Back to Blue

An initiative of
Economist Impact and The Nippon Foundation

THE ROLE OF REGULATION IN ADDRESSING MARINE CHEMICAL POLLUTION

- excerpts from The Invisible Wave

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About The Invisible Wave

Chemical pollution—of land, air, rivers, watersheds—has been a festering issue for decades, occasionally prompting resolute action. But only recently has the scale of chemical pollution become more apparent. Chemicals in the form of nutrients, heavy metals, persistent organic pollutants, sewage and many others are being uncovered almost everywhere—in soils, aquifers, food chains, remote ecosystems such as the Antarctic, in the highest and lowest places on Earth, and in humans. As evidence accumulates of its impact on nature and human health, there is a gathering consensus that chemical pollution is a first-order global threat, alongside climate change and biodiversity loss, and often compounding the impacts of these other issues.

This awakening to the systemic nature of chemical pollution understandably focuses on where humans live, on land. This report seeks to raise awareness of marine chemical pollution, as its scale and potential impact—and thus urgency—are not widely appreciated, and to focus minds on delivering solutions that prevent, reduce and minimise chemical pollution in the marine environment. An aspiration towards zero pollution is gaining currency. The hope is not so much that the ocean can be free of pollution, which may be impossible, but rather that more will be accomplished if the goal is seen to be ambitious. Back to Blue shares this aspiration.

The Back to Blue initiative grew out of the findings of our 2021 global survey, which showed that plastic and chemical pollution are the two greatest concerns that people have about ocean health, with climate change ranked third. As this report will show, the three are profoundly connected.

The ocean is fundamentally important to all life on Earth. It covers 70% of the planet's surface and comprises 99% of its habitable space.[1] It is therefore remarkable that there has not yet been a serious scientific assessment at scale of marine chemical pollution and its impact on life in the ocean, marine biodiversity and how ocean ecosystems function, and ultimately on the ocean's overall health. The Invisible Wave seeks to set out clearly what is known about its impact and where our knowledge gaps sit, prompting the urgent need for more research.

This urgency is underscored by a further point that this report seeks to demonstrate: that despite lacking a complete picture of the dangers posed by marine chemical pollution, failing to act now is a risk too far. The report therefore suggests solutions for various groups of stakeholders that, if taken, would ameliorate chemical pollution in the marine environment. It is a starting point: mapping out the paths to those solutions is the function and aim of a research and engagement programme that the Back to Blue initiative will undertake following the launch of the report.

Despite lacking a complete picture of the dangers posed by marine chemical pollution, failing to act now is a risk too far

The marine environment

This report concerns itself with the impact of chemicals on the marine environment. In other words, we are looking at the saltwater part of the hydrosphere: from the deep ocean to coastal seas, bays and estuaries, and including the array of ecosystems found there, including coral reefs, seagrass beds, mangroves, mudflats, sediments and water columns. The freshwater part of the hydrosphere—rivers, land run-off and groundwater—is a key transport mechanism for chemical pollution reaching the ocean and coastal areas, but otherwise is not a focus of this report.

The importance of the saltwater hydrosphere to life on Earth is greatly underestimated. Not only is the ocean a crucial food source for billions of people, but it also provides more than half the planet's atmospheric oxygen, acts as a massive carbon sink (without which global warming would be far worse), regulates the weather and climate, and provides countless formal and informal jobs in economically crucial activities that include fishing, shipping, tourism, recreation and offshore hydrocarbon exploration. The ocean provides services estimated to be worth trillions of dollars—services that are at risk from marine chemical pollution.

Despite the ocean's centrality to all life on Earth, humanity's view has been that the seas have an infinite capacity to absorb waste. That is wrong. While there is patently a need for more research on the harm that chemicals inflict on the marine environment, the existing evidence is clear: chemical pollution has damaged marine biota, from polar bears to plankton to large-scale ecosystems such as the seas and beyond. As the production and use of chemicals rises, so inevitably will their impact escalate too.

There are many reasons why this matters. Science has already shown that climate change is in large part due to human activities, and this anthropogenic cause is true too for marine chemical pollution. Importantly, the two are linked: science is learning that synthetic chemicals in the seas can increase climate change's negative effects, while the effects of climate change (including warming water temperatures, increased acidification due to higher carbon levels, and greater salinity) can heighten the negative effects that chemicals have in the marine environment. In other words, climate change and marine chemical pollution are deeply interlinked. Consequently, it is crucial to tackle both.

Failing to do so will lead to accelerated damage to marine life and biodiversity—"the variety of life ... and the natural patterns it forms"[2] —and would come even as the number of species on Earth is declining at perhaps its most rapid rate due to factors like climate change, pollution and activities like overfishing. And while biodiversity loss is common to the terrestrial environment and ocean, one key difference is that we know very little about countless marine creatures. Consequently, when it comes to the ocean, we often do not even know what we are losing.[3]

This damage to marine biodiversity, and the complex interactions that underpin it, has important knock-on effects on the functioning and resilience of ocean ecosystems. Exactly how such ecosystems are affected by complex and multiple stresses such as warming waters, acidification, chemical pollution and the growing industrialisation of the seas, including overfishing, is still not well understood. The science is in its infancy. Yet rising levels of marine chemical pollution are an important factor in undermining, even potentially imperilling, the capacity of marine ecosystems to provide the services on which all of humanity relies, and that are crucial to the stability of wider systems, including climate and the carbon cycle.

Why marine chemical pollution?

Marine pollution as a broad topic has deservedly gained greater attention in recent years, with plastic taking centre stage. As many of our interviewees pointed out, this is because plastic pollution is highly visible and emotive: who can forget the video of a turtle with a plastic straw in its nostril, or media coverage of whales and seabirds found dead with plastic waste in their stomachs?

Plastic is a challenge of epic proportions and complexity, and is also important to the chemicals story. Marine chemical pollution, however, is of a different order:

- For a start, it is invisible and, in a world where awareness-raising is often most effective when it is visual, as the turtle video shows, this hinders understanding its scope and significance.

- Second, synthetic chemicals production is increasing rapidly and set to grow fastest in the coming years and decades, with many new chemicals being created and circulated. The green transition is an important driver of these trends.

- Third, production is shifting to middle- and lower-income countries where regulations to manage chemicals and combat chemical pollution are typically limited and less effective. At the same time, higher-income countries that have addressed conventional chemical contaminants to some degree face new challenges with the relentless pace of chemicals' innovation and associated pollution risks.

- Fourth, scientists are open about the need for more research to better determine how marine chemical pollution will damage the ocean, which is not surprising given that there are tens of thousands of chemicals with, in most cases, completely unknown effects on human health and the environment.

- And fifth, while marine chemical pollution continues to be a threat in wealthier countries, much of the new and incremental damage taking place globally is in poorer countries where people and ecosystems are at a great remove from the markets ultimately driving the increased use of chemicals. This further decreases its visibility.

For these reasons and more, as we explore in detail in this report, marine chemical pollution is an under-appreciated and underestimated danger. It must not be.

Key chemicals and their sources

A recent study found that there are at least 350,000 synthetic chemicals and mixtures of chemicals, with thousands being added each year.[4] Yet, worryingly, we know almost nothing about most of their health and environmental consequences. Additionally, even when chemicals are deemed so harmful that they must be replaced, their replacements are also often found to be toxic (known as regrettable substitution).

In recent years, hundreds of chemicals have been placed on lists for banning, restriction or substitution. Of particular concern are persistent organic pollutants (POPs), which, as the name indicates, linger in the environment, can travel long distances, and have serious effects on the environment and biota. Although hundreds of chemicals have been recognised as POPs, some researchers believe thousands of other unrestricted chemicals meet the requirements to be classified that way.

The sheer volume of chemicals makes drafting a list of the worst of them a significant challenge, and inevitably this report does not provide a comprehensive list of all chemicals of concern. For that reason, our expert panelists have suggested a list of classes or groups of chemicals that they feel are the most severe or that could have the greatest impact in terms of:

- Environmental health, particularly the health of the ocean.
- Human health.
- Economics (quantifying this is a long-term goal of the Back to Blue initiative).

Given their effects, POPs are an obvious category for inclusion, and feature heavily in this report. The others include heavy metals, nutrients, pesticides, plastics, pharmaceuticals, radioactive materials, oil products, household chemicals and pseudo-persistent chemicals. While some of these chemicals are banned or restricted, most are not.

By default, these are the chemicals or chemical groups that we know most about. However, future research will surely identify others that constitute a greater threat or that inflict increased harm to marine ecosystems. It is entirely possible, then, that the potential impact of marine chemical pollution will prove to be wider and more serious than currently estimated.

That raises two important questions:

- What effects do these chemicals have in the marine environment?
- How do they enter the marine environment?

Answering the first with accuracy requires more research, particularly when it comes to determining how chemicals react individually and collectively in the real world. The answer to the second question begins by identifying the various parties involved in the chemicals value chain: the chemicals industry (which to date has externalised its costs), its clients (more than 95% of manufactured goods contain chemicals) and financiers. It also includes regulators and governments (with public sector sources of pollution including dredging and defence), end-of-life operators and civil society.

Consumers are also of note. Sources of marine chemical pollution here include pesticides, fertilisers and plastics, with pharmaceuticals and personal care products—sometimes referred to as chemicals of emerging concern—becoming increasingly important due in part to the growth in the number and size of coastal cities and towns in recent decades, and with the background rise in population numbers and incomes globally.

Our efforts to map accountability across the value chain of the chemicals' lifecycle also includes the pre-production phase: extracting and processing the fossil fuels, minerals and metals used to manufacture chemicals, with oil and gas majors like ExxonMobil, Shell and BP involved in both extraction and chemicals manufacturing. Given the projected growth of the chemicals industry and its role at the heart of marine chemical pollution, as well as often-lax industry oversight, accountability will become more important going forward.

The end-of-life phase of the chemicals value chain is another important source of marine chemical pollution, with municipal waste, e-waste and untreated sewage growing in importance. Plastics, for instance, are laced not only with chemicals from the manufacturing process, but they also break down into micro- and nano-sized particles that can adsorb chemicals in the water and transport them vast distances.

Overseeing, in theory at least, this vast value chain from extraction to disposal are regulators.

The success of any strategy to combat marine chemical pollution hinges on regulators enacting and enforcing stricter rules on pollution, and working in concert with peers elsewhere to combat regulatory arbitrage, where firms move to jurisdictions with less oversight. Encouragingly, research by the European Commission shows that regulations bring numerous benefits, cutting the costs of marine chemical pollution on the environment and human health, and lowering water pollution levels.

The success of any strategy to combat marine chemical pollution hinges on regulators enacting and enforcing stricter rules

Regulations, properly enforced, also require that producers adhere to common standards, and should be employed to ensure that product designers factor in end-of-life aspects, particularly impacts on the marine environment.

The dangers of inaction

Most marine chemical pollution is caused by humans, and most of that has taken place in the past 100 years. Given that the pace of chemical production and innovation is predicted to rise rapidly in the coming years and decades, and that much of the production growth will happen in countries with less regulation, it is likely that marine chemical pollution will get significantly worse unless action is taken.

Assessing the scope, extent and impact of marine chemical pollution, now and in the future, is a pressing task for scientists and environmentalists, as is evaluating the cost of such pollution. Armed with a clearer picture, action is more likely to succeed. And while inaction remains a possible response, it is no longer necessarily the likely response. The past few years have seen a broad awakening to the problem of pollution. The UN Environment Programme (UNEP) has elevated pollution (chemicals, plastics and waste) alongside climate change and biodiversity loss as one of three interconnected anthropogenic crises. Pollution is one of the key stresses that led the UN to state that ocean sustainability is "under severe threat", and that addressing pollution was vital to achieve the UN Sustainable Development Goals (SDGs). Meanwhile, *New Scientist* rang the alarm in mid-2021 with the headline: "Why chemical pollution is turning into a third great planetary crisis".[5] The Stockholm Resilience Center has, for the past decade, included pollution as one of several planetary boundaries within which humans need to operate to ensure stable Earth systems.

The language of crisis and emergency is nothing if not a call to action. While more research (and funding) is needed to close some significant knowledge gaps, it makes no sense to refrain from acting until every gap is filled. After all, it will be decades before we understand the effects that the tens of thousands of synthetic chemicals might have on health and the environment, whether individually or collectively, and the world does not have that much time. Additionally, intervening is in line with the precautionary principle, which demands that we act now on the grounds that we know enough about the effects of marine chemical pollution to be concerned about its potential effects.

A large part of this burden to act must fall on the chemicals industry and on its clients in the broader business world. In part, this will require that the business community factor in its impact on marine chemical pollution in the way that it has started to do on climate change.

If the world does not act, it is reasonable to assume that the problem of marine chemical pollution will worsen. Rising production volumes is one reason, but there are others like weak regulation and enforcement, poor product design, the lack of domestic and industrial wastewater treatment in much of the world, and insufficient waste management.

Yet perhaps the biggest problem, our experts said, is assuming that we can keep dumping waste into the ocean because it is vast enough to absorb and dilute the array of toxic substances that we produce. As this report shows, we cannot.

A global problem that lacks local research

The transboundary nature of marine chemical pollution means it affects everyone, no matter how far they are from its production. Toxins have been found in islanders in the Pacific and the Faroes, as well as in people living in the Arctic Circle—and, notably, in women and children in poorer countries who rely on seafood.

Marine chemical pollution, in other words, is a global problem. That said, much of our understanding of its economic costs is derived from a few high-income countries, which means that research is lacking that would be most relevant to billions of people for whom the seas are crucial to lives and livelihoods. This needs to be remedied. Funding should be targeted at the chemicals with the greatest potential to harm ocean biota and, in turn, human health and local economies.

