A ‘Toxic-Free Future’: Providing a blueprint towards ‘zero discharge’ of hazardous chemicals

Greenpeace Policy Questions & Answers

The Pathway to a ‘Toxic-Free Future’

Greenpeace is calling for governments to adopt:

1. A political commitment to ‘zero discharge’¹ of all hazardous chemicals within one generation,² based on the precautionary principle and a preventative approach to chemicals management. This commitment must have the substitution principle at its core, and include producer responsibility³ in order to drive innovation and toxics-use elimination.

2. An implementation plan to:
   - establish a dynamic priority hazardous chemical list, for immediate action;⁴
   - establish intermediate targets to meet the generation goal above; and
   - establish a publicly available register of data about discharge, emissions and losses of hazardous chemicals.

3. Measures to ensure infrastructure and policies are in place to support implementation, including:
   - identifying priority chemical restrictions;
   - policies and regulations that require mandatory audits and planning;
   - the provision of technical help and appropriate financial incentives; and
   - research and support for innovation in green chemistry.

Cease or less release?

Q1 Are water discharge or emission standards and ‘dilution’ sufficient to address hazardous chemical pollution?

Discharge permits, while eliminating the worst discharge excesses, also permit a continuous level of background pollution. Experience and science have shown that even low levels of pollution can be extremely harmful;⁵ many chemicals are persistent in nature.

---

¹ ‘Discharge’ means all discharges, emissions and losses. In other words, all pathways of releases.
² Typically, one generation is understood to be 20 to 25 years.
³ For example, ‘no data, no market’ provisions.
⁴ Based on the eight basic intrinsic properties of hazardousness – persistence; bioaccumulation; toxicity; carcinogenic, mutagenic and reprotoxic; endocrine disruption; and equivalent concerns.
⁵ Of particular note is recent research pertaining to discharges of pharmaceuticals and personal care products, and other substances found to be disruptive to endocrine systems, causing reproductive disorders in aquatic organisms, and possibly others, sometimes at extremely low levels that would formerly have been considered to be thoroughly diluted and therefore safe levels. See, for example: Drugged Drinking Water, Environmental Health Perspectives Volume 108, Number 10, October 2000. http://ehp.niehs.nih.gov/docs/2000/108-10/forum.html.
and are not removed by natural processes, but dispersed (for example, flame retardants have been found in the bodies of arctic mammals).\(^6\)

Due to growth in human populations (ie volumes of substances used) and technological changes in the products produced (ie variety of substances used), the amount of hazardous chemical discharges and their variety have been growing, loading natural systems with a chemical cocktail\(^7\) – the impacts are nearly impossible to predict.

**Background:** Water pollution control gained a firm legal footing in the US in 1972 with the passage of the Clean Water Act (CWA), which established the requirement that no discharges of pollutants were legal without a permit. The system is called the National Pollutant Discharge Elimination System\(^8\) [emphases added]. The CWA established the ambitious national goal of elimination of all discharge of pollutants by 1985.

A similar evolution began in Europe in 1976 with the Directive on Pollution Caused by Certain Dangerous Substances Discharged into the Aquatic Environment of the Community (commonly known as the Dangerous Substances Directive, or DSD),\(^9\) which regulated potential aquatic pollution by chemicals. The DSD created awareness about hazardous substances and kicked off the establishment of policy objectives guided by the precautionary principle – specifically, by introducing a zero emission regime for groundwater and the objective of eliminating pollution from a list of substances dangerous because of persistence, toxicity and bioaccumulation (PBTs).

There is no question that traditional environmental protection, which focused on finding acceptable levels of discharge, has reduced - to some degree - harm from environmental releases.\(^10\) However, despite the original recognition of the need for eliminating hazardous discharges and subsequent efforts of policies towards this goal, chronic (ie low-level but continuous or repeated) pollution continued to be allowed by many pollutant discharge limits, leading to the steady accumulation in sediment, soil, water, flora and fauna of substances that do not biodegrade rapidly and safely.

