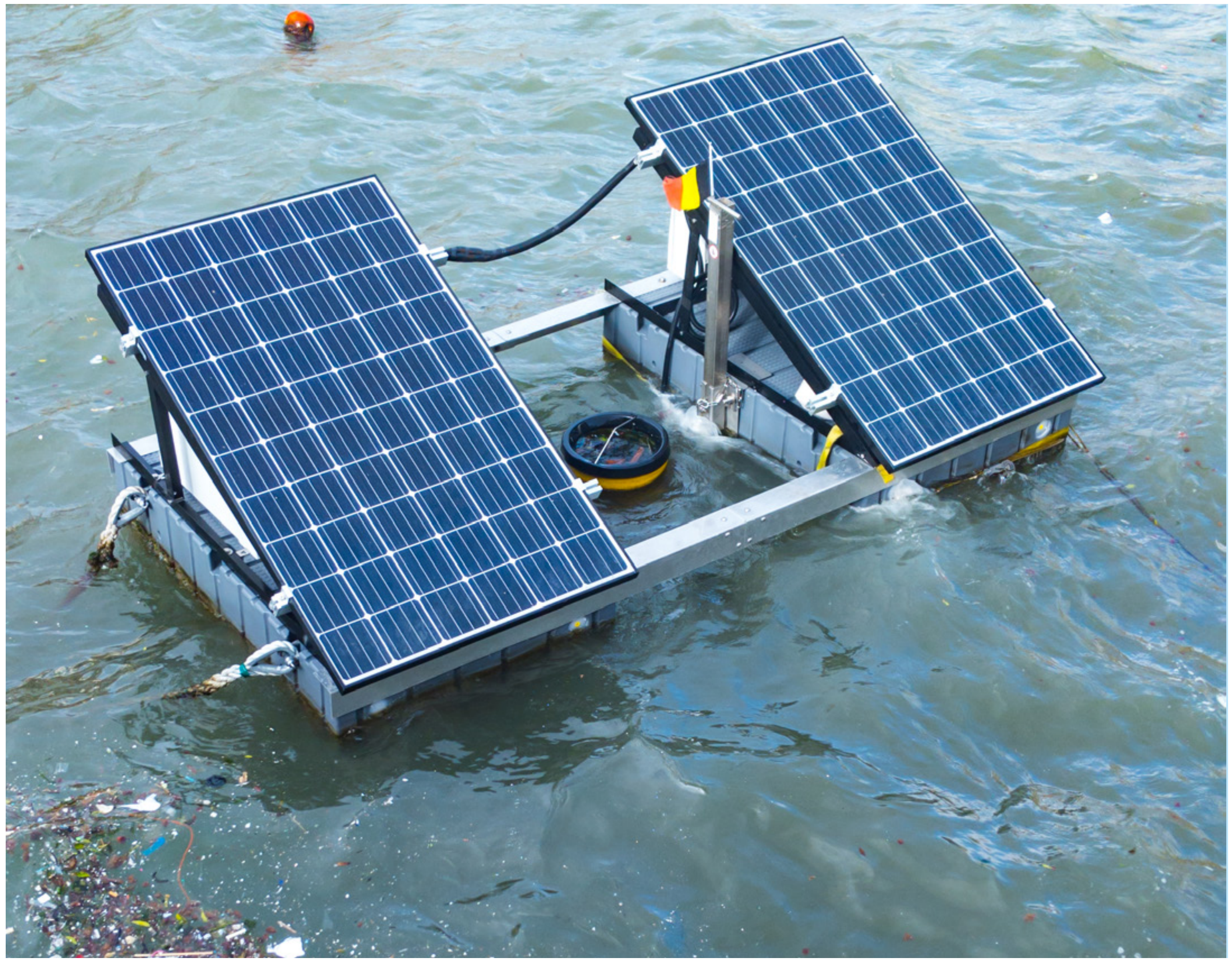
Environmental impacts

Researchers have highlighted concerns that efforts to clean up plastic pollution to improve environmental health actually pose a threat to the very same ecosystems impacted by plastic. This is partly because plastic clean-up technologies do not discriminate between aquatic life, plastic and organic debris.