It is also clear that much more research is needed on chemicals and their impact—particularly in conjunction with other chemicals in the marine environment. This needs to factor in climate change variables like temperature, acidity and salinity, as each can affect how chemicals react.

One result of the research bias favouring wealthier nations is that the studies cited often examine marine chemical pollution in the rich world. While this is an unavoidable consequence, we have kept this imbalance in our minds and endeavoured where possible to incorporate research that covers poorer nations. Clearly, a key task for the future is tipping the scales back.

A final point on research is that what is known needs to be brought to the wider community. As UNEP notes, this includes improving the flow of communication between researchers and policymakers. This could help to motivate change by quantifying the costs of inaction and the rewards of intervention. Our bespoke case study on marine chemical pollution in the US Gulf of Mexico, for instance, found that dead zones worsening—where the sea has been starved of oxygen owing to pollution—would cost the US about US$838m a year in fisheries revenue. Taking measures to reduce dead zones, on the other hand, would boost marine biodiversity and therefore increase revenue by more than US$117m.

Industry

As the ultimate source of chemical pollution, the chemicals industry has the primary responsibility to act. It could hugely influence resolving the issue. However, if it fails to act, it could face an existential crisis for two reasons. First, this industry is dependent on fossil fuels to manufacture feedstocks, with the likely regulatory and financial pressures this carbon-heavy operational base will bring. Second, owing to the growing understanding of the impacts of chemical pollution on environmental and human health, there is increasing consumer and investor pressure on this issue, which could ultimately prove as critical as climate change.

Additional pressure on laggards in the sector will come as more innovative firms step up in areas like green chemistry, which could hold the key to sustainable change for the sector, even as clients come under pressure from customers to better manage the chemicals in their product portfolios, and as public awareness compels governments to enforce stricter regulations.

Surprisingly, though, industry efforts have been piecemeal at best, even though the momentum for a circular economy is growing—as with plastics. Accelerating change will require a shift at the corporate culture and systems levels.

Conclusion

Although marine chemical pollution remains a largely invisible problem, this is starting to change. There is now enough evidence to show that the problem is extensive and worsening. Moreover, given the crucial role that the ocean plays in regulating climate and weather, generating oxygen, absorbing carbon, and providing food for billions of people, we also know that inflicting further harm risks too much.

Action, then, is vital. It requires that all stakeholders play their part. Although marine chemical pollution is a huge challenge to solve, it is not impossible. In mapping the sources of marine chemical pollution, the consequences (as we know them) and a series of paths that can resolve one of the defining issues of our times, this report and the Back to Blue initiative aim to raise awareness and galvanise action from all of those involved.

The role of regulations in addressing marine pollution

This excerpt of The Invisible Wave regulatory and policy solutions to prevent marine chemical pollution, as well as ways to mitigate and resolve it. To that end, it outlines key aspects of international, supranational and national regulation, explains the current state of play—including explaining why the EU is the global leader—lists key barriers to progress, and details a number of crucial interventions needed on the regulatory and policy sides.

5.1 Principal findings and recommendations

- **The current legal and regulatory landscape is complex and ultimately ineffective.** There is a vast array of treaties, laws and regulations designed to mitigate the effects of types of marine chemical pollution, including at a supranational, regional, national and sub-national level. Europe's REACH legislation, for instance, is among the most proactive, and puts the burden of proof on companies to show their products are not harmful. This approach, however, is unusual. The existing landscape has significant shortcomings: there is no comprehensive international law to tackle marine chemical pollution; laws are far weaker for the open seas than they are for areas that fall within countries' exclusive economic zones; and what does exist is fragmentary and runs up against laws covering trade and intellectual property, for example, whose goals are often at odds with protecting the marine environment.
- **Excessive caution, misframing and time lags are key risks in tackling marine chemical pollution via regulation. Yet getting it right remains crucial.** Regulatory actions to combat marine chemical pollution could be undermined by the lobbying of different stakeholders or by poor framing of what is needed—as happened with initial attempts to combat climate change. Another risk is that governments are excessively cautious or reactive, acting only when faced with incontrovertible scientific evidence of harm. A third risk is that, even when actions are agreed upon, they take overly long to implement. However, analysis shows that robust policies do help to manage the conflict between the goals of business and society, and that it is effective to apply the precautionary principle, which guides decision-makers to reduce delays between early warnings and acting. And regulatory clarity and accountability does help to encourage businesses to be more sustainable.

- **Progress in regulation requires overcoming awareness, capacity and timescale problems—and vested interests.**
The barriers to progress on regulation include failure to acknowledge that the capacity of the ocean to dilute chemical pollution is limited; a lack of data to inform policymaking; a lack of awareness among policymakers and the public of the dangers of chemicals and of the risks of failing to act; insufficient knowledge of the effects of the chemicals that are in use; and the length of time often needed to act on harmful chemicals. The actions of chemicals-industry players in deliberately shifting operations to other countries in order to take advantage of inferior regulatory oversight, as well as the fact that regulators are in a constant state of catch-up with the chemicals industry (and that industry, politics and finance operate on a short-term horizon) are also problematic.

- **Best practices in regulation stipulate monitoring and assessment, as well as steps specific to the marine environment.**
Some agreements and regulations offer useful best practice lessons. The OSPAR Convention, for instance, has a mandate to identify priority chemicals in the marine environment of the North-East Atlantic, measure their levels, and then feed that evidence-based research into recommendations for policies and regulations, while the EU's Marine Strategy Framework Directive contains specific descriptors that look at chemicals and food chains, including food for human consumption, as well as at chemicals and their impact on fish and shellfish. In some instances, "good practices" might be sufficient, given that it takes time to define best practices.

- **Better regulations to improve the treatment of wastewater and solid waste, and better enforcement of them, is a priority to protect coastal ecosystems.**
Global progress on wastewater treatment has been slow, with nearly half of household effluent (and much industrial effluent) still not safely treated. Even where wastewater is treated, numerous chemicals remain, and much wastewater ends up polluting the seas. Lowering the levels of toxic chemicals in wastewater is an important step in combating marine chemical pollution. Also important is improved treatment of municipal waste, much of which contains chemicals. Given that Asia and Africa are set to be the largest generators of municipal waste in the coming years and decades, and given that many of those nations are poor, rich nations will need to step up their technical and financial assistance. Regulatory failure is a problem in even the richest countries. Linked to this, stringent regulatory oversight—including levying penalties of sufficient scale—is crucial.

- **A regulatory wish list: Ten interventions to combat marine chemical pollution.**

1. **Raise awareness** of the causes of and remedies for marine chemical pollution, including by improving communication between science and policymakers.

2. **Improve the regulation** of harmful chemicals **and the enforcement** of restrictive measures internationally; in addition, agree on a global treaty to tackle marine chemical pollution.

3. **Follow a risk-based approach and use the precautionary principle,** which states that where there are threats of "serious or irreversible damage" to the environment, "a lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation".

4. **Establish a global science-policy body** whose remit covers all chemicals and waste, yet that does not duplicate the work being done by bodies like those under, for instance, the Stockholm Convention.

5. **Create a comprehensive register** of chemicals at the national and global levels using best practice (or even "good practice") methods.

6. **Mandate disclosure** of all chemicals in products and their potential effects.

7. **Adopt best practice laws and principles** and ensure better enforcement, with nations acting in concert to overcome key imbalances. Countries should also use funding and policy measures to increase the take-up of green chemistry, and must ensure the terms "green chemistry" and "sustainable chemistry" are properly defined in law to avoid industry greenwashing.

8. **Provide more funding to measure the impact** of chemicals, with developing countries particularly in need, many of which suffer disproportionately from marine chemical pollution.

9. **Make the polluter pay** by using a range of fiscal measures like taxation, removing subsidies for high-risk substances, or using subsidies to encourage good behaviour by industry.

10. **Promote efforts to restore ocean health,** including measures at the national level to cut the flow of chemical pollution into the seas, fiscal measures to encourage improved behaviour, and regenerating areas that have been degraded, like seagrass beds, mangroves and coral reefs.

5.2 Current regulations: A patchwork net

When it comes to regulatory actions taken to tackle marine chemical pollution, the EU leads. Whether through its REACH regulation, which imposes obligations for manufacturers, importers and downstream users of chemicals, its Water Framework Directive (WFD), which deals with the input of chemicals and nutrients into the aquatic environment, or its Marine Strategy Framework Directive (MSFD), which seeks to protect the marine environment and use it sustainably, the bloc has for years been well ahead of the world.[1]

Take REACH, for example. Its goal is to protect the EU's people and environment from the harmful effects of chemicals, and it applies (in principle, at least) to all chemicals used in the bloc—whether in industrial processes, domestic cleaning products, clothing or furniture, to name a few. REACH puts the burden of proof on the companies that fall within its scope, and those firms must "identify and manage the risks linked to the substances they manufacture and market in the EU".[2]

To that end, companies need to show ECHA, the EU's chemicals regulatory agency, how their chemicals can be used safely. They must also ensure that users are aware of measures to manage risks associated with those chemicals. Those chemicals whose risks cannot be managed are subjected to restrictions, while those regarded as the most hazardous are meant to be replaced over time with less harmful substances.[3]

Europe's Green Deal and Chemicals Strategy

A key element of Europe's approach to better chemicals management is its Chemicals Strategy. It was published in 2020 and is part of the bloc's Zero Pollution goal under its 2019 Green Deal, the goal of which is to ensure that Europe is the world's first climate-neutral continent.[4]

The Chemicals Strategy, which was under review at the time of writing, has two key objectives:[5]

- First, to improve the protection of citizens and the environment by: banning the most harmful chemicals from consumer products (unless their use is deemed essential); accounting for the risks associated with multiple chemicals (the "cocktail effect"); and phasing out PFAS (see p.27), chemicals unless their use is deemed essential.
- Second, to improve innovation for safe and sustainable chemicals, including by implementing a simpler process for risk and hazard assessment, and by promoting high standards for chemicals worldwide.

For its part, the Green Deal encompasses the EU's newly integrated approach to tackling pollution—the first time that it has dealt collectively with the various realms of pollution (for soil, marine and health, for instance) rather than in silos. Attaining the goal of Zero Pollution does not mean having no pollution whatsoever, though; instead, the aim is to ensure that whatever pollution is emitted does not have a harmful impact on human health or the environment.

Another area that overlaps with the marine environment is the EU's Farm to Fork Strategy, which is at the heart of the Green Deal, and which seeks to take regulatory and non-regulatory steps "to make food systems fair, healthy and environmentally friendly"—including ensuring that seafood is not contaminated, and reversing the loss of biodiversity.[6]

Another piece of EU law is its POPs Regulation,[7] which implements the bloc's obligations under the UN's Stockholm Convention on Persistent Organic Pollutants, which is itself the key global agreement on eliminating or limiting several dozen of the most harmful synthetic chemicals, many of which have found their way into the marine environment.

There are numerous international agreements related to marine chemical pollution, with two others that fall within the UN's remit being the Basel Convention, which aims to cut the cross-border movement of most-hazardous waste, and the Rotterdam Convention, the prior informed consent procedure of which is designed to ensure that the listed chemicals—many of them pesticides—are not exported to countries that object to their import. The Minamata Convention on Mercury is another landmark treaty, while the box on the next page lists some of the other international and regional instruments that are directly or indirectly designed to address marine pollution.

Key international instruments to address marine pollution

Global instruments and strategies

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972)

Also known as the London Convention, it addresses deliberate at-sea disposal of land-based waste, with each member regulating discharges of waste on its own ships. Eighty-seven states are currently party to the convention.[8]

International Convention for the Prevention of Pollution from Ships (MARPOL) (1973)

Addresses pollution and dumping from ships due to operational losses or accidents. Various annexes deal with specific aspects including oil (Annex I), noxious liquid substances (Annex II), sewage from ships (Annex IV) and air pollution (Annex VI). Annex V focuses on reducing the amount of garbage—including plastics—disposed of at sea by vessels.[9]

UN Convention on the Law of the Sea (UNCLOS) (1982)

It sets out rules for the use of the ocean and its resources, and includes measures to protect and preserve the marine environment. Among these are restrictions on pollution from vessels, land-based sources and dumping. It also restricts the transfer of pollutants between nations.[10]

International Convention on the Control of Harmful Anti-fouling Systems on Ships (2001)

The convention, which entered into force in 2008, requires parties to ensure that ships that fly under their flag, use their ports or shipyards, or that operate under their authority do not use organotin anti-fouling paints that stop sea life like barnacles and algae from attaching to hulls.[11]

Strategic Approach to International Chemicals Management (SAICM) (2006)

The SAICM is a global policy framework to promote chemical safety, with objectives covering five areas: risk reduction; knowledge and information; governance; capacity-building and technical cooperation; and illegal international traffic. Its initial goal, which was not achieved, was that by 2020 chemicals would be produced and used "in ways that minimise significant adverse effects on the environment and human health".[12]

Selected regional instruments

Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (1983)