This has lead agencies such as the US Environmental Protection Agency (EPA) to recognise that ‘almost 40 years later, the CWA’s ambitious goals have not all been met. Many US waters are still not clean enough to support healthy fish, shellfish and wildlife populations or allow for human recreation’.\(^11\)

Experience with discharge standards is that they have only been able to address a fraction of chemicals in use – for example the CWA’s toxic and pollutant list includes only 0.15% of the chemicals on the US Toxics Substances Control Act list of existing chemicals.\(^12\) The EU Water Framework Directive priority substance list only includes 33 substances,\(^13\) which are only 7.7% of the substances covered by the various lists of hazardous substances in the EU,\(^14\) or less than 9% of the chemicals on the SIN list 2.0\(^15\) (a list of 378 substances meeting the EU Regulation REACH’s properties of Substances of Very High Concern).

---


\(^7\) Chemical cocktail is a term used to describe the mix of several chemicals that can, in addition to the more common impacts of the multiple chemical load, also sometimes lead to synergistic impacts. Synergistic impacts of pollutants means the combined and sometimes unexpected effect of exposure to more than one pollutant. Pollution law typically relies on risk assessments for individual chemicals. For example, the synergistic activity of some endocrine disrupting chemicals. See Crofton KM, Craft ES, Hedge JM, Gennings C, Simmons JE, Carchman RA, Carter WH (Jr) & DeVito MJ (2005). Thyroid-hormone-disrupting chemicals: evidence for dose-dependent additivity or synergism. Environmental Health Perspectives 113:1549–1554.


\(^10\) For example, the US Environmental Protection Agency estimates that since 1970, the Clean Air Act has prevented 228,000 premature deaths, 692,000 cases of chronic bronchitis, 21,000 cases of heart disease and 253,000 cardiovascular hospitalisations. http://www.epa.gov/40th/achieve.html


\(^12\) For example, the US Clean Water Act’s toxic and pollutant list includes only 126 chemicals (Section 307(a)(1), and at 40 CFR 401.15), but there are more than 84,000 chemicals on the US Toxics Substances Control Act’s list of existing chemicals. http://www.epa.gov/opt/newchems/pubs/inventory.htm

\(^13\) Priority Substances Listed in Annex 1 of the EU Water Framework Directive (version 2008/105/EC)

\(^14\) It was calculated that there were 427 individual substances altogether on the 4 EU lists of 23 PBT substances (listed as fulfilling PBT and/or vPvB criteria on the European chemical Substances Information System -http://ecb.jrc.ec.europa.eu/esis/index.php?PGM=pbt), 196 carcinogens and 19 reprotoxic chemicals (listed as a Category 1 Carcinogen or a Category 1 Reproductive Toxicant under Directive
In addition to this, many chemicals find their way into the water even when not directly discharged from factory operations. Indirect discharges through sewage or septic treatment systems, air deposition or improper disposal can all result in this. For example, relatively high levels of nonylphenols (NP) have been found in discharges from wastewater treatment plants in EU countries. This has been the case despite a rather restrictive pollution standard and bans on industrial and household use of NP since 2005, which would imply that NP is being released to the environment through products to which the EU bans do not apply – ie imported products. The multiple pathways a hazardous chemical can take to enter the environment illustrate the complexity of trying to address hazardous chemicals through discharge standards. Pollutants such as NP are of growing concern not just in countries in the EU, but also in countries such as China.

Other types of standards sometimes set are environmental quality standards (EQS). EQS are different from discharge standards in that they set a level of pollution in the ecosystem that ensures a high level of environmental protection. EQS are based on the logic that for some kinds and burden levels of pollution the natural environment has the capacity to assimilate the impacts. This is however not the case for persistent bioaccumulative toxic chemicals (PBTs; as discussed below – see Q2).