Plastic and marine life often accumulate in the same areas. In the North Pacific High, sometimes referred to as the Great Pacific Garbage Patch, ocean currents and eddies appear to consolidate plastics and marine life into highly concentrated regions.[5] In coastal regions, (e.g. Hawaii), nearly 100 per cent of large larval fish and more than 95 per cent of floating plastics are concentrated into calm regions of the surface water called slicks, which represents only eight per cent of the ocean surface, making it extremely difficult to separate life from plastics.[6] Ecosystem models show that large-scale high seas clean-ups could cause significant environmental harm from bycatch, leading to possible declines or even extinctions of regional populations.[7] Research also shows that even passive technologies, such as SeaBins, deployed in coastal areas, capture significant amounts of marine life along with the plastics they collect.[8]

In riverine ecosystems, clean-up devices may also pose a threat to ecosystem stability. Organic material is critical for estuary stability and for coastal marine life. In some cases, clean-up technologies remove more organic matter than plastic.[9] Therefore, it is important to note that large-scale deployment of clean-ups of this nature could have significant consequences for ecosystem stability in the areas where they are used.

Clean-up technologies can also be climate-intensive processes. Vessel-based clean-up technologies, such as The Ocean Cleanup's System 002 and 03, emit greenhouse gases through the burning of fuel. Independently peer-reviewed studies have suggested that as many as 200 vessel-based clean-up devices running uninterrupted until 2150 would only have a modest impact on floating plastics pollution in the world's oceans in light of the virgin plastic production trajectory.[10] However, scaling up clean-up to such an extent would have significant climate implications, despite minimal estimated impact on removing plastic pollution.



Efficiency and capital intensity

Most clean-up technologies to date have been deployed as part of small-scale pilot projects or local community projects and will require scaling. For example, to continually clean a marina of 25,000m2 would require the deployment of 500 SeaBins. Remediation of plastic pollution through clean-ups at a global level would require scaling to an unprecedented level. As mentioned in the previous section, models have suggested that even 200 vessel-based clean-up devices would not clean the world's oceans in more than 100 years of continuous operation.

In cases where clean-up technologies have been deployed for large-scale pollution events, their efficacy and efficiency have been called into question. After the X-Press Pearl disaster in Sri Lanka in May 2021, the Alliance to End Plastic Waste donated eight 'Sweepy Hydro' machines to rehabilitate the beaches impacted by the spill. However, a Bloomberg Green investigation found that a little over a year later the machines were not in use due to only being able to clean surface layers, clogging from wet sand and limited supplies of fuel and spare parts.[12] Instead, local women worked six days a week to remove pellets by hand. This failed deployment of a clean-up solution underscores the need for context-specific and appropriate solutions, informed by local knowledge of the environment, the local community, ecosystems, infrastructure and operating conditions.

A review of the cost and effectiveness of various solutions to plastic pollution found that interventions increase in cost the further along the pollution chain you go. The study assessed three clean-up technologies; mechanical recycling directly from consumers may cost only $0.23/kg, compared to the cost of collection technologies, such as booms, which cost $30/kg of waste collected, trash racks which cost $8.46/kg and SeaBins which cost $1.55/kg of waste collected. Of course, plastic collection is not the end of the lifecycle and disposal costs are thus added to collection (see next section). It is important to note that policy tools to prevent plastic consumption were the most cost-effective measure assessed, with a maximum cost of $0.09kg plastic.[13]

Left: Rubbish extractor boat at klang river.

Above: Solar pannel SeaBin.

Waste management

If clean-up technologies were to be successfully deployed in an environmentally sound and efficient manner, the eventual fate of the collected waste still poses a problem. The collected waste will have to enter the waste stream and face the same waste management challenges, with three potential options: (1) recovered plastic is mechanically recycled; (2) recovered plastic is landfilled and/or permanently buried; (3) recovered plastic is incinerated or burnt as waste to energy.