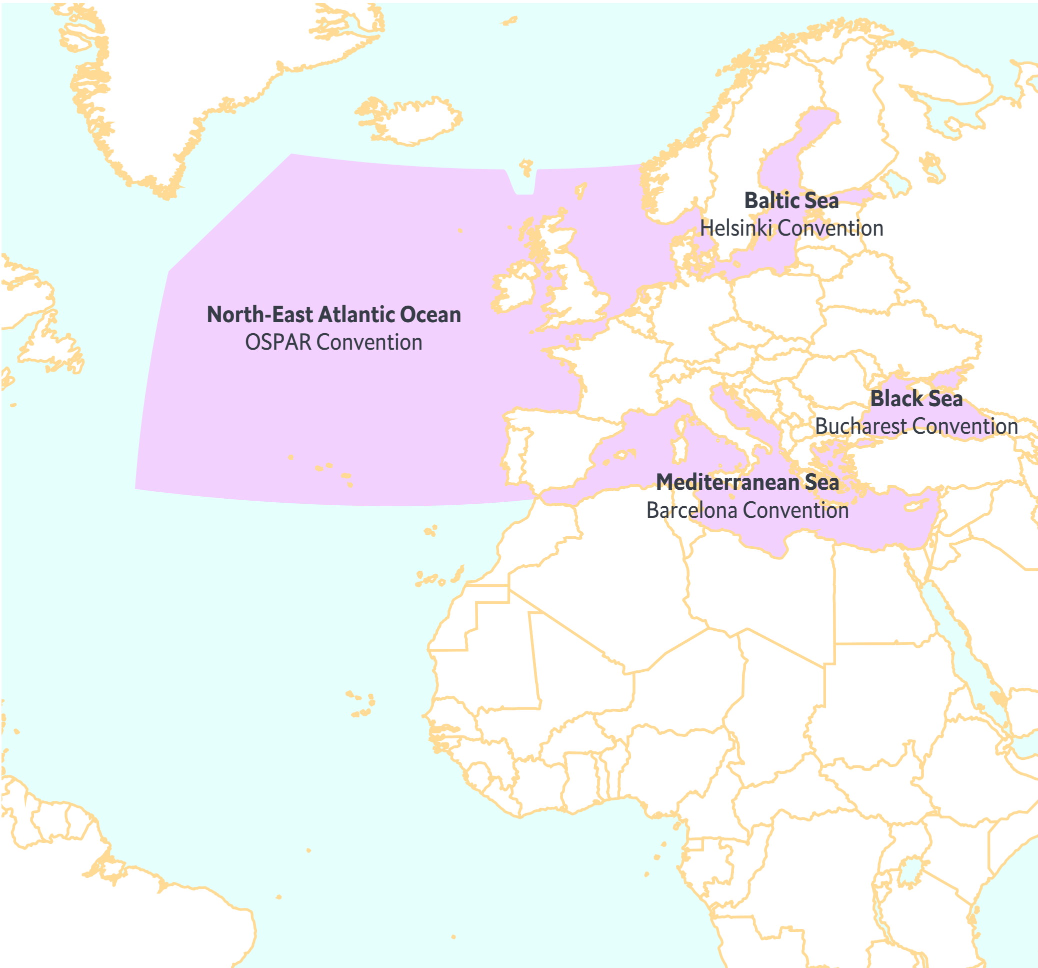
Also known as the Cartagena Convention, it addresses pollution from ships, dumping at sea and land-based sources of pollution in the Wider Caribbean Region. It has been ratified by 26 UN member states.[13]

EU Marine Strategy Framework Directive (2008)

It is designed to protect the bloc's marine environment and ecosystem from, among other aspects, chemicals. Among its provisions are tackling litter in European Union seas based on where it is found (for example, washed ashore, detected in the water column or ingested by marine animals) and by type (for example, microplastics).[14] Each member state must develop a management strategy for its marine waters, and must also monitor and report on chemicals and pollutants.

Another regulatory layer consists of the four Regional Seas Conventions (RSCs) that seek to conserve Europe's marine environment by engaging EU and non-EU countries to cooperate, and which cover the maritime areas on the map below.

Europe's four Regional Seas Conventions (RSCs)



Source: Regional Seas Conventions, WISE Marine (EU and EEA)

The four RSCs are:

- *The Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (1978)*: Also known as the **Barcelona Convention,** it addresses land and ocean-based waste from dumping, runoff and discharges (including plastics) in the Mediterranean Sea region. It has 22 contracting parties, one of which is the EU.[16]

- *The Convention on the Protection of the Marine Environment of the Baltic Sea Area (1980)*: Also known as the **Helsinki Convention,** it seeks to protect the Baltic Sea from all sources of pollution, whether from the land, sea or air, and commits its nine contracting parties and the EU to conserve the habitat and biodiversity of the marine environment, and to use its resources sustainably. Members must also establish legislation for the prevention and abatement of marine pollution.[17]

Impressive though the range of national and supranational legislation is, the system does not work as well as it needs to

- *The Convention for the Protection of the Marine Environment of the North-East Atlantic (1992)*: Also known as the **OSPAR Convention,** this seeks to prevent and eliminate pollution in the North-East Atlantic, including from ship discharges, lost and discarded fisheries materials from vessels, land-based waste from coastal or riverine disposal and recreational littering. It also requires its 16 contracting parties to monitor the marine environment and report regularly on their findings.[18]

- *The Convention on the Protection of the Black Sea Against Pollution (1992)*: Also known as the **Bucharest Convention,** it is the legal framework around which the six member countries work to protect the Black Sea and conserve its living resources.[19] It is the only one of the four RSCs of which the EU is not a member.[20]

In addition to this array of global and supranational instruments and legislation, many countries have adopted laws that target chemicals—which, given that chemicals are in almost everything we use, means the scope of legislation can range widely. Such laws might, for instance, regulate factory emissions, vehicle emissions and other forms of pollution, or they might ban or restrict single-use plastics and microbeads.

Other measures by which countries can influence the impact of chemicals include economic and fiscal measures like the taxation of plastic bags, control and demand approaches in which restrictions are imposed on the use of chemicals within their jurisdiction and in specific areas (for instance, in food packaging), or mandating packaging and labelling requirements for hazardous chemicals.[21] Whichever approach is chosen, the goal is typically to reduce and/or avoid the harm that chemicals inflict on human health and the environment.

Impressive though the range of national and supranational legislation is, the system does not work as well as it needs to. Later in this chapter we will examine in more detail the barriers that hinder protection of the marine environment from chemical pollution and will outline interventions needed to drive improvements.

Why the EU leads the world on marine chemical pollution

The fact that the EU is—for the most part—ahead on marine chemical pollution is no accident, says Dr Aleke Stöfen-O'Brien, a lawyer and policy expert at the WMU-Sasakawa Global Ocean Institute at the IMO-World Maritime University in Sweden.

Crucial to this leading role is the EU's *sui generis* legal system that has seen member states hand over some of their sovereign competences to the supranational level. As a result, nations cannot simply do what they want in those areas.

Specifically, protection of the environment—and therefore of the marine environment—is a shared competence between the European Commission and EU member states, and relevant laws are passed by a qualified majority in the European Parliament. In other words, even those member states that vote against environmental laws will be bound by them should they pass.

In addition, says Dr Stöfen-O'Brien, the EU is guided by robust principles that can be used in countries' courts as well as at the European Court of Justice. These include the polluter pays principle, the principle of prevention, and the principle of source, which requires that countries address pollution at source instead of waiting until it enters the environment.

"And this is legally binding," she says. "Also, you can legally measure every single act by a private entity against these principles, and you can measure any legislation against these principles."

Furthermore, the European Commission's mandate to protect the environment has seen it implement ambitious goals to ensure high legislative standards—for example, in REACH and the Marine Strategy Framework Directive, but also in areas like ship emissions, plastics and chemical pollution.

"The European Commission has developed an extremely ambitious set of instruments, sometimes against the will of some member states," says Dr Stöfen-O'Brien. "And if those are adopted, then they can be used as a legal basis for action by countries and therefore also against polluters in those countries, and they need to comply."

Finally, further underpinning the regulatory regime, nations can be held responsible by the European Commission for failing to act against polluters within their jurisdiction. That creates an additional incentive for national regulators to implement and enforce EU law obligations.

Learning lessons

Examining the different approaches taken can help by showing what works and what does not. How to learn these lessons was the subject of a report by the European Environment Agency (EEA). Despite being published in 2013, many of its conclusions remain valid—among them, that sound policies can help to manage the often-conflicting goals of business and society.[22]

The EEA's report also noted how matters of profound importance can be manipulated (as seen in decades of lobbying by the tobacco industry, for instance) or poorly explained. Climate change is an example of the latter, and saw a false choice presented to the American public. Instead of being asked whether climate change was something worth worrying about, US Vice President Al Gore framed the question as "a matter of choice between believers and sceptics," the EEA stated. This saw the public required to assess a matter of profound importance when most lacked the necessary scientific qualifications to do so.[23]

The EEA drafted a series of steps, the first of which was to apply the precautionary principle and to reduce the delays seen between early warnings and taking action. It also noted that there was little reason to fear that acting pre-emptively was unwise

The obvious risk is that marine chemical pollution, which some interviewees feel could have as big an impact on Earth as climate change, and with which it is inextricably linked (see Chapter 3), suffers a similar fate. That would lead to delays, confusion and inaction—despite a litany of early warnings. And, as the EEA has made clear, ignoring early warnings often ends badly.[24] When it comes to the environment, the EEA notes, success requires an effective response, and that requires, among other actions, creating better-quality risk assessments, and rethinking the way that existing studies on the environmental and health impacts are funded, with too much focus on well-known hazards like mercury and lead, and not enough on emerging ones.[25]

"A more equal division of funding between known and emerging issues, and between products and their hazards, would enrich science and help avoid future harm to people and ecosystems and to the long-term economic success of those technologies," it states.

To avoid repeating past mistakes, the EEA drafted a series of steps, the first of which was to apply the precautionary principle and to reduce the delays seen between early warnings and taking action. It also noted that there was little reason to fear that acting pre-emptively was unwise—on the contrary, it was clearly effective, with just four out of 88 potential risks that it assessed turning out to be false alarms. In addition, experience had shown that acting in this way stimulated innovation rather than hindering it.[26]

"The frequency and scale of harm from the mainly 'false negative' case studies indicate that shifting public policy towards avoiding harm, even at the cost of some false alarms, would seem to be worthwhile, given the asymmetrical costs of being wrong in terms of acting or not acting based on credible early warnings," the report concluded.[27]

That goes to the heart of one of the core issues with respect to marine chemical pollution: being overly cautious, which can see insufficient action taken on potentially catastrophic developments. History shows that governments are inclined to act only when there is indisputable evidence of harm from a specific chemical or groups of chemicals, as shown by the Montreal Protocol, which targets ozone-harming chemicals, and the Minamata Convention, which tackles mercury.

This also holds true for organotin compounds like tributyltin (TBT) that were for years used as anti-fouling paints on ships and boats, stopping organisms like barnacles and algae from attaching to their hulls. Once it was clear that these compounds were extremely damaging to the marine environment—they also enter the food chain—their use was made subject to the provisions of the International Convention on the Control of Harmful Anti-fouling Systems on Ships, which largely banned or restricted them for that purpose. Under the convention, parties must ensure that ships using their flag, under their authority or entering their ports and dockyards do not use such paints on their hulls.[28]

The convention entered into force in 2008, and to date has been signed by 91 states parties representing nearly 96 percent of world tonnage.[29] While that is clearly beneficial to the marine environment, researchers have found that even TBT, with its known toxicity, remains available in many countries.[30]

Excessive caution is one problem. Another is that action can easily take years or even decades. Although the International Maritime Organisation (IMO) recognised in 1989 the harm that organotin compounds inflict on the marine environment, the convention itself did not enter into force until 2008—nearly two decades on. Interim steps included:[31]

- In 1990, an IMO committee adopted a resolution recommending that governments take measures to bar the use of anti-fouling paint that contains TBT on vessels with non-aluminium hulls longer than 25 metres, or where the paints leach more than four micrograms of TBT each day.
- In 1992, the Rio Conference on Environment and Development asked states to act against organotin compounds in anti-fouling paints to reduce pollution.
- In 1999, the IMO's assembly called on one of its committees to draft a legal instrument to tackle such anti-fouling paints.
- In 2001, the document that would later be named the International Convention on the Control of Harmful Anti-fouling Systems on Ships was adopted.
- In 2008, the convention came into force.

Furthermore, the convention applies only to anti-fouling paint. Yet organotin compounds, including TBT, are still widely used in biocides, PVC plastics (as a stabiliser) and disinfectants, even though some are known neurotoxins and immunotoxins, or are harmful to reproduction and development.[32] And because some of those products will enter the ocean, so too will TBT, if on a smaller scale than before.

That is not all, because having a convention does not mean the battle against toxic anti-fouling agents is won. Regrettable substitution remains a risk, as seen by the efforts in 2017 by an IMO committee to amend the convention to include cybutryne, another anti-fouling agent that "causes significant adverse effects to the environment, especially to aquatic ecosystems". As of late 2021, that work was still ongoing.[33]

When it comes to tackling marine chemical pollution, then, several aspects stand out:

- Regulation, while crucial, particularly for global instruments, takes too long to put in place. And without effective enforcement, regulation is of limited value.
- Adding chemicals to the scope of existing treaties is a lengthy process that typically takes years.
- Existing agreements are fragmented, and their objective (to protect the environment) is often at odds with international laws that protect economic interests, like trade law and intellectual property law.

Best practice

Despite the shortcomings of existing agreements when considering marine chemical pollution on an overall basis, some do offer useful best practice lessons, says Dr Aleke Stöfen-O'Brien, a lawyer and policy expert at the WMU-Sasakawa Global Ocean Institute at the IMO-World Maritime University in Sweden.

Part of the problem with many international agreements that seek to protect the broader environment is that they do not focus on the marine environment

One such example is the OSPAR Convention that seeks to protect the North-East Atlantic, and which has undertaken significant work on hazardous substances. This includes identifying priority chemicals in the marine environment, in part by assessing biota for certain chemicals, with that evidence-based approach then feeding into efforts to guide policy.

"So, they start with evidence-based [data] and then move on to regulation," she says.