The EU Water Framework Directive is clear in this aspect. While discharge standards or EQS are set for some priority chemicals in terms of water management, for those identified as priority hazardous (PBTs), chemicals cessation is the end goal.

In other words, while allowable discharge limits and water quality standards can be useful for avoiding the most severe and short-term impacts, they will not address the long-term impacts of hazardous chemicals such as PBTs or equivalent (unless they are set to zero). Meeting EQS should never be seen as an alternative to meeting the ultimate goal of elimination or cessation of discharges, emissions and losses to the environment when it comes to hazardous chemicals.

**Recognition of the need for zero discharges**

**Q2a Is it possible to set a ‘safe level’ of pollution for hazardous chemicals?**

The idea of eliminating discharges of chemicals hazardous to the aquatic environment – ‘zero discharge’ – is based on the understanding that it is not possible to define safe levels for the multitude of hazardous chemical pollutants that are toxic, persistent (ie do not readily break down in the environment), can accumulate in organisms, and can even increase and potentially magnify as they work their way up a foodchain (ie bioaccumulate) – properties known as PBT.

Despite initial dilution in large volumes of water or air, such pollutants can persist long enough in the receiving environment to become transported over long distances, to concentrate in sediments and biota, and to cause significant harm even at what may appear to be very low doses.
In addition to the problem of persistence, there are other harmful properties that are difficult to define ‘safe’ levels for, given the irreversibility of their impacts, even at low doses, combined with the cocktail phenomena mentioned above (see Q1). Examples include the ability to cause cancer; the ability to be toxic to reproduction or alter genes (known as CMR\(^{23}\)); the ability to interfere with hormone systems (known as EDC\(^{24}\)); and other properties of equivalent concern.

**Based on this logic, the OSPAR commitment\(^{25}\)** combines the preventive and precautionary principles and a simple and ambitious objective or target: cessation of releases\(^ {26}\) for hazardous chemicals by 2020.

**Background:** In 1995, the Mediterranean coastal states revised the **Barcelona Convention** (dating from 1976) and agreed to phase out hazardous substances based on their inherent hazardous characteristics. Following closely on its heels, in 1998, a ministerial meeting under the **1992 OSPAR Convention** for the protection of the North-East Atlantic adopted a new and far reaching objective of achieving near background values for naturally occurring and close to zero values for manmade synthetic hazardous substances; and the phase out of discharges, losses and emissions of priority hazardous substances within 20 years [emphases added]\(^ {27}\).

Central to the OSPAR strategy is the concept that chemicals presenting certain intrinsic hazards (PBTs and chemicals with other hazardous properties\(^ {28}\)) simply cannot be tolerated as contaminants of the marine environment. In turn, the only way in which to ensure that such chemicals do not reach the marine environment is to prevent their release in the first place.

Hence, the commitment signed by all parties\(^ {29}\) to the OSPAR Convention is to make every endeavour to move towards the target of cessation of discharges, emissions and losses of hazardous substances by the year 2020. The OSPAR Commission goes beyond control and treatment – the conventional means of environmental regulation – to include ‘measures on substitution of hazardous substances, use bans or restrictions’\(^ {30}\).

In 1992, the **Helsinki Convention** (which entered into force in 2000) adopted a similar commitment to phase out hazardous substances into the Baltic Sea, banning some substances immediately and - in 1998 - adopting a strategy\(^ {31}\) and a list of substances for priority action.

The latest commitment to ‘zero discharge’ was the EU **Water Framework Directive**\(^ {32}\) (WFD), adopted in 2000 in response to the need for a more protective system to tackle aquatic pollution. The WFD follows in the steps of OSPAR in requiring EU member states to take measures with the aim of phasing out discharges, losses and emissions of priority hazardous substances to the aquatic environment within 20 years after their identification.\(^ {33}\) While EU member states are still in the process of implementing the WFD, it nonetheless represents a central and vital component of measures designed to ensure a high level of protection for the environment and human health.