Incineration of plastics is unfavourable due to the toxic chemicals and climate emissions released during the process and poses potential compliance issues with environmentally sound management of waste. Mechanical recycling may also prove difficult, as most collected ocean plastic is difficult to recycle due to the different types of plastic types and quality of plastic collected and the contamination caused by exposure to aquatic and other environments,[14] such as bioaccumulation of marine life. This leaves, in many cases, permanent burial in landfill sites as the only cost-effective option. For many countries, and particularly SIDS, this is not a viable long-term waste management option due to limited landfill capacity and still poses environmental threats through the leaching of toxic chemicals contained in plastic into soils, the coastal ocean, or indeed the run-off of plastics from landfills during adverse weather.

To avoid renewed pollution by recovered plastic waste, post-collection management has to be an integral part of the clean-up process from the outset. Before even starting the clean-up, it should be entirely clear and transparent what happens with the collected plastic, with a waste management plan in place.

Above: Plastic landfill with digger on top for scale.

Vulnerability to greenwashing

Many environmental organisations and academics have raised concerns that some clean-up efforts, despite creating public awareness of plastic pollution, can distract from solutions to the plastic crisis at large and even constitute 'greenwashing'. For example, in its investigation referenced above, Bloomberg Green found that the Alliance to End Plastic Waste did not follow up on its donation of clean-up devices and was "unaware" they were not being used. While clean-up technologies have the power to capture public attention, they also present the risk of technological lock-in and distraction from solutions aimed at prevention at source and reduction of production, which are vital to stem the relentless flow of plastics into the ocean.

It is relevant to note that many high-profile clean-up operations are actually funded by the very companies responsible for the products causing pollution in the first place,[16] with public relations efforts focusing on these initiatives rather than concrete upstream policy change to reduce production, promote reuse and refill, or to improve product design, in an effective attempt at misdirection from the problems at hand.

Impact of technology clean-ups to date

Assessment of the success of clean-ups to date is important to understand how effective these technologies have been in remediating plastic pollution and what scaling that success would entail. However, publicly available data on plastic clean-up technologies is extremely limited. Indeed, studies of more than 100 remediation technologies for marine plastic pollution have shown that data on the environmental impacts and efficiency is virtually non-existent.

Above: Beach microplastics examined under magnifying glass.

A case study: The Ocean Cleanup

Efforts to date

The stated goal of the Ocean Cleanup is to "clean up 90 per cent of the world's floating ocean plastic by 2040". In that regard, it has so far focused its ocean-bound operations on the North Pacific High region, sometimes referred to colloquially as the Great Pacific Garbage Patch. When initially launching System 002 in 2021, TOC anticipated that it would collect between 22,000-33,000 pounds of waste per week[19]; that is between 9,900-14,900kg.

By the time System 002 had been transitioned out of use in August 2023, a total of 282,000kg of plastics had been cleaned from an area of 8,300km^2. Accordingly, we can estimate that System 002 was able to collect about 2,700kg of waste per week, between 3.7 and 5.5 times lower than the estimated catch rates.

Even if we were to consider average catch rates only in comparison to the days the system has been actively operational at sea, catch rates are still lower than what was anticipated at the launch of System 002. Based on TOC's own statements about the number of days operational at sea between July-December 2021 (47 days)[20] and during 2022 (150 days)[21], and compared to the amounts collected by these operations, the average weekly catch rate would reach ≈ 6,000-7,000kg. It is unclear from statements and published materials exactly how TOC intends to calculate catch rates and whether those include normal aspects of operating at sea (including transits, testing, repairs, weather delay, etc), but such clarity should be considered a requirement for all such clean-up projects so that their success can be measured against precisely defined and generally agreed goals.

TOC has estimated the Great Pacific Garbage Patch to be 1.6 million km sq in size and constitutes 100 million tonnes of floating plastic. Therefore, TOC has covered 0.52 per cent of the Great Pacific Garbage patch, collecting about 0.28 per cent of the floating plastic.

Environmental impacts to date

As highlighted above, large scale ocean clean-ups have the potential to cause significant ecological impacts. TOC itself is well aware of the significant risk of these impacts. In an independently produced Environmental Impact Assessment, TOC's activities are rated as high risk for plankton and surface life, with estimates ranging from hundreds to millions of individual surface animals impacted per day.[22]

Reported bycatch from TOC's 2020 high-seas clean-ups include sea turtles (Pacific green and loggerhead turtles are both endangered), sharks, diverse fish species and cephalopods.[23]

Capital intensity?