That approach—a mandate that allows the negative effects of chemicals to be subject to evidence-based assessments—is a good example of best practice. And while such a mandate might seem logical, not all conventions that cover regional seas have one. A best practice approach, Dr Stöfen-O'Brien says, should encourage countries to monitor and assess, and then to take measures relating to the marine environment—and not just the broader environment.

Another agreement with best practice elements regarding marine chemical pollution is the EU's Marine Strategy Framework Directive, which contains specific descriptors that look at chemicals and food chains, including food for human consumption, as well as at chemicals and their impact on fish and shellfish.

"This means countries are obliged to monitor the marine environment and some vital biota for chemicals, and then create measures [in response]," says Dr Stöfen-O'Brien.

For similar reasons, the IMO's antifouling convention is another, as is its ship recycling convention, where beach-based shipbreakers in, for instance, India and Bangladesh, are increasingly required to have an environmental chemical protocol. A fourth is the IMO's Ballast Water Convention, which requires the use of UV light rather than chemicals to treat ballast water prior to release.

Part of the problem with many international agreements that seek to protect the broader environment is that they do not focus on the marine environment. From a technical perspective, says Dr Stöfen-O'Brien, drafting agreements to tackle chemicals that focus on the terrestrial or atmospheric environment means they are of far less use for the marine environment. This is because they lack key information on chemical pollution in the marine environment, and will not incorporate the means to capture data or to initiate regulatory monitoring and reporting on the impact that chemicals have on the seas.

"The marine environment is something different—but if you don't know enough about the topic, how can you develop and identify pressing issues and pick them up in a regulatory system?" she says. "I'm not saying that all of these environment treaties need to be changed, but there needs to be more focus on the marine effect of chemicals."

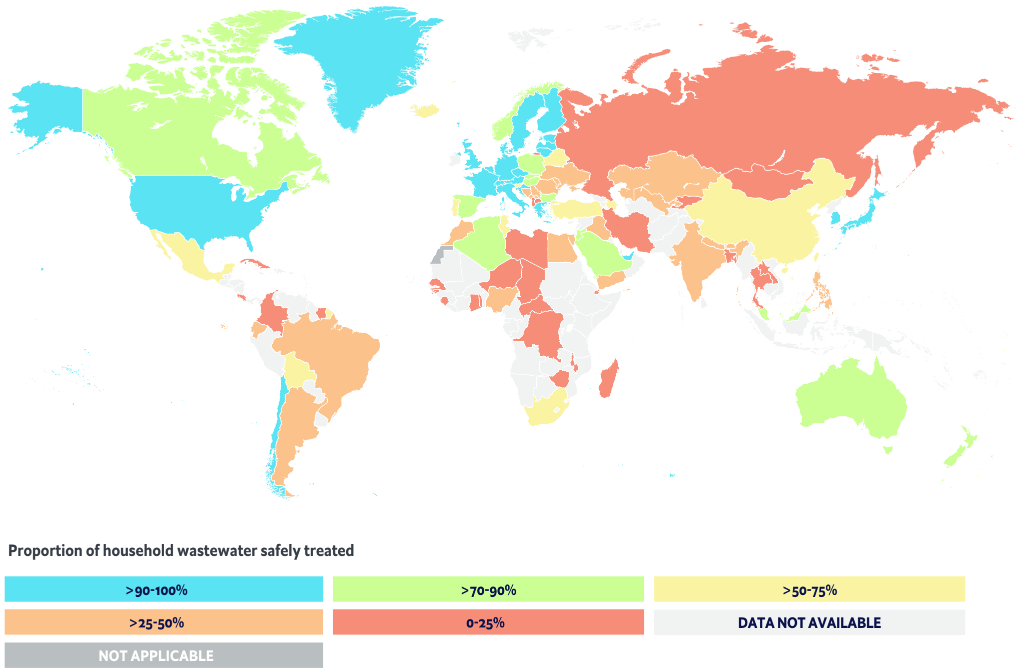
Focus on wastewater

As noted earlier, a key source for marine chemical pollution is wastewater from households and industry. Wastewater treatment is one of eight targets contained within the UN's Sustainable Development Goal (SDG) 6, the goal of which is the provision of water and sanitation for all by 2030.[34]

Progress has been slow. When it comes to household wastewater, 44 percent worldwide is not safely treated, the UN says, with significant regional disparities (see map). Meanwhile, it is impossible to say how much industrial wastewater is safely treated globally: just two nations have data on that, compared with 128 countries that collect data on the safe treatment of household wastewater flows. Logically enough, the UN says a greater proportion of countries' populations must be connected to sewers and septic tanks, and it wants less direct discharge of sewage into the environment.[35]

SDG 6.3.1: The percentage of safely treated household wastewater flows, 2020

The figures denote the proportion of domestic wastewater flow that is safely treated in 128 nations. In 62 of those countries, less than half of the wastewater generated by households was safely treated. Among the goals of Target 6.3.1 is that water quality is improved by 2030 by "reducing pollution, eliminating dumping and minimising release of hazardous chemicals and materials", and by halving the proportion of wastewater that is untreated



Source: Summary Progress Update 2021: SDG 6 — water and sanitation for all, UN Water

The treatment of wastewater

The three main stages of wastewater treatment are known as primary, secondary and tertiary. Each stage removes certain pollutants, and the remaining water becomes progressively cleaner. A fourth stage can be used to generate even cleaner water.[36]

- *Primary treatment*: the flow is pumped into a settling tank, where heavier solids sink to the bottom of the tank and are pumped to a sludge treatment facility.
- *Secondary treatment*: the flow from the primary treatment is subjected to processes that lower the levels of biodegradable contaminants. These include biofiltration, aeration and oxidation ponds. Typically, secondary treatment does not remove nitrogen.[37]
- *Tertiary treatment*: the flow from the secondary treatment further raises the quality of the water, including by the removal of pathogens so that the water is fit for human consumption.[38] Removing nitrogen typically requires tertiary treatment.[39]

Household wastewater is classed as "safely treated" if it is "treated by secondary or higher processes or that effluent discharges met relevant standards". The reason that 44 percent of household flows worldwide did not fall into this category is because they are not collected at centralised treatment plants or in septic tanks.[40]

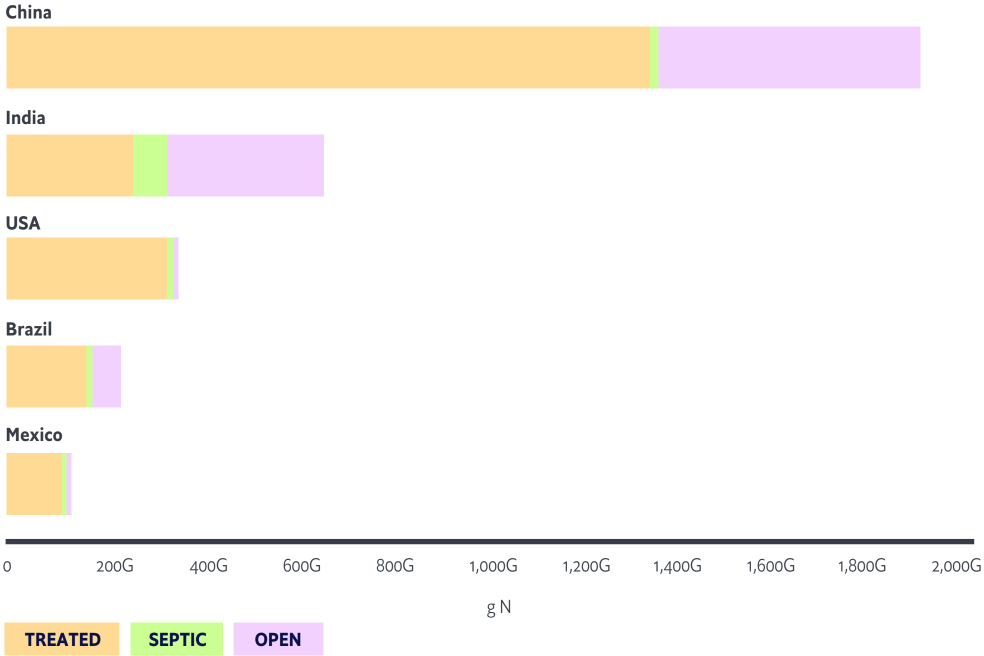
Improving this is far from an academic exercise. A ground-breaking 2021 study mapped global wastewater outputs, specifically nitrogen and pathogens (known as faecal indicator organisms, or FIOs) from human sewage, for about 135,000 watersheds around the world to understand what treatment wastewater gets and where it ends up.[41]

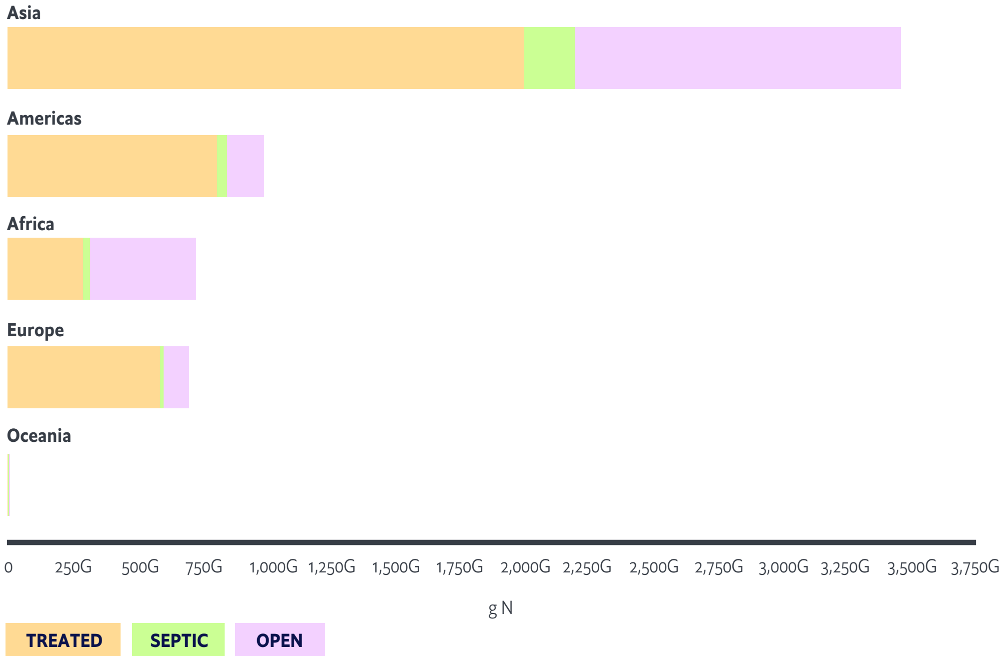
Among the findings is that wastewater adds 6.2 teragrams of nitrogen annually to coastal waters—or about 45 percent of the total nitrogen flow into the ocean from agriculture. Almost two-thirds of wastewater nitrogen comes from sewered systems, while nearly a third is from direct input to the seas. The remaining 5 percent comes from septic systems.[42]

"We find that just 25 watersheds contribute nearly half of all wastewater [nitrogen], but wastewater impacts most coastlines globally, with sewered, septic, and untreated wastewater inputs varying greatly across watersheds and by country," the authors wrote.[43]

Of the 25 watersheds responsible for the largest amounts of nitrogen, nine are in China (the Yangtze River alone accounts for 11 percent of the global total) and three are in India. Others include Bangladesh, Egypt, Pakistan, the US, Argentina, Russia and Niger as well as three European nations: Romania, the Netherlands and Ukraine. Overall, just five countries account for half of all the wastewater input measured, while Asia's flows of wastewater nitrogen comfortably exceed the rest of the world combined (see charts).[44]

Top five countries (above) **and regions** (below) **as measured by total nitrogen** (g) **input into their coastal zones by source type** (sewer, septic, direct)





Source: Seminal Study Maps Impacts of Wastewater on Coastal Ecosystems: An Interview with Dr. Ben Halpern, Our Shared Seas (2021).

Of those 25 watersheds, the five rivers with the most nitrogen per square cubic metre are DRC's Congo (36,679 N(g/m2), the US's Mississippi (27,602), Argentina's Rio Parana (26,329), Niger's Niger River (25,580) and Russia's Amur River (24,424). Others exceeding the 20,000 N(g/m2) level are Egypt's Nile, Iraq's Shatt al-Arab and Ukraine's Dnieper.[45]

The consequences of nitrogen and FIOs—whose input levels the study found were generally correlated—are well known, with excess nitrogen, for example, leading to eutrophication and dead zones in the marine environment. The study concluded that 58 percent of coral and 88 percent of seagrass beds were exposed to nitrogen from wastewater. China, Kenya, Haiti, India and Yemen had hotspots for nitrogen exposure for coral, while hotspots for seagrass were found in Ghana, Kuwait, India, Nigeria and China. Other hotspots for coral reef impacts from wastewater include the Caribbean and Indonesia.[46]

When it comes to wastewater treatment, different countries have vastly different approaches. In the US, for example, nearly all households are on sewerage systems or use septic tanks; that is not the case for 3.6 billion people around the world.[47] As a result, the UN says, more than 80 percent of wastewater globally is released into the environment without being sufficiently treated, with most water-related pollution due to "intensive agriculture, industrial production, mining and untreated urban runoff and wastewater".[48]

Take India, for example. Government figures show that of the 16 billion gallons (60 billion litres) of sewage generated in the country's urban areas, less than half is treated. Much of the rest ends up in India's rivers. Wastewater treatment in rural areas is non-existent. A big part of the reason for the failure to resolve the country's urban sewage problem is red tape and regulatory overlap which, a government adviser admits, have stymied progress on wastewater treatment for decades.[49]

In most developed countries, wastewater from households and industry, as well as that emanating from hospitals, restaurants, educational institutions and businesses, is fed into the same system and ends up at the same centralised wastewater treatment plant (although local regulations might require certain industries to treat their effluent to some degree prior to pumping it into the centralised sewerage system).