---

\(^{23}\) CMR is the abbreviation for carcinogenic, mutagenic and reprotoxic.

\(^{24}\) EDC is the abbreviation for endocrine disruptor chemicals.


\(^{26}\) ‘Releases’ covers all discharges, emissions and losses. In other words, all pathways of releases.


\(^{28}\) Other harmful properties that would classify a chemical as hazardous are: very persistent and very bioaccumulative (vPvB), carcinogenic, mutagenic and reprotoxic (CMR) - i.e cause cancer; are toxic to reproduction or alter genes - and endocrine disrupting (ED) - i.e substances that interfere with hormone systems - or other properties of equivalent concern.

\(^{29}\) 15 North East Atlantic states plus the European Commission.

\(^{30}\) Paragraph 5.3.c of the OSPAR Strategy with Regard to Hazardous Substances, OSPAR 98/14/1, Annex 34


\(^{33}\) Directive 2000/60/EC reads (article 16) ‘measures shall be aimed at the progressive reduction and, for priority hazardous substances […] at the cessation or phasing-out of discharges, emissions and losses.’ See also http://ec.europa.eu/environment/water/water-framework/info/timetable_en.htm for timetables of objectives.
Recognition of the need for precaution

Q2b Is it possible and/or easier to clean up the hazardous chemical pollution later?

By the time you get to the stage of cleaning up hazardous chemicals they may have caused some irreversible damages, such as genetic disorders, and it’s almost always very expensive to clean up.34

Persistency and bioaccumulation mean that it is very complex, and often impossible, to predict what dose of a particular substance is safe, given the unpredictability of the various pathways a substance might take into ecosystems and foodchains. Our natural environment is not able to assimilate and break down manmade synthetic PBT35 chemicals. An example of this is the built-up of organochlorine chemicals in the Great Lakes in the US (see box below) or the bioaccumulation of PCBs in polar bears.36

A report from the European Environment Agency, appropriately titled ‘Late Lesson From Early Warnings’, illustrates the benefits of precaution and demonstrates the human, ecological, and economic costs of not taking precaution and the need to learn from past failures to heed early scientific evidence of risks.37 The case of sediment contamination in the Great Lakes is one of these well-known cases (see box below).

The precautionary principle and early warnings of chemical contamination of the Great Lakes – a multibillion dollar lesson38

The report ‘Late Lessons From Early Warnings’ by the European Environment Agency analyses the costs and benefits of the various organochlorine contamination clean-up and remediation actions and their distribution across time. It recognises that it has taken scientists more than 50 years to fully comprehend the impacts on human health and wildlife of persistent chemicals such as the organochlorines on the Great Lakes.

It shows that, in 1998, the sediment clean-up costs (aside from the huge costs of waste water treatment infrastructure, waste dump clean-up and other measures) in the US part of the Great Lakes alone were calculated by the US Environmental Protection Agency (EPA) to be about $580m US dollars, spent on 38 sediment remediation projects since 1985. Estimates for treatment costs for remedial work on the sediments of just one specific area, the Hamilton Harbour, range from $60m to $1bn Canadian dollars. Furthermore, existing evidence indicates that it will probably be several more decades before the necessary remedial actions will have reduced concentrations sufficiently to protect human reproduction and development from chemically induced injury, particularly from consumption of contaminated Great Lakes fish.

Experiences such as the Great Lakes drove the shift to replace the failed ‘assimilative capacity approach’ (based on the assumption that pollution with hazardous substances could be absorbed and diluted to harmless levels) with the precautionary principle (ie the principle that we should take preventive and elimination action prior to conclusive scientific proof – by which time it is too late), where there are some indications of the potential for harm.

This principle can now be found in numerous regional treaties and global conventions. One well-known example is the Rio Declaration,39 which established 27 principles to govern sustainable development and conservation of the world’s natural resources.