In its initial feasibility studies developed in 2014, TOC estimated the break-even cost of €4.53 (= $5.9[24]) per kilogram of waste collected for its operations to be commercially viable.[25] According to its own estimates, about 0.5 per cent of the 400 million tonnes of plastic produced enter the ocean each year,[26] equating to about two million tonnes of plastic annually.

At the estimated breakeven cost calculated by TOC, to collect 90 per cent of the total volume of plastic that enters the ocean each year would incur an annual cost of more than $10 billion, not counting the existing plastic pollution that is already present in the environment. In the submission made on behalf of the Innovation Alliance for a Global Plastics Treaty, TOC highlighted the need for an annual injection of at least $30 billion to support innovation to reduce plastic leakage into the environment.[27] Accordingly , already one third of the sum would go to TOC's own collection of the yearly inflow of plastic.

At a global scale, an independent study found that the cost to reduce marine plastic pollution by 25 per cent (as compared to 2010 levels) in one decade and using only technology (i.e., the Ocean Cleanup Project) is between 0.7 and one per cent of the global Gross Domestic Product in 2017 (€492-708 billion).[28] This further highlights the high capital intensity of ocean-bound clean-up operations.

Vulnerability to greenwashing?

Ten years on, and with millions of dollars in raised funds, three ocean-bound clean-up 'systems' tested and various 'river interceptors' deployed, the Ocean Cleanup has not been without controversy.[29] Of particular concern is the distraction that TOC creates from the more decisive solutions for plastic pollution, such as reductions in production and consumption of plastics and the opportunity for polluters to greenwash their reputations.

TOC's past funders have included Saudi petrochemical and polymer producer SABIC and Dutch industrial conglomerate and plastics manufacturer DSM, as well as the family foundation of major US LDPE (Low Density Polyethylene) producer Westlake Corporation and notorious plastic waste-maker Coca-Cola.[30,31,32]

What can be learned?

Through a careful media and marketing machinery, the Ocean Cleanup has brought the issue of plastic pollution to the attention of the public; however, the issues identified to date show a clear need for global regulation related to plastic clean-up technologies to both provide guidance on best practice for implementation, monitoring and evaluation of cost-benefit and to avoid an exacerbation of harm to the environment.

Here, we use the case study of perhaps the most well-known private clean-up initiative, The Ocean Cleanup (TOC). In 2013, when then TOC conceived of a machine to clean a region of the North Pacific, termed the North Pacific High (or the Great Pacific Garbage Patch), the proposition was enticing to many and garnered the attention of the world. We use publicly available information to assess their efforts at sea.

Below: The ocean cleanup vessel docked at the San diego harbor, USA

How should remediation be treated in the Global Plastics Treaty?

As part of a comprehensive approach to addressing the lifecycle impacts of plastics, restoration of currently polluted habitats will be necessary in situations where pollutants pose a demonstrated systematic risk to human and non-human safety, health and enjoyment.

Measures on remediation must be coupled with binding provisions to reduce overall production and consumption of plastics and global design criteria to promote the safe and sustainable design of plastic products. While clean-up technologies can create potential negative environmental impacts, these are distinct from community-run initiatives such as the Ocean Voyages Institute, which collected > 200 tonnes of ghost gear from the Great Pacific Garbage Patch via hand collection to protect marine life, or local beach clean-ups, which can bring together communities to target and address specific regional challenges.

The disruptive potential of clean-up technologies has led to studies on how remediation can be regulated to avoid unintended consequences, including a recent study by Falk-Andersson et al (2023). A more ecologically minded and community-focused approach, guided by strict criteria in areas of demonstrable need (such as 'dead rivers' etc), is necessary. This can be facilitated through clear regulation, guidelines and monitoring.