This approach makes sense, says Professor Paul Westerhoff of the School of Sustainable Engineering and The Built Environment at Arizona State University, because it is more cost-effective and makes regulating discharges into the environment easier. In the US, he says, wastewater from industrial sources accounts for about 10 percent of the volume, while households comprise just under half.

What is interesting, Professor Westerhoff says, is how the US's 15,000 wastewater treatment plants differ in the processing that they carry out. His research shows a clear difference between the quality of water discharged from inland wastewater-treatment plants versus that from coastal-based plants.

Most US wastewater treatment plants discharge their flows into surface waters. For plants on the coast, that is the sea; for inland plants, it is rivers or lakes (though even then, he says, many of the chemicals discharged end up in estuaries and the sea).

"The first thing that comes out of the study is that [coastal-based plants] have a much lower level of treatment in general than those further inland," he says.

The reason is regulation. The US has more stringent rules on discharging treated water into rivers than into the sea, and that is largely because rivers have a lower capacity to dilute. In particular, the US imposes specific limits on the levels of nitrogen and phosphorus. Coastal-based wastewater treatment plants, on the other hand, are not required by law to remove nitrogen or phosphorus. That, it turns out, has important consequences for other contaminants.

"As a consequence of improved treatment of nitrogen and phosphorus, you actually remove pharmaceuticals and industrial chemicals better. And the reason is because to remove, say, nitrogen, you have to add oxygen, but then you also need other microbes—bacteria that operate in the absence of oxygen," he says. "So, if you can remove nitrogen—it's called biological denitrification—you actually get better removal of most of these pharmaceuticals and personal-care products. It's a double benefit."

Cleaning up: How Los Angeles is looking to improve its water reuse

Los Angeles County—home to Los Angeles, the second-largest city in the US—currently pumps about 1 billion gallons (about 3.8 billion litres) of partially treated wastewater directly into the ocean daily, with the contaminants polluting the marine environment.

In the near future, the body that treats and delivers drinking water for the broader region, the Metropolitan Water District of Southern California, is set to implement a project that could see a sizeable amount of that wastewater reused. In large part, this is being driven by the need to deal with the effects of droughts and water shortages.[50]

The Regional Recycled Water Programme (RRWP) is currently in its demonstration phase, with a US$17m water purification facility designed to treat 500,000 gallons (1.9m litres) of effluent from Los Angeles County daily. Once the approach is proven to the satisfaction of regulators, the goal is to implement a full-scale regional programme costing around US$3.4bn to build and US$129m annually to operate. That should be functioning by 2032, and could produce as much as 150m gallons (570m litres) of treated wastewater each day—enough for 500,000 homes.[51]

The RRWP would take effluent from homes, businesses and industry. After undergoing advanced treatment, it would be further purified using microorganisms, membranes, reverse osmosis, ultraviolet light and advanced oxidation to produce high-quality, purified water.[52]

While producing water in this way is much cheaper than desalination, it still leaves the remaining wastewater, which will by then be additionally concentrated with the salts and chemicals that were removed by the advanced treatment processes. This mix of treated wastewater and concentrate from the advanced treatment plant will continue to be pumped several miles offshore into the ocean. In short, cleaning wastewater in this way does not maximise the potential environmental benefits to the ocean.

However, from an environmental perspective there are opportunities to treat what remains in this concentrated stream before its disposal into the ocean. And, although this mix is heavy with salts, their concentrated presence is advantageous as it means other technologies that work well in salty solutions (for instance, using advanced oxidation processes like ultraviolet light irradiation in the presence of titanium dioxide[53]) can be used to remove the problematic chemicals that remain.

Pharmaceuticals are a particular challenge for wastewater treatment plants, which typically use bacteria to remove chemicals, because oral pharmaceuticals are designed not to stick to fatty biological tissues. (If they did, manufacturers would need to increase the dose to ensure enough was delivered to the target site in humans.)

Pharmaceuticals are a particular challenge for wastewater treatment plants, which typically use bacteria to remove chemicals, because oral pharmaceuticals are designed not to stick to fatty biological tissues

"Wastewater treatment plants essentially just grow bacteria, and a lot of things stick to the bacteria—lots of carcinogens, whether those are polyaromatic hydrocarbons or PCBs, for instance," says Professor Westerhoff. "That's because bacteria aren't so different from us—they have an outer cell membrane made up of liposomes, which are kind of fatty, and so things stick into these fatty parts of their cells. After that, you take out the bacteria [and dispose of it]."

But because pharmaceuticals are designed not to stick to fat, they get through. To remove pharmaceuticals requires other technological solutions, and those cost more, which is why few countries bother to do so. One exception is Switzerland, where wastewater treatment plants will have to implement one of two technologies—either activated carbon, which absorbs trace organics, or ozone, which oxidises and breaks down chemicals.[54]

The reliance on bacteria at many wastewater treatment plants explains why the chemicals that tend to get through are hydrophilic chemicals that do not accumulate in fatty tissues.

"These are the things that move through the environment very quickly. They oftentimes react more slowly, but they don't necessarily bioaccumulate," he says. "So, if you think about the ecosystem in the ocean, there are lots of chemicals that build up in whales, other mammals and predatory fish at the top of the food chain in their fatty tissues, because they eat smaller things—that's biomagnification. But a lot of those chemicals, if they were at a wastewater treatment plant, probably would have gotten absorbed or stuck onto bacterial cells."

Improving wastewater treatment around the world is only part of the challenge in addressing marine chemical pollution; other solid waste from households and business is also a concern. With increased urbanisation, particularly along coastlines, and with more people and industries generating more effluent and more waste, the need to tackle these twin problems will increase.

Take municipal waste. By 2030 Asian nations are forecast to be the largest generators of municipal waste, much of which contains chemicals, while Africa is expected to overtake Asia later this century. In 2012, countries in Africa, where infrastructure to deal with waste is the exception, generated 125 million tonnes of municipal solid waste; that figure is forecast to double by 2025.[55]

Dr Kevin Helps, a geochemist with the United Nations Environment Programme (UNEP) who spent a decade in the waste management industry removing hazardous waste from developing countries, and more than 22 years in the UN system working on waste issues, considers issues such as better wastewater management to reduce the levels of pollutants in effluent as key to curbing marine chemical pollution.

"Technologically, it's not a matter of, 'Can it be done?' The answer is yes. It's a matter of the standard to which it needs to be done. The technology exists to take out microplastics and harmful chemicals, for example, or to take out or reduce the levels of pharmaceutical residues which can interfere with biological systems," he says.

The challenges are the cost and the access to technology in developing countries that often lack basic sanitation.

"And one of the points that I consistently try to get across is that all the 'stuff' we crave in a modern consumer society is just too cheap. Basically, we don't internalise the externalities of dealing with things later in the product life cycle properly," Dr Helps says.

To ensure sustainable consumption and production, then, requires adopting circular approaches where possible, redesigning and retooling—not simply recycling—and, he says, "designing out the dangerous chemicals which go into the processes—because they ultimately all end up in the air and the ocean because they get rained out, and they end up depositing in our water".

Good enough to drink?

Wastewater treatment plants are one of the main ocean sources of PFAS compounds, says Professor Elsie Sunderland of Harvard University, "because they're receiving all of the consumer products that contain PFAS, and then whatever goes through your body" goes into the wastewater.

And while microplastics generate headlines, it is chemicals like the PFAS group that are likely of far greater consequence to human and marine health.

"Should we do something about microplastics? Absolutely," she says. "And if microplastics raise awareness, and people care about microplastics, then that's a great transition point to chemical pollution. But in terms of the severity of the issue in terms of health, I do not believe [microplastics] are on the same magnitude at all."

Professor Paul Westerhoff of the School of Sustainable Engineering and The Built Environment at Arizona State University says existing wastewater treatment plants cannot remove all chemicals (though they do remove about 90 percent of nanomaterials). However, they could do so if they were upgraded to use technologies like reverse osmosis membranes—as happens in some places in the US and Australia, as well as in Singapore.

"You can take wastewater and make drinking water," he says. "So, we could remove everything. However, I know of no wastewater treatment plant in the world that uses reverse osmosis, and then just discharges that clean water into the ocean or river just because they want to clean things up—instead they do this when extremely high-quality water is wanted for human or industrial reuse."

While using reverse osmosis is more costly than simply using existing wastewater treatment, it is only about half the cost of desalination, "which is why some cities want to do that instead of de-salting seawater". Going down this route, however, still means that they are left with 20 percent of the wastewater flow "that contains everything that you physically removed".

One option to deal better with this remaining 20 percent of water is zeroliquid discharge (ZLD), a solution that the US Department of Energy is helping to fund. ZLD evaporates the remaining 20 percent of water that contains the concentrated levels of salt and chemicals, leaving those behind. However, ZLD is expensive—as much as ten times the cost of existing wastewater treatment.

Continued on next page

All of which raises another question: Existing wastewater treatment typically uses bacteria, which grow fat on the chemicals during their time at the plant. What happens to them after that?

"In the United States, roughly half are land-applied. So, we concentrate all this stuff, and then we spread it back out in the environment," Professor Westerhoff says. "This can be on farms to grow hay or cotton and other non-human consumptive crops. Or they put them in forests to grow tree forests. Some people see them as a resource—and they are pretty nutrient-rich—but I think that's a mistake."

In the US, about half of these so-called sewage solids, or bio-solids, are land-applied, about 30 percent go to landfill, while the rest is incinerated. In Switzerland, on the other hand, all sewage solids must be incinerated, "and I think that is the right thing", Professor Westerhoff says. Using them on the land, on the other hand, means that the organic chemicals and metals in the original wastewater end up in the soil, and from there they can leach into the air or water sources, "and these things are persistent".

Yet innovative solutions abound. One option is to extract the chemicals in the remaining water; another is to generate 98 percent clean water, which would leave 2 percent of high-salt, chemical-laden water. Other advanced technologies will likely bring other solutions. However, says Professor Westerhoff, very few countries are currently putting in place such measures.

"And that's because there are no regulatory drivers even to treat these chemicals in this 20 percent and, outside of a few countries in Europe, there are no regulatory drivers to manage pharmaceuticals [in wastewater]," says Professor Westerhoff.

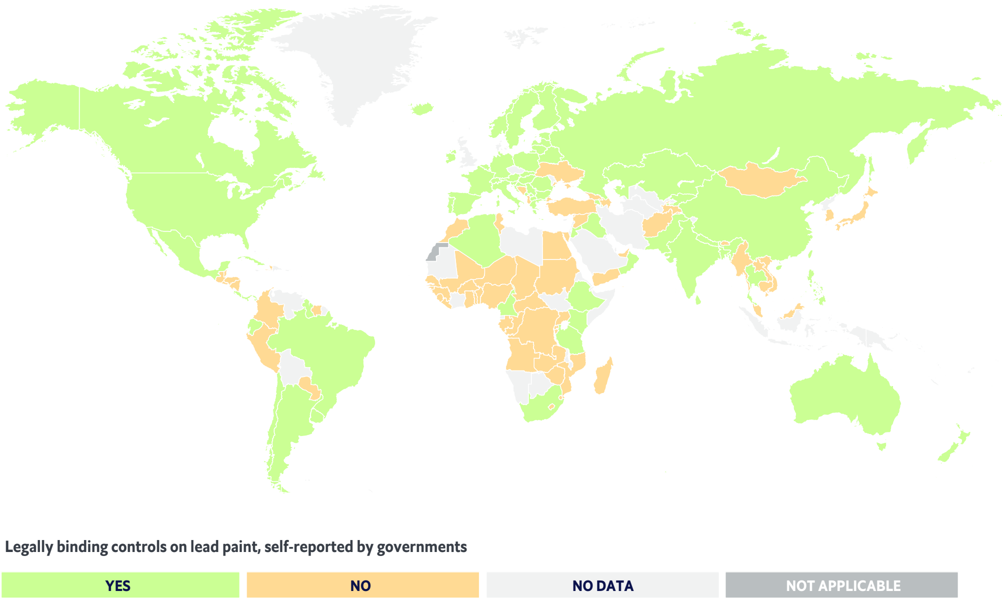
Acting on toxic chemicals takes far too long. It typically takes years for legislation to be drafted, agreed upon and implemented, whether at a national or supranational level

Although the cost of building infrastructure to mitigate factors like wastewater pollution is high—which explains why nearly half of the planet's population lacks access to sewerage systems and septic tanks—it is also the case that many countries fail to act on pollutants even when doing so is largely cost-free.

Take lead, whose dangers are well-known, and which accounted in 2019 for nearly half of the world's two million excess deaths due to chemicals. As at the end of 2020, the WHO says, just 41 percent of countries had confirmed to the global health body that they had legally binding restrictions on lead in paints.[56] And when it comes to the use of lead paint in the marine environment, this toxic chemical element is still used as an additive in marine paints—which brings contamination concerns.[57]

Countries with legally binding controls on lead paint, 2020

Just 41 percent of countries (in green) told the WHO that they have regulations controlling the production, import, sale and use of lead paints. Countries in most of Africa and the Middle East and much of South-East Asia and South America either lack controls (in orange) or have not provided data (in grey)



Source: The public health impact of chemicals: knowns and unknowns - 2021 data addendum, WHO (2021)

5.3 Barriers to progress: One ocean, many jurisdictions

The narrative with lead—that, even today, too few countries have acted against a contaminant whose harm is clear—explains some of what lies behind marine chemical pollution: at an international and national level, action requires overcoming barriers, and that can be difficult.