35 Abbreviation for persistent, bioaccumulative and toxic properties – ie substances that can accumulate in our bodies and in the ecosystem.
Principle 15 of the Rio Declaration states: ‘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.’

As laid down in the Rio Declaration, the precautionary principle is often understood only as acting prior to conclusive evidence, but the principle, more definitively called the principle for precautionary action, can be defined in terms of four elements:

1. Serious or irreversible damage to ecosystems must be avoided in advance, both by preventing harm and by avoiding the potential for future harm.
2. High-quality scientific research is employed as a key mechanism for early detection of actual potential impacts.
3. Actions to protect ecosystems is necessary, not simply possible, even in the presence of uncertainty, ignorance and irreducible indeterminacy.
4. All future technical, social and economic developments implement a progressive reduction in environmental burden.

For action to be truly precautionary it must ensure that the fundamental objective of reduction of overall burden is observed. In order to meet this objective it must recognise that the decision to prevent the discharge of a certain chemical may require a fundamental re-evaluation of a need for a product or process and may not always imply simple substitution with an alternative.

The precautionary principle is also a fundamental cornerstone of EU environmental policy (Article 191 of the EU treaty) and of conventions such as Stockholm, OSPAR and others.

The so-called end-of-pipe (waste and waste water removal and treatment) approach dominated practice in the northern hemisphere for many decades (and still often does today). Governments and citizens in the EU and the US are still paying dearly for the consequences. An example of this is the high costs of sediment pollution in the Dutch Deltas, which cost the Dutch taxpayers and port authorities approximately €2.8bn in 22 years. However, leaving contaminated sediments behind would cause even larger economic damage, especially to shipping trade, water management and ecosystems.

---


42 Means uncertainties and unknowns that cannot be addressed.

43 Article 191 of the Consolidated Treaty of the European Union states: ‘Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay.’ http://www.consilium.europa.eu/showPage.aspx?id=1296&lang=en [accessed 15 December 2010].

44 It is estimated that on average from 1987 till 2009 about 6.8 million m³/year of contaminated sediments in the Netherlands must have been dredged, resulting in a total volume of about 160-165 million m³ for that period. The costs for dredging and processing contaminated sediments so far is estimated at about €2.8bn. Continued natural transport and deposition of contaminated sediments from the upstream parts of the Rhine and its tributaries continues to pose a serious threat for future dredging maintenance costs in the port of Rotterdam. However, although the costs of dredging contaminated sediments are high, the option of leaving it behind, in some cases, poses even larger risks of economic damages via its potential to build up and obstruct shipping trade (see Rhine Delta case in Section 2 of ‘Hidden Consequences: The costs of industrial water pollution on people, planet and profit’, Greenpeace International, 2011 for more information. At: http://www.greenpeace.org/ international/en/publications/reports/Hidden-Consequences/

Repeating the same chemical pollution mistakes?

The pollution of rivers such as the Hudson in the US are cases where ecological limits were exceeded due to severe chemical pollution load. The long-term exposure to persistent hazardous chemicals such as Polychlorinated Biphenyls (PCBs) has caused widespread contamination of the wildlife along the Hudson. At one point, fish were found with levels of PCBs over 1000 mg/kg [ppm original] with widespread consequences on surrounding natural and human communities and clean-up costs in excess of $1.4bn US dollars.46 This phenomenon is already being repeated in other parts of the world and may get a lot worse as the industry continues to shift from developed to developing economies. The Marilao in the Philippines for example, has already been classified as one of the world’s pollution hotspots47 and important rivers essential for supporting livelihoods, for example the Chao Phraya in Thailand and the Yangtze in China, among others, face the risk of serious and possibly irreversible chemical contamination.48

Another example is the Riachuelo in Buenos Aires, Argentina, which is heavily contaminated with heavy metals and other persistent chemicals, registering levels sometimes 10 times the permitted levels for water pollutants and in some heavy metal cases up to 30 times the expected levels for sediments.49

It is estimated that the clean-up of the Marilao-Meycauayan-Obando River System alone would cost around 2.2bn Philippines pesos (approximately $50m US dollars or €37m50), just for dredging activities along with disposal and treatment.51

Q3 Is it just discharges from pipes we need to focus on?