The Zero Draft of a new Global Plastics Treaty provided in advance to INC-3 provides a firm basis for discussion on remediation and should be retained and strengthened. Here, we summarise a number of recommendations for policy-makers when assessing these elements to ensure remediation is conducted in the context of restoration and social well-being, is environmentally sound and is responsive to the special circumstances of SIDS, LDCs and other developing countries.

Above: Jellyfish at surface of ocean surrounded by floating marine plastcs.

Recommendations

Regulating clean-ups

Remediation activities should be considered part of a comprehensive approach to ending plastic pollution across the full lifecycle of plastics, but this should not include the promotion of disruptive clean-up technologies.

- Policy interventions aimed at prevention, such as the reduction of production and consumption of plastics, are the most cost-effective measures to minimise and eliminate plastic pollution. Legally binding upstream measures on reducing production, addressing chemicals and polymers of concern, global product design criteria and promoting alternative systems of delivery, such as reuse, repair and refill, should be priority measures. Remediation only makes sense when upstream measures are in place to truly turn off the tap. Mopping up plastic pollution when the sources of pollution are not first fully addressed is not a sustainable solution from a financial or environmental perspective.

In the context of the Zero Draft, remediation should be conducted in an environmentally sound manner. 'Environmentally sound' is mentioned in a number of places in the Zero Draft text, also with regards to environmentally sound waste management, technologies, use, recycling and disposal.

Defining 'environmentally sound' approaches

- In line with the Zero Draft, we support the need to "promote engagement of local populations and citizens in safe and environmentally sound remediation activities"[1] in Part 2 (11.1.c). In addition, we stress the need for future drafts to include support for robust restoration/conservation science, traditional knowledge, knowledge of indigenous peoples and local knowledge systems.
- We strongly suggest applying a robust precautionary approach when considering clean-up technologies and activities. These should be informed by best-available science to ensure the new Treaty does not promote nor facilitate the use of harmful technology.
- Such definitions and criteria should exist under the auspices of the new instrument rather than relying on existing definitions or guidance established elsewhere.

Remediation of existing plastic pollution should include restoration

- Any guidelines adopted by a future treaty should include the broader objectives of ecosystem and habitat restoration in order return the ecological system to a pre-pollution state.

Remediation activities that choose to include clean-up technologies should target only areas of highest priority and need

- Remediation activities should be directed towards areas of acute plastic pollution that pose demonstrated and significant risks to the polluted ecosystems, human health and local economies.
- Identifying highly polluted habitats and hotspots should happen in a scientifically sound, transparent and collaborative manner using the best available science, traditional knowledge, knowledge of indigenous peoples and local knowledge systems, pursuant to Op4(d) of UNEA resolution 5/14; not just informed by those who would provide the technology or actually carry out the clean-up, but involving relevant communities in the identification, prioritisation and evaluation of costs/benefits.

1. In the authors views, 'environmentally sound' should include the notion that human disruption on a ecological system is decreased and that these systems are restored to a pre-pollution state without causing additional disruptions

Guidelines regarding safe and environmentally sound clean-up activities and technologies are necessary

- The governing body should be required to adopt and update guidelines on the identification of priority remediation activities and how to conduct environmentally sound clean-ups. Part 2 (11.4) of the Zero Draft mandates the governing body to adopt such guidance, but may be strengthened to empower the governing body to update guidance based on emerging evidence. Regardless, the inclusion of this element from the Zero Draft is important. A science and technical body under the auspices of the new instrument could inform these criteria.
- Guidelines on remediation activities should include a number of key aspects:
    - identification of remediation activities should include assessments of plastic pollution that poses risks to local communities; biodiversity; natural resources; human and organismal health; tourism; and navigation and maritime safety;
    - guidance on the development of environmentally sound remediation plans which include evaluation of plastic interaction with ecosystem components, eventual fate of recovered plastics and other debris, in the event clean-up technologies are used, the risks related to implementation and use, as well as risks related to malfunctioning and loss of technology, design requirements of technologies and, where possible, as part of broader conservation plans.
- Guidelines should include measures to ensure transparent reporting on clean-up technologies:
    - reporting on environmental impacts (e.g. bycatch, carbon intensity, etc), costs and efficiency of approaches are necessary to allow for development and sharing of best practices for clean-ups and to inform the development of relevant guidance for the consideration of the governing body.