The list of barriers is long. One is the failure to acknowledge the finite nature of the ocean, and its interconnectedness with human activities on land. For too long, the world has mistakenly assumed that the ocean can continue to absorb and dilute chemical pollution.

Another is that there is insufficient chemical data to inform regulatory decision-making. Linked to this is a lack of knowledge about which chemicals are being produced, used and released, the amounts involved and their potential effects. A fourth is the pressure to side-line or ignore science in regulatory processes.

It is also the case that acting on toxic chemicals takes far too long. It typically takes years for legislation to be drafted, agreed upon and implemented, whether at a national or supranational level, or for parties to file applications for, say, the Stockholm Convention to consider adding a chemical—which then must be considered and ruled on.

A recent example is provided by PFAS chemicals, the dangers of which have long been apparent to researchers. However, it was only in late 2021 that the world's wealthiest nation, for instance, announced it would target them, after decades of river pollution, ill-health and contamination of the seas. Michael S. Regan, the head of the US's Environmental Protection Agency (EPA), said the agency would set legal limits for levels of PFAS in drinking water, boost research and monitoring of the chemicals, and designate them as a hazardous substance, with further steps to come in 2022.[58]

Additionally, manufacturers of PFAS compounds will need to test the levels of PFAS, divided into 20 sub-categories based on their characteristics, in household items like furniture and cookware, and report those results publicly—with those costs borne by industry. Regan said it was “time for manufacturers to be transparent and provide the American people with this level of detail”.[59]

The PFAS story is a complex one that covers many issues, not least industry deception. A lawsuit brought by the North Carolina attorney-general, for instance, claims that polluters knew for decades that some PFAS chemicals were toxic to humans and animals, with links to cancer and liver damage, yet told regulators they were safe.[60] And even in 2019, a senior executive at PFAS manufacturer 3M told a Congressional inquiry that “the data available today show no conclusive evidence of adverse health effects”, despite studies from 3M and DuPont finding higher rates of cancer among workers making PFAS chemicals.[61]

What has happened with PFAS chemicals in the US also illustrates other shortcomings of the existing global system. Among these are a failure by governments to implement legislation, a failure by regulators to understand the toxicity of chemicals and to exert stronger oversight over them, and a lack of extended producer responsibility (EPR), which seeks to boost industry accountability by making polluters pay.

Other barriers include:

- A lack of awareness among policymakers and the public of the dangers that many chemicals pose to human health and to the marine environment, and of the significant risks to the environment of failing to act. In part, that is due to a lack of communication between researchers and policymakers, and because much research is carried out in silos.
- Linked to the lack of awareness is that the effects of tens of thousands of chemicals are wholly unknown. When Dr Zhanyun Wang of the Technology & Society Laboratory, Swiss Federal Laboratories for Materials Science and Technology (EMPA) compiled his ground-breaking list of 350,000 chemicals in 2020,[62] he found at least 75,000 polymer and other substances about which, in terms of their composition, “we just have no idea”.
- Less scrupulous players take advantage of regulatory arbitrage to move operations to countries or regions with lower standards and less oversight. Often these are poorer nations, whose people and environments pay the price.
- Regulators are in a constant state of catch-up with the chemicals industry. In part, that is because regulation typically tackles only a single chemical (or occasionally chemicals within the same group, as with PFAS). However, it is relatively straightforward for the industry to create “drop-in” replacement chemicals that have similar chemical structures, and firms know they have years before regulators get around to assessing their effects—if they ever do.

When the EEA undertook its “Late lessons from early warnings” review in 2013, it highlighted other barriers to taking precautionary measures. One is that technology advances so fast that it can prove impossible to act in a timely manner. Others include the fact that politics and finance typically function on a short-term horizon, that technology often operates within monopolies, that science is inherently conservative and works in silos, and that policymaking usually favours the status quo.[63]

Those are a particular challenge at the national level, where pressure exerted by corporations and lobbyists on politicians can slow or stymie legislation and can undercut enforcement. And, as has become clear, some firms in wealthy countries simply ignore their obligations on the grounds that they are unlikely to get caught and that, if they do, the penalties are worth paying (see box).

England's wastewater landscape—regulatory failure meets corporate deception

Regulatory failure is central to the problems associated with the privatised water companies in England and Wales, with weakness by Ofwat, the regulator, described as "a systemic part" of the issue.[64]

England and Wales privatised their wastewater treatment companies in 1989, and today most are owned by private equity, sovereign wealth funds and pension funds. The companies have long been accused of excessive executive pay and overly generous dividends while loading up on debt.[65]

At the same time, they have for years effectively enjoyed a free pass to offload untreated or under-treated sewage in rivers and the seas, with significant environmental and human health consequences. (That is not the situation in Scotland, whose state-owned water firm vastly outperforms its privatised peers in England and Wales, and whose water standards are on a par with Scandinavian nations).[66]

In theory, such pollution should happen only rarely and be notified to the regulator. However, data analysis in late 2021 determined that 95 percent of dry and early sewage spills are not recorded by the UK's wastewater treatment companies. (While firms are permitted to discharge some untreated sewage during extreme rainfall, they are not allowed to do so if there is no rain—so-called dry spills.)[67]

To many, it is no coincidence that firms have since 2009 had the responsibility to monitor and report those sewage outflows, a case of the fox guarding the henhouse. Court actions against two UK companies—Thames Water and Southern Water—showed both firms breached legal limits on numerous occasions at some sewage plants.[68]

After years of public outrage over firms dumping sewage into the seas and rivers, the water and environmental regulators decided to investigate the sector's conduct and announced a major probe to determine non-compliance at about 2,000 wastewater treatment plants in England and Wales.[69]

That level of scrutiny is overdue. Southern Water, for example, was fined £90m—a record—in 2020 for dumping raw sewage, with the judge saying the firm had shown "a shocking and wholesale disregard for the environment" and human health.[70] In 2019, Thames Water was fined £20m for dumping 1.4 billion litres of raw sewage in the Thames. The previous year, Southern Water was fined £2m after releasing raw sewage into the seas off southern England, forcing beaches to close for days.[71] A 2019 investigation by Ofwat concluded that Southern Water had "deliberately misreported data" and water samples for years to avoid paying fines.[72]

The situation has become so egregious that the chair of the Environment Agency said directors guilty of repeated breaches should be barred from holding directorships and, in the most serious cases, jailed.[73] If nothing else, the saga shows that regulatory failure and corporate misdoings are a significant risk in even the wealthiest nations, with pollution of the marine environment in these cases an inevitable consequence.

Two further barriers mentioned by interviewees are the lack of a single global body to tackle marine chemical pollution (an issue to which this chapter will return), and insufficient funding at a national and international level for research about marine chemical pollution and for solutions to it.

The world lacks the comprehensive international legislation necessary to tackle marine chemical pollution. The existing system is highly fragmented and also at times in conflict with a range of other laws and agreements

There are also significant shortcomings in law. First, the world lacks the comprehensive international legislation that is necessary to tackle marine chemical pollution. Second, the existing system, which includes numerous multilateral environmental agreements and instruments like REACH and the Minamata Convention, is not only highly fragmented; it is also at times in conflict with a range of laws and agreements that cover trade, intellectual property (like patents) and the protection of national and corporate economic interests, and whose inherent objectives are wholly different from protecting the marine environment.

Structural issues in law relating to intellectual property rights, for example, allow companies—to a certain degree and depending on the jurisdiction—to keep secret any information about the harm that certain chemicals cause, even though there is a clear public interest to the contrary. That is the unintended consequence of a system that seeks to protect national interests or keep companies competitive, says Dr Stöfen-O'Brien of the IMO-World Maritime University.

"[The drafters] did not think about the negative externalities that these measures have on the marine environment. And that's also why there is such a long timescale when it comes to taking action, because to translate that between these different systems takes a long time," she says, adding that very few people work across these areas. "In my opinion, there's very little exchange—it's very much working in silos."

The issue of intellectual property also raises its head when it comes to scents, which are typically comprised of dozens of chemicals. Dr Wang says the ability companies have to claim that "everything is confidential business information" is a significant problem that stems in part from the fact that the global system underpinning such rules is decades old, "so maybe it's time for us to reflect on that".

By way of an example, Dr Wang had recently sought information online on the use of a specific group of fluorinated polymers, the group to which PFAS belong.

"There were about 75 substances on my list, and when I went through them most were claimed as confidential business information," he said. "That means the public definitely doesn't know where they're used or how much they are used. And then we just release them all during the use phase and the disposal phase."

In recent years, much of the effort to counter marine chemical pollution at the use and disposal phases has centred on green chemistry, which this report assesses in more detail below (see Chapter 6). However, much of the promise of green chemistry—whose goal is "the design of chemical products and processes that reduce or eliminate the use or generation of hazardous substances throughout the life cycle of products" to support the goals of a circular economy[74]—remains unfulfilled.

In part, that is because it is difficult to measure the impact that green chemistry has, which slows its uptake, and in part because most countries lack sufficient policy incentives for chemicals firms to pursue green chemistry solutions. That said, green chemistry is starting to increase in importance: a 2021 study noted “significant growth” in recent years, and predicted this would continue—fuelled in part by increased demand by consumers and institutional investors for less-harmful products.[75]

That study also concluded that robust government policies help to overcome barriers to the adoption of green chemistry. It highlighted the European Commission’s Chemicals Strategy for Sustainability, policies enacted by individual states in the US, as well as the implementation in the US of the Lautenburg Chemical Safety for the 21st Century Act. Those, it stated, “have created strong regulatory signals to the marketplace that are influencing investors”—a clear indication of the importance that regulation can play in surmounting barriers to marine chemical pollution.[76]

“Policies that foster increased investments in research and development, preferred acquisition status on government contracts, preferred product placement in retail establishments, and private and public labelling and certification programs that assist consumer and institutional purchasers in identifying safer and more sustainable products are attracting more and more companies to pursue green chemistry objectives,” the report stated.[77]

Interviewees said that regulatory clarity is crucial when it comes to encouraging business to follow a more sustainable line, not least because this helps to create incentives to change corporate behaviour by, for instance, driving improvements in production methods, locations and the chemicals used.

Also important is an environment of entrepreneurship and business innovation—areas in which the US, for example, excels. And that aspect of differing national values in areas that are central to marine chemical pollution, like the tolerance for risk, raises far-reaching contextual issues around how different countries or regions perceive and deal with pollution. That will feed into determinations of how best to craft a global body of law, or refine what currently exists, to protect the marine environment.

Switzerland, Sweden or Norway, for instance, are more risk-averse on chemicals than, say, the US, and typically have more restrictive emissions and pollutant regulations, says Dr Stöfen-O’Brien, “and this is reflected in their regulations”.

“It comes down to the threshold of acceptability of risk in a society, and the society’s values when it comes to environmental protection and the use of chemicals,” she says. “This is very important to consider—the threshold of acceptance of risk in a society. And I would argue that the US has a higher tolerance for risks associated with chemicals than, say, the European Union.”

That societal tolerance extends to awareness-raising. In Sweden, where Dr Stöfen-O’Brien lives, even young children learn about chemicals and the harm that people can do to the environment, “because there’s not a lot of tolerance to have toxic pollutants and chemicals flying around”.

“And I think Sweden does this right—they start with educating people, and then people will look out for this, and say, ‘This is enough,’” she says. “Again, it comes down to values: What does society expect? And that has implications for how you shape and negotiate national, regional and international law.”

5.4 Interventions and pathways to success

While there are many barriers to tackling marine chemical pollution, there are also many interventions that can be taken at the sub-national, national and international levels. At their heart, these need to be based on a framework that is underpinned by the principles of sound chemicals management and equity, with that framework a central part of the material that the Invisible Wave programme will develop at a later stage.

One of the core tenets is to employ the "essential use" concept, which reduces the unnecessary production and consumption of chemicals. Many chemicals that are added to products are not essential to the technical function—for example, they are used as fillers or bulking agents—and could be removed, cutting chemical pollution at the source.

This section focuses on ten interventions that our expert panellists believe are the most important when positioning the ocean and humanity for a healthier future.

Intervention 1. Raise awareness

The first intervention is to **raise awareness** nationally and internationally of the causes of and potential remedies for marine chemical pollution. Although knowledge of plastics pollution has risen fast in recent years among policymakers, consumers and businesses, chemical pollution in the marine environment is far less understood.

One way to change this is to improve the two-way flow of knowledge between policymakers and researchers. That requires better communication of scientific knowledge to policymakers, but it also means that the needs of policymakers be relayed to researchers. Additionally, the often-siloed areas of scientific enquiry would benefit from better communication with each other.[78]

Another difficulty is that the various bodies tasked with chemicals and that talk to policymakers do so within their specific field of expertise, like mercury, POPs or e-waste. While this is understandable, it breeds inefficiencies due to the overlapping nature of marine chemical pollution. In addition, these bodies often do not communicate the developments in the policy space to the scientific community or the needs policymakers have for further information. As a result, researchers are less able to meet emerging policy needs on a timely basis.[79]

Lastly, communicating this knowledge of threats and solutions for marine chemical pollution should not stop at the doors of policymakers, but must be part of the wider public discourse through education, media and other outreach efforts, including promoting behavioural shifts like "reduce, reuse and recycle".

Intervention 2. Improve the regulation of harmful chemicals

The second intervention is to improve the existing system whereby chemicals or groups of chemicals are **regulated or banned**, and ensure tighter enforcement of such regulation. Currently, it can take years or even decades before chemicals that are known to be toxic go through the bureaucratic process of being placed on a list for restriction or elimination—and, even then, enforcement might be patchy or carried out only on a sub-national, national or regional basis.