Unfortunately, just focusing on one source of release of hazardous chemicals, such as the classical discharge pipes, is not enough. If we merely filter out or capture the chemical in one place, we can inadvertently ‘displace’ the problem to another place or environmental medium – for example into air through incineration of water treatment sludges. Only a focus on all pathways assures that when tackling the release of a hazardous chemical in one place, ie a discharge pipe, we do not disregard other pathways.

Similarly, the substitution principle requires finding solutions through non-hazardous alternatives – not simply transforming a hazard into another hazard, or substituting a hazard with one that is slightly less hazardous but still chemically problematic (as is happening with the replacement of some brominated flame retardants with other brominated flame retardants52).

---

46 See Hudson River case study in Section 2 of ‘Hidden Consequences: The costs of industrial water pollution on people, planet and profit’.
47 The Marilao River is part of the extensive Marilao-Meycauayan-Obando River System, a 130 km² body of water that runs through the province of Bulacan in the Philippines. In 2007, the Blacksmith Institute, an international organisation working to identify and remediate polluted places in the developing world, placed the river on its ‘Dirty Thirty’ list of World’s Worst Polluted Places. Subsequent monitoring of the river system in 2008 confirmed the presence of exceedance of water and sediment standards for heavy metals such as hexavalent chromium, lead and cadmium, along with pesticides, sewage, solid waste and tannery waste in the river system. See The World’s Worst Polluted Places. Blacksmith Institute, September 2007 or case study on the Marilao in Section 1 of ‘Hidden Consequences: The costs of industrial water pollution on people, planet and profit’, Greenpeace International, 2011.
48 Studies that analysed the presence of Persistent Organic Pollutants (POPs) at various stations all along the Yangtze River (China) in 2008 found that of the 236 most commonly-screened anthropogenic organic pollutants, ‘the most notorious were detected at levels above quantification limits’ (Muller, Berg, Yao, Zhang, Wang, & Pfluger, 2008). See also case study on Yangtze and Chao Praya in chapter 3 of this report (if included).
The OSPAR commitment\textsuperscript{53} includes a mandate to tackle all pathways (whether a discharge from a pipe, emissions from another point in the production process or losses of pollutants throughout the lifecycle of the product, eg when it becomes waste). It promotes seeking alternatives or substitutes to the hazardous chemicals, and using direct bans or restrictions where necessary.

Already in the 1990s, there was a growing recognition\textsuperscript{54} that cessation of discharges was only possible via the elimination of all routes\textsuperscript{55} of releases of hazardous chemicals. In the US, the 1990 Pollution Prevention Act (PPA)\textsuperscript{56} affirmed the new understanding that the best way to address pollution in all of its forms is to try to reduce it at the source. Under the Pollution Prevention Act, recovery, treatment, and disposal are not included within the definition of Pollution Prevention (P2), or prevention at source.\textsuperscript{57}

In 1996, the European Council adopted 96/61/EC, the Integrated Pollution Prevention and Control Directive (IPPC). Under the IPPC Directive, permits must use best available techniques to prevent pollution. The most recent revision of the IPPC Directive, 2008/1/EC,\textsuperscript{58} clarifies that permits must consider the use of low-waste technologies and the use of less hazardous substances and codifies the intent of the directive as ‘preventing, reducing and as far as possible eliminating pollution by giving priority to intervention at source and ensuring prudent management of natural resources, in compliance with the ‘polluter pays’ principle and the principle of pollution prevention’.

Recognition of the need for prevention

Q4 Can't hazardous chemicals be filtered out or treated to make them harmless? Isn't that more efficient?