Environmental Impacts Assessments and precautionary approach for clean-ups

- Clean-up technologies, in particular in the marine environment beyond areas of national jurisdiction, pose regulatory and governance challenges. Under the general obligation under the UN Convention on the Law of the Sea (UNCLOS), it has to be ensured that activities under its jurisdiction and control of a State do not cause damage to other States or to the marine environment, including in areas beyond national jurisdiction (ABNJ).
- The Environmental Impact Assessment (EIA) provisions in the new BBNJ Agreement have a number of implications and would be applicable in the assessment of clean-up operations and the devices used, as well as in monitoring of the impact of clean-up operations on the marine environment in ABNJ when it cannot be excluded that an activity may cause significant harm to the marine environment, including marine biodiversity.[33]
- Generally, robust, independent EIAs need to be conducted pre-deployment and made transparently available to determine their effectiveness and impact. Best Available Techniques (BAT) and Best Environment Practices (BEP) should be applied to avoid removal of biomass, or cause or exacerbate harm to the environment.
- Subsequently, continuous independent monitoring of removal impacts, including cumulative impacts, need to be ensured with reporting made publicly available.

Financing remediation

- We suggest, based on our analysis, that clean-up technologies should not be included in multilateral financing structures for the following reasons: they are cost-ineffective, increase environmental disruption and do not address root causes.
- For targeted remediation activities, as it pertains to multilateral financing, eligible countries should be supported with resources, capacity-building and technology transfer in order to comply with mandatory obligations on remediation, similar to other obligations in the eventual instrument:
    - assessments for where targeted remediation should take place and the development of plans and EIAs may be covered within incremental costs of compliance and provided for on a grant basis
    - other forms of concessional and private finance should be made available to undertake remediation projects.
- A Plastic Pollution Trust Fund operating under the authority of the Parties could be established in order to provide additional financial assistance to developing countries, economies in transition and Small Island Developing States to support remediation of existing plastic pollution as well as other costs. The Plastic Pollution Trust Fund should be funded from fees, levies and voluntary contributions from producers and other companies and would be an appropriate mechanism to apply the 'polluter pays' principle in the design of the instrument by ensuring companies producing plastics are financially supporting the cost of remediating the impact from their operations.
- This would also ensure that privately financed clean-up initiatives are required to follow the relevant guidance agreed by the Parties and reduce the risk of adverse-impacts from such systems that currently operate outside any regulatory or agreed best practice framework.

Extended Producer Responsibility (EPR)

- When implementing obligations related to EPR parties may consider whether a portion of the funds collected through EPR schemes should replenish a trust fund or other nationally or regionally administered fund related to financing targeted plastic clean-ups to ensure private sector financial flows towards clean-up operations and producers are held genuinely accountable.

Private clean-up operations

- Parties should adopt into their legislation measures to ensure private organisations, including researchers, non-profit organisations and private companies, undertaking remediation activities should be subject to the same assessment criteria outlined above.

Conclusion

We cannot clean up in perpetuity – it is neither environmentally nor economically sound and locks us into continuous production and consumption to sustain the cost of clean-up operations and allows us to shirk responsibility for genuine systemic solutions that will protect human and environmental health for future generations. Yet, communities living at the front line of legacy plastic pollution and experiencing the continuous flow of plastics on ocean currents cannot be ignored. Therefore, restoration/remediation will have to play an important role in the future plastics treaty and this should be done in an environmentally sound manner.

However, the use of clean-up technologies is cost-ineffective, poses serious environmental concerns and may distract from local solutions. They should only be considered in cases of extremely polluted ecosystems and should be subject to independent prior mandatory Environmental Impact Assessments, rigorous and continuous monitoring of environmental impacts, with a clear check-and-balance system, to ensure they do not create new environmental disruption.

The Zero Draft provides a strong basis for addressing existing plastic pollution, including in the marine environment. The goal of forthcoming negotiations should be to ensure this strong foundation is strengthened with a continued focus on preventing plastic pollution and supporting local community solutions. Effective policy is always the best cleanup.

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