The transboundary nature of marine chemical pollution, though, requires a consistent approach. One obvious solution is a global treaty to tackle marine chemical pollution. Although discussions would take years, the outcome would have universal (or near-universal) coverage, which would constitute a significant step forward. Additionally, the negotiating process itself would see stakeholders learn at each stage, and build awareness of key issues.

BPA: A tale of two regulatory regimes

Bisphenol A, or BPA, offers a clear example of how different regulatory regimes approach harmful chemicals. BPA, an industrial chemical, has for decades been added to plastics and the plastic linings of tins, among other uses, and is a known endocrine disruptor for humans and animals.

In the US, the Food & Drug Administration has not banned BPA in plastic food containers or the linings of tins on the grounds that it is safe, and that reviews of studies "have shown no effects of BPA from low-dose exposure".[80] (The FDA did ban the use of BPA in baby bottles in 2012, but only after manufacturers had stopped using it.)[81]

The EU's ECHA, on the other hand, says BPA's "hazardous properties" have seen it classified as causing "toxic effects on our ability to reproduce", which is why it is listed in the agency's Candidate List of substances of very high concern.

To that end, its use "has been limited or is being limited in the EU to protect people's health and the environment", including an outright ban on the use of BPA in infant feeding bottles and food packaging for children under three. (France has banned BPA in food packaging, containers and utensils outright.)

The ECHA notes, too, that its risk assessment committee is supportive of a bid by Germany to have BPA classified as a hazard for the aquatic environment.[82]

Regulation and international policy are crucial because they provide signals to business, which often will not act until there is certainty in direction. (The COP process, for instance, has catalysed sectors to adopt net-zero targets.) And it is clear that regulations to protect the marine environment work. A 2017 assessment of the impact of the Stockholm Convention, for instance, concluded that "monitoring results indicate that regulations targeting POPs are succeeding in reducing levels of POPs in humans and the environment", with the greatest gains seen in those POPs that were listed earliest.[83]

POPs are not the only chemicals to have been targeted in recent years. In mid-2021, for instance, Thailand announced that it would ban from its marine national parks the use of sunscreens whose chemical ingredients (oxybenzone and octinoxate) are known to be harmful to coral.[84] Similar bans exist in the US state of Hawaii and the Pacific nation of Palau.

At a broader level, the issue of banning chemicals from products entirely (as opposed to banning certain products like sunscreen from marine national parks) raises an important issue about the need to eradicate regrettable substitution—or the replacement of one toxic chemical with another that is later also found to be toxic. Take BPA: one common replacement is BPS, which is a similar chemical and which the European Commission is now considering as "a substance that may damage fertility and the unborn child".[85]

A further challenge is developing regulations to deal with mixture toxicity, which involves determining real-world effects of that exposure to multiple chemicals. This is crucial because existing safety assessments of chemicals typically focus on the effect that individual substances might have—yet it is known that exposure to multiple chemicals, even if each is within their safety level, can cause harm.[86]

One regulatory solution is to apply what is called a Mixture Assessment Factor (MAF) when risk-assessing individual chemicals, which involves testing that chemical with others to determine their combined effects.[87] The idea is gaining traction in some quarters. CHEM Trust, a collaboration between British and German charities, has called for MAF legislation as part of its "12 Key Asks" to the United Kingdom's government,[88] which is revising its Chemicals Strategy following its departure from the EU.[89] The European Commission is also examining MAF at the time of writing.[90]

REACH shifts the burden from one where science needs to prove damage to environmental and human health to one where companies need to show that their production, use and disposal of chemicals will not do harm

However, the solution is unpopular with at least some in industry: the Association of the European Adhesive and Sealant Industry (FEICA), which has more than 450 member companies across Europe, described MAF as "a political decision" with "no scientific justification behind the MAF concept as it is too broad, largely covering hypothetical exposures and risks rather than real-life scenarios". The result, it predicted, would be the disappearance of numerous products from the market, including building insulation, lightweight vehicles and paper products like books and labels for bottles.[91]

Intervention 3. Use the precautionary principle

The **precautionary principle** as it applies to business is hardly new—the UN Global Compact's Principle 7, for example, which covers the environment, outlines why a precautionary approach is strategically sensible, because it is cheaper to prevent damage than to clean it up afterwards.[92]

That logic, though, assumes that firms will be compelled to clean up. With marine chemical pollution, tracking who is responsible for what pollution is often impossible; even where it can be done—for example, the UK's wastewater treatment company Southern Water polluting beaches with untreated sewage—it is clear that some firms prefer to take the risk.

The solution is to regulate based on the precautionary principle, which is what the EU's REACH legislation largely does—Article 1 states that its provisions are explicitly underpinned by the precautionary principle,[93] as per the overriding principle expressed in the 1992 Maastricht Treaty, and it operates on a "no data, no market" approach, as per Article 5.[94]

In this way, REACH shifts the burden from one where science needs to prove damage to environmental and human health to one where companies need to show that their production, use and disposal of chemicals will not do harm. Or, as REACH puts it, the legislation "shifts the responsibility from public authorities to industry with regards to assessing and managing the risks posed by chemicals and providing appropriate safety information for their users".[95]

(The principle was at the centre of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, one of the world's most effective agreements, when the signatories agreed to protect the ozone layer by "taking precautionary measures to control equitably total global emissions of substances that deplete it".)[96]

Although there is no definitive definition of the precautionary principle, the version in Principle 15 of the 1992 Rio Declaration is one that many states recognise:[97]

"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

When it comes to chemicals legislation, though, the approach of REACH remains unusual; in many countries, the burden of proof lies on governments or civil society to prove harm, not on the chemicals companies to prove their products are safe.

A global science-policy body on chemicals and waste could warn policymakers of the issues, and the need for action, and help tackle marine chemical pollution in numerous other ways

More countries need to adopt the precautionary principle to tackle marine chemical pollution, not least because it is a transboundary issue. Another to consider adopting is the polluter pays principle,[98] which the European Environment Agency identified in 2013 as one way to create an effective response, and in particular to correct market failures.[99]

Intervention 4. Establish a global science-policy body on chemicals and waste

The fourth intervention is to **create an international science-policy body** whose scope covers all chemicals and waste, yet does not duplicate the efforts made by other science-policy bodies such as those under the Stockholm Convention. EMPA's Dr Wang says such a body could help to tackle marine chemical pollution in numerous ways.

First, he says, the science on chemical pollution is moving extremely quickly, with more than 20,000 papers published annually. Not only is much of that research hidden behind paywalls, making access expensive, but following this volume of material is impossible for individuals.

"A global body, though, could capture what is happening in the science space and tell policymakers [and scientists] that we have identified these issues, and we should take action as soon as possible," Dr Wang says, adding that such an approach would have seen much quicker action on, for instance, PFAS and PCBs.

Second, while policy development often requires scientific evidence, it is also true that scientists are often unaware of the information that policymakers require. This lack of hard evidence can be used as a reason to delay action.

"Such a body could close the gap between science, scientists and policymakers, and also help to inform scientists of policymakers' needs so that scientists can generate timely research," he says, adding that it could also act to provide an early-warning system on problem chemicals, thereby closing another gap in the existing approach.

A further benefit would be to promote the two-way transfer of knowledge between developed and developing nations. Another would see the body able to support the global community to work together on issues of concern, with pesticides a prominent example. Marine chemical pollution is, after all, a global challenge, and such an institution would be able to paint a picture of the global situation to drive global actions.

Having a global science-policy body established by international agreement and operating as an intergovernmental institution would help to close two other gaps in the existing system:[100]

- The current lack of coverage that stems from the limited remits of each of the existing bodies such as those under the Stockholm and Basel conventions.
- The lack of interaction on chemicals between different disciplines. Scientists, physicians and lawyers, for example, typically operate within their own silos, yet when it comes to marine chemical pollution, they all have crucial insights to bring in drafting solutions.

Intervention 5. Create a comprehensive register of chemicals

A key step in mitigating marine chemical pollution is to **create national registers as well as a global register of chemicals**. As noted earlier, the 2020 study by Dr Wang determined that there were at least 350,000 chemicals in existence, though as the research excluded dozens of countries, the true number is certainly higher.[101]

One recommendation in his study is to develop global "good practices" to help countries that lack a chemical inventory to establish one. (Why not "best practices"? Because, says Dr Wang, "sometimes it takes a very long time to reach consensus on best practices, but we actually just need practices that are good enough".) Another is to establish a global inventory of chemicals which—among other things—could be used to study and understand what is called the "planetary boundary" of chemical pollution, or the point beyond which such pollution risks inflicting irreversible harm.[102]

The study suggests that information about chemicals in the inventory, which should be publicly accessible and managed by an independent third party, should be provided by the owners of the various national inventories.

As for corporate concerns about the intellectual property (IP) associated with chemical compounds—those are overdone, says Dr Wang. Claiming IP protection as a reason to withhold such information—to protect trade secrets from competitors—is flawed, he says, because technological advances mean those competitors can already determine the chemical compounds through reverse engineering. Falling back on IP protection, then, simply serves to prevent regulators from protecting the interests of the public and the environment, he says, as regulators lack the means to reverse-engineer chemical compounds.

Another aspect to tackle is the issue of chemical mixtures. Existing chemicals legislation typically focuses on individual substances, which means mixtures currently do not need to be registered. What is key, says Dr Wang, is that the register be a global effort, otherwise less-scrupulous players might move production to countries or regions with laxer legislation, and those chemicals could return to more-regulated markets as mixtures or constituents in manufactured articles. Failing to act on a global basis, then, would not resolve the problem but create a new one.

It should be said that global registries are not new. The Organisation for Economic Co-operation and Development (OECD), for instance, has a Pollutant Release and Transfer Register (PRTR), which compiles emissions data from about 40 countries across a range of industries for several hundred chemicals. However, the global PRTR system does have some drawbacks and would benefit from an internationally harmonised system that saw, for example, a "common list of chemicals, thresholds for reporting [and] units by which the data can be aggregated or made available to the public".[103] Dr Wang's approach would see consistent nomenclature, terminology and standards to avoid that drawback.[104]

Intervention 6. Mandate disclosure of all chemicals in products and their potential effects

In a sea of challenges, one of the most significant is the lack of knowledge of the chemicals in products and their effects. One solution is to **mandate disclosure** at an international level of all such chemicals and their known consequences.

Some firms already do this. As UNEP notes, these so-called frontrunner companies (which include some chemicals producers and retailers) are implementing sustainable supply-chain management, with full disclosure of materials used.[105] Currently, though, transparency is optional. What customers of chemicals companies and end-consumers need are ways to know what chemicals are in the products that they are buying, and the risks those hold. This requires an international, policy-driven approach.

One of UNEP's key messages to policymakers in its 2019 report on chemicals management is that they use a lifecycle approach to ensure, in part, full material disclosure. This would involve "developing harmonized approaches across sectors to share chemical information and to advance full material disclosure across supply chains, including chemical-intensive industry sectors and the recycling/waste sector".[106]

Success would require overcoming legislative gaps, enforcement issues, providing information to end-of-life users, and raising awareness and building capacity for such measures in poorer countries.

However, it need not compromise confidential business information, as UNEP notes: balancing that with users' right to know could involve the use of non-disclosure agreements between business parties, or of a third-party that holds the information and provides users with a proof of compliance. Importantly, UNEP notes, "information on chemicals relating to the health and safety of humans and the environment shall not be regarded as confidential".[107]

Although the frontrunner companies are currently the exception, there are no technological barriers preventing others from following their lead. Sourcemap is a US-based firm that works with multinationals to help them account for all inputs along their supply chain, whether they wish to do so for compliance reasons or to be more efficient or productive. That allows them to track every input for every product—from the raw material to the finished good itself.

Dr Leonardo Bonanni, the founder and chief executive officer (CEO) of Sourcemap, notes that such an approach—accounting for all inputs at every stage of the process—meets the best practice requirements for environmental assessments. Achieving that can be hard for firms to attain on their own because the further up the supply chain one goes, the murkier the source of materials can become, while the further down the supply chain one goes, the more removed the firm is from end-of-life factors.

"We specialise in getting multinationals extremely familiar with what's going on three, four or five steps away from them in their supply chain. And that includes the environmental impact like land use, but also chemicals use in places like farms or on mines, where there has been relatively little record-keeping before we showed up," he says.

Such an approach may be new, but it will become more common, because "it's only a matter of time" before firms will have to account for their waste outputs, for example, whether those be solid waste, liquid waste or gas emissions. Regardless, the idea of supply chains constituting a trade secret is outdated, "because no one knows a company's supply chain better than its competitors—they're competing every day for the same suppliers".

Being transparent can be profitable for firms—and that includes chemicals companies, several of which are Sourcemap clients.

"Because, very simply, if you have to choose between two suppliers and one of them isn't willing to tell you even what is in the products that you're buying from them but the other one is willing to give you full transparency, you can effectively de-risk the entire product," says Dr Bonanni. "Increasingly, brands are choosing the transparent supplier, even if there's a price premium, because it carries so much less risk."