Some hazardous chemicals can be captured, but filters and treatment – especially biological treatment – are often inefficient in addressing hazardous chemical pollutants and invariably add costs to a process, not least by generating other hazardous wastes (in the form of sludges, ashes, etc.), which then also need to be managed. Preventing the pollution before you have to treat it (clean, and sometimes, cleaner production\textsuperscript{59}) has turned out to be the most efficient approach. Prevention through cleaner production and substitution and/or elimination of hazardous chemicals at source often saves companies money – for example savings of $90m US dollars compared to costs of $76m\textsuperscript{60} in the US State of Massachusetts under the Massachusetts Toxics Use Reduction Act Programme (see Q10 below). These cost savings and avoidance of treatment costs can actually keep companies in business for longer – at least another decade as the textile sector in North Carolina discovered (see case under Q10 below) – by keeping them competitive on global markets as well as stimulating innovation.

Background: In the US, the 1990 Pollution Prevention Act (PPA)\textsuperscript{61} proposed that the best way to address pollution in all of its forms is to try to reduce it at the source. Under the Pollution Prevention Act, Congress established a national policy that clearly defined Pollution Prevention (P2) as ‘source reduction’.

‘Source reduction’ is ‘any practice which reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal …’\textsuperscript{62}
The US Pollution Prevention Program has been successful at sharing information and supporting efforts, of varying degrees of obligation, towards reducing emissions and resource efficiency, essentially from industrial processes. The National Pollution Prevention Roundtable (NPRC), the largest non-profit organisation in the US devoted solely to pollution prevention (P2) is one of the most comprehensive platforms for this information sharing.\(^{63}\) The NPRC’s report on its achievements of state pollution prevention programmes show reductions of over 6 bn pounds (2.73 m tonnes) of air and water pollution between 2001 and 2003, and this trend has continued with overall reductions of approximately 7.7bn pounds (3.5m tonnes) of pollution from 2004 to 2006.

60m pounds (27.3 thousand tonnes) of this pollution reduction was just from reducing water pollutants,\(^{64}\) 64% of which was toxic water pollutants.\(^{65}\)

![Figure 1. Total chemicals in Water Pollution Reduced 2004-2006 from state and local programmes documented under the US National Pollution Prevention Roundtable (NPRC), National Pollution Prevention Roundtable report, February 2009.\(^{66}\)](image)

Toxics prevention and elimination information sharing resources

- Pollution Prevention Resource Exchange, http://www.p2rx.org, is a consortium of eight regional US centres gathering case studies, fact sheets and guidance from US state and local programmes; and P2 Gems

- http://www.turi.org/library/other_online_resources/web_links_at_p2gems__1, which contains hundreds of case studies gathered by the Toxics Use Reduction Institute in Lowell, Massachusetts

- http://www.cleanerproduction.com/directory/sectors/industri.htm, which lists resources such as the UN Environment Management Center, http://emcentre.com/unepweb/index.htm (with 441 case studies).

One of the well-known cases of a state P2 programme focusing on source prevention is the Massachusetts Toxics Use Reduction Act (TURA) passed in 1989. TURA has combined the setting of clear and ambitious targets including chemical use reporting with an aggressive programme of assistance and education, and a requirement for large quantity toxic users to analyse their options for prevention (see section below on the Massachusetts TURA for more information on results).

---

\(^{62}\) Under the Pollution Prevention Act, recovery, treatment, and disposal are not included within the definition of P2. Some practices commonly described as ‘in-process recycling’ may qualify as P2.

\(^{63}\) See http://www.p2.org/about.

\(^{64}\) See page 3 in ‘Road to Sustainability: Pollution Prevention Progress from 2004 to 2006 - Results from the National Pollution Prevention Data Management System. National Pollution Prevention Roundtable’, February 2009 available at http://www.p2.org/category/publications/measurement-reports/

\(^{65}\) Calculated from Figure 8, page 11 in ‘Road to Sustainability: Pollution Prevention Progress from 2004 to 2006 - Results from the National Pollution Prevention Data Management System. National Pollution Prevention Roundtable’, February 2009 available at http://www.p2.org/category/publications/measurement-reports/. Note: Toxic Water Pollutants here refers to any of the 650 chemicals reported via the US Toxic Release Inventory as releases to water. See http://www.epa.gov/tri/trichemicals/index.htm for which chemicals. Figures refer to the pounds of chemical pollutants in the water and not the gallons or litres of polluted water discharged.

\(^{66}\) Copied from Figure 8, page 11 in ‘Road to Sustainability: Pollution Prevention Progress from 2004 to 2006 - Results from the National Pollution Prevention Data Management System. National Pollution Prevention Roundtable’, February 2009 available at http://www.p2.org/category/publications/measurement-reports
Recognising the importance of preventing toxic chemicals at source and strengthening protection of ecosystems, the United Nations Agenda 21 also launched the Cleaner Production programme. There are now National Cleaner Production centres in 46 countries. Many countries have established vigorous programmes to assist companies in switching to non-toxic inputs as a strategy for achieving sustainable environments and economies. Following closely on its heels, the Stockholm Convention was adopted in 2002 and came into force on 17 May 2004. For both intentional and unintentional Persistent Organic Pollutants (POPs), elimination through substitution is a priority.  

Note: It is important to make a distinction between Cleaner Production and Clean Production.

Clean production is any practice which eliminates at source the use or formation of hazardous substances through the use of non-hazardous chemicals in production processes, or through product or process redesign, and thereby prevents releases of hazardous substances into the environment by all routes, directly or indirectly.

Cleaner production includes conserving raw materials and energy; eliminating toxic raw materials; and reducing the quantity and toxicity of all emissions and wastes before they leave a process. In other words, clean production requires elimination and cleaner production requires only reductions. Cleaner production also goes well beyond just the issue of reducing or elimination hazardous chemicals.

Q5 Which hazardous chemicals should we tackle first?

There are currently around 100,000 chemical products on the EU market alone. It is often difficult for governments or other actors to know where to start when trying to eliminate hazardous chemical usage. To focus policy and other actions needed to tackle hazardous chemical pollution, many governments and conventions have established ‘priority’ lists, based on consideration of a combination of intrinsic properties of hazardousness and patterns and volumes of use.

A common list of priority chemicals also allows business to focus more resources on the important job of how to set their own priorities and tackle them instead of getting slowed down by the very complex task of reviewing the universe of chemicals or searching for information to characterise them (as is sometimes done now by some companies on a voluntary basis – for example the Restricted Substances lists that some sectors/companies have developed, often differing from company to company).

In addition to providing important policy principles and mandates (precaution and addressing all release pathways), OSPAR is one policy that has established such a list. OSPAR has taken a two-step process: first

69 Online article at Taiwanese Ing-je Hwang, Center for Environmental, Safety and Health Technology Development, ITRI. http://proj.moeadb.gov.tw/isdn/Files/isdn/2-1/new_page_1.htm
72 Persistent Organic Pollutants are organic compounds that are resistant to environmental degradation through chemical, biological, and photodecomposition processes. Because of this, they persist in the environment, being capable of long-range transport.
74 Taken from Greenpeace Clean Production factsheet, written by Beverly Thorpe, June 2009 - see http://www.cleanproduction.org/library/factsheet1_Clean_Production.pdf
75 Taken from UNEP Cleaner Production Program - http://www.unido.org/index.php?id=05152
76 ‘Over 100,000 were registered in the European Inventory of Existing Commercial Chemical Substances (EINECS) in 1981, but the current estimate of marketed chemicals varies widely, from 20,000 to as many as 70,000 (Teknologi-ådet, 1996).’ Taken from Low Doses, High Stakes, EEA 2000. See http://www.unep.