Being transparent can be beneficial for chemicals companies. Increasingly, brands are choosing the transparent supplier, even if there's a price premium, because it carries so much less risk

Intervention 7. Adopt best practice laws and principles, and ensure implementation and better enforcement

While there is no shortage of laws that tackle some of the causes of marine chemical pollution, most could do better in terms of **implementation, best practice and enforcement**. Chemical regulation and chemical management systems are highly complex areas that vary nation by nation, which makes a scorecard between nations impractical. Yet although many countries have initiatives from which others can learn, most face four major imbalances:

- Legislation almost always focuses only on new chemicals. This means countries are ignoring the potential impact of the tens of thousands of existing chemicals that are in use within their borders, on the misguided assumption that they are all safe. (A few countries, like Canada and Australia, examine existing chemicals, but they are outliers.)
- It typically takes years to phase out problematic chemicals, but just weeks to evaluate and register new chemicals. In short, it is far easier to get chemicals onto the market than off it.
- Developing nations typically have less robust, responsive, equitable and effective regulatory systems than wealthy nations, which allows firms to engage in regulatory arbitrage by moving production, for example, to poorer countries with less or no oversight.
- Even when laws are well drafted, enforcement is often inadequate—and such laws can have unintentional consequences. In China, for example, which leads in areas like wastewater treatment, it costs a producer hundreds of thousands of dollars to test a new chemical; however, the fine for not bothering to register is about US$1,000, which creates an incentive to release untested chemicals on the market. And in many nations, it is cheaper to break the law than follow it—assuming firms even get caught.

The solution is for nations to act in concert and on an international basis, and this includes better funding for enforcement agencies. Acting in concert would also benefit industry—after all, it makes no sense for a producer to test the same chemical in 50 countries if there were instead an internationally recognised assessment system that allowed companies to undertake a single safety test that was accepted globally.

Countries can do better in other areas too. As noted earlier, the regulatory process typically assesses only single chemicals, not mixtures. However, many chemicals—pesticides being one example—when considered on their own have limited toxicity, yet when a surfactant is added they can become highly toxic. That additive, however, is not something that regulatory processes currently take into account. They should.

It is also the case that developing nations need far more funding and assistance to help them implement best practices at home in areas like regulation, enforcement and reporting. Helping countries to build capacity in reporting, for example, would see data used in a more systematic and comparable manner, which would help to monitor progress and drive improvements globally.[108]

Greater focus is needed on "green" and "sustainable" chemistry, where much promise lies for chemical pollution. But without clearer definitions for these terms, chemicals companies will paint themselves greener than they are

Another area that requires a heightened focus is that of green chemistry and sustainable chemistry, where much of the promise in tackling marine chemical pollution lies. However, even the terms "green chemistry" and "sustainable chemistry" are insufficiently defined in law in Europe and elsewhere, says Dr Stöfen-O'Brien. That has allowed chemicals companies to create definitions that favour their industry and allow them to paint themselves as greener or more sustainable. While using such weaknesses in the regulatory framework to the industry's advantage is smart business, it also heightens the risk of greenwashing. Consequently, a key step for policymakers is to define the terms "green chemistry" and "sustainable chemistry".

Additionally, although the green chemistry industry has been in existence for two decades, the adoption rate is still low. As noted below, funding to encourage green and sustainable chemistry would help to promote its uptake, while policy measures can help to level the playing field between innovators and less progressive chemicals players, including by crafting incentives to pursue green or sustainable chemistry solutions.

Among the policies that have been shown to work are those that foster investment in green chemistry research and development, preferential status on government contracts, and certification programmes that help customers and end-users to choose more sustainable options.[109]

Some countries have implemented policies to promote green chemistry in governance, industry and education, including Canada, China, South Korea, Japan, Taiwan, the United Kingdom and the US.[110] There has been progress at the international level too. In 2017, the United Nations Industrial Development Organization (UNIDO) launched its global Green Chemistry project to boost awareness of its technologies, using it to "bridge the gap between the science of green chemistry and real-world application of green chemistry approaches".[111] Another UNIDO project, the Transfer of Environmentally Sound Technologies (TEST), provides small- and medium-sized enterprises with tools to improve business operations as they move towards sustainable production, and helps them to curb pollution.[112] A third, by UNEP, is its Green and Sustainable Chemistry Framework Manual providing a high-level view of green and sustainable chemistry, and which is the first of a series of manuals on the subject.[113]

Boosting the adoption of green chemistry and sustainable chemistry, however, requires funding. One focus is to provide educational materials and training for teachers and students at secondary and tertiary institutions. Another is to provide basic training in environmental and public health factors for chemists, who could incorporate that knowledge when deciding which chemicals to use in products by screening them for adverse behaviours like toxicity, bioaccumulation and persistence. This would provide a relatively easy way to end the use of dangerous chemicals, and could save the industry money, as it would not need to redesign products at a later stage.

Intervention 8. Funding to measure the impact of chemicals

One of the clearest messages to emerge from this study is that the amount of **funding available for research** to assess the impact of chemicals on the marine environment is woefully insufficient—at both the national and international levels. Given that the global chemicals market is likely to double by 2030 from 2017 levels, further increasing the chemical load on the marine environment, the need to act is clear. [114]

The amount of funding available for research to assess the impact of chemicals on the marine environment is woefully insufficient—at both the national and international levels

Doing so requires an approach that puts funding for ocean science on a sustainable footing, as UNESCO notes in its Ocean Science Roadmap, which found that the COVID-19 pandemic saw funding for marine World Heritage sites cut sharply. As a result, some essential monitoring was not carried out. A lack of funding, UNESCO states, is “the most pertinent obstacle to ocean research at marine World Heritage sites”.[115]

In addition, as UNEP has stated, increased funding for research on chemicals and waste management would help to close existing gaps, meet priorities and inform policymakers. It would also allow for a global study that would determine the benefits of action and the costs of failing to act on chemicals and waste management.[116]

Funding could also help to extend the use of highly efficient and innovative technological solutions like artificial intelligence in monitoring marine environmental changes—for example, assessing satellite images of seagrass meadows so that researchers can determine their health and the effectiveness of restorative actions.[117]

It is also crucial that funding be made available to developing nations, which are typically not part of the conversation, says Dr Stöfen-O’Brien, despite the fact that they are the first to feel the brunt of chemical pollution through plastics and contamination of fish. Many lack the capacity and the ability to monitor, and as a result “we know almost nothing about marine chemical pollution in the Global South”.

“These externalities imposed by chemical companies with a global reach must be considered,” she says. “And funding needs to be much more structural and reliable. It needs to start with education, with regional knowledge centres based on specific regional chemicals, with strong monitoring and assessment programmes—and you need to have an inventory of what’s going on. This might then lead to suitable evidence-based policy and regulatory measures.”

Intervention 9. Make the polluter pay

The lack of sufficient funding for poorer nations is a well-known hindrance for better chemicals management. One **innovative fiscal measure** was the subject of a 2020 report by the Center for International Environmental Law (CIEL) and the International Pollutants Elimination Network (IPEN).

Given the difficulties of imposing a direct "polluter pays" tax, it proposed levying a 0.5 percent tax on the volume of feedstock chemicals—the basic chemicals produced from natural gas and oil, and that are the building blocks for almost all chemicals.

With 2018 sales of basic chemicals worth US$2.3 trillion, the tax would raise an estimated US$11.5bn, or about 85 times the total annual sums currently allocated to global chemicals management. This sum, it notes, "has the potential to generate sufficient financing for the global sound management of chemicals and waste".

"Such a fee places the financial responsibility for chemicals and waste management where it belongs: on the industries profiting from the production of those chemicals," the report notes. "The fee would be collected by the country where the company producing basic chemicals is registered and be paid to a global fund."

The proceeds would support "regulatory capacity, infrastructure, information and monitoring systems, and waste management and clean-up systems".

In this way, the 0.5 percent tax would help countries to implement the principle that the polluter pays, and would create a level playing field for the chemicals industry, as every manufacturer of feedstock chemicals would be taxed equally.

"Further benefits of the plan include that it would use existing domestic regulatory infrastructure to collect the taxes or fees while avoiding the challenges of delegating taxation authority to an international body. It is also in accordance with World Trade Organization law and would not affect consumer pricing," the report states.

At the time of writing, the issue of financing is one that the Strategic Approach to International Chemicals Management (SAICM) is working on, with an assessment of industry involvement in financing the sound management of chemicals and waste. That review came about after two reports—one by UNEP and the other by SAICM—that highlighted shortcomings on industry's part.

UNEP's report noted gaps "including lack of clarity of what counts as industry contributions, absence of a mechanism for tracking activities and financial flows, and poor understanding of industry involvement at the national level", while SAICM concluded that "insufficient progress had been made in taking forward the mainstreaming and industry involvement components of funding identified in the Integrated Approach to the sustainable financing of sound management of chemicals and waste proposal". In short, industry has not done enough.[118]

Taxation is one potential solution, but other fiscal measures are also possible. Among those highlighted in SAICM's review are:[119]

- The removal of harmful subsidies for high-risk substances, which is a particular issue with agrochemicals.
- Using subsidies to encourage good behaviour by industry by, for example, recognising steps taken to internalise costs, engage in best practice and adhere to national or international regulations. Subsidies can also be used to fund public investments in research and development of sustainable chemical solutions.
- Using tradable permits to phase out harmful chemicals, which can be of particular use as a policy to control agricultural pollution.

Intervention 10. Promote efforts to restore ocean health

The tenth solution is for countries to take steps to restore ocean health in their waters. Once again, Europe's legislative steps provide some useful best practice lessons including banning certain single-use plastic items and microbeads, ensuring that ships offload waste only at ports, and reducing the flow of pollutants into rivers and seas.

There are many other steps that countries can take to mitigate marine chemical pollution, including:

- Protecting more of their nation's seas and ensuring that existing protected areas are not harmed.
- Curbing overfishing and other destructive practices.
- Working to reduce marine chemical pollution, including the excessive use of nitrogen fertilisers and the influx of sewage and plastics.
- Using fiscal measures to encourage improved corporate and agricultural behaviour that will benefit the seas.
- Engaging in regenerative efforts such as planting kelp forests and encouraging the growth of shellfish populations—these steps can improve water quality by removing nitrogen and phosphorus, reducing CO_2, boosting oxygen levels and providing improved habitats for other marine life.[120]

Last, given the imbalance in knowledge and capacity between developed and developing countries, nations in the Global South could partner with each other and with wealthy nations. This would not only bring access to expertise that might be lacking; it would also ensure that best practice lessons could be passed on, and that failures were not duplicated.

One such example is between Mauritania's Banc d'Arguin National Park and the Wadden See (Germany, Netherlands and Denmark), whose twinning agreement sees them jointly monitor migratory birds. Another, this time between rich countries, has seen the US's Glacier Bay National Park work with Norway's Geirangerfjord and Nærøyfjord to determine how best to reduce the impacts that cruise ships have on their marine environments.[121]

"From harm to harmony"—the legal effort to define the proposed crime of ecocide

In 2021, a panel of twelve international legal experts drew up a definition for the proposed crime of ecocide, which they hope will be added to the Rome Statute of the International Criminal Court. The definition was drafted after a global public consultation with, among others, youth, faith and indigenous groups.[122]

The reason for acting, the Stop Ecocide Foundation explained, was because science has shown that "the emission of greenhouse gases and the destruction of ecosystems at current rates will have catastrophic consequences for our common environment". It noted that international law has a role to play alongside initiatives in the political, diplomatic and economic arenas in shifting humanity's relationship with the environment "from one of harm to one of harmony".[123]

"Despite significant progress, the inadequacies of current global environmental governance are widely acknowledged," the foundation stated. "National and international laws are in place to contribute to the protection of the natural systems upon which our well-being depends, yet it is apparent that such laws are inadequate and more is needed."[124]

Should ecocide be added, it would join the other four international crimes: genocide, crimes against humanity, war crimes and the crime of aggression.[125]

The panel defines ecocide as "unlawful or wanton acts committed with knowledge that there is a substantial likelihood of severe and either widespread or long-term damage to the environment being caused by those acts".[126]

The idea of enshrining ecocide in international law has some high-level support. France's President Emmanuel Macron is in favour, as is Pope Francis, who called on the international community to recognise the proposed crime. Should that happen, though, it would take years. [127]

In the meantime, those behind the push recognise that the proposal's mere existence could improve corporate behaviour—including by influencing how banks and insurers view potentially damaging projects. The campaign, said panel co-chair Philippe Sands QC, is adding to what is already underway: "A change of consciousness." [128]

What next?

In the view of the experts interviewed for this report, those ten steps would move the world from inaction—or insufficient action—to action on marine chemical pollution. That said, much of what is needed relies on the chemicals industry playing its part. But, as is clear, business has a chequered history when it comes to this, not least because it operates in opaque ways and with commercial, rather than environmental, priorities.

Yet while business often gets blamed for its failure to act on early warning signals about the harm that products or operations can do, this fails to account for the environment in which firms operate, where decisions are influenced by a range of factors beyond mere profit-seeking behaviour.[129]

As the EEA concluded, in nearly every case businesses failed to take account of early warning signs. Instead, they chose to focus on short-term profit. That held true for asbestos, lead in petrol and insecticides, to name just a few

Profit, though, is a powerful motivator. Part of the problem is that its influence is compounded by standard economics metrics that favour ignoring external risks to human health or the environment—unless those are likely to see the company sued, run afoul of regulators or harm its reputation. As the EEA report concluded, nearly every case that it reviewed saw businesses fail to take account of early warning signs that were available. Instead, they chose to focus on short-term profit. That held true for asbestos, lead in petrol, insecticides and fishing methods, to name just a few.[130]

The implication is that business was in many cases given too long a leash.

"Numerous case studies show that decisions to act without precaution often come from businesses. There are, however, several impediments to businesses acting in a precautionary manner, including a focus on short-term economic value for shareholders alongside psychological factors that lead to a so-called 'ethical blindness' or a 'self-serving bias', whereby people largely interpret ambiguous situations in their own interests," it states.

That echoes the conclusions of the Dasgupta Review, as noted in the previous chapter, which highlighted market failure as a key reason for the destruction of the environment.[131] With that said, it is time to turn to the other stakeholders in the effort to turn the tide on marine chemical pollution: the chemical industry itself, but also business in general (including banks and insurers), civil society and consumers.

Please see Notes for references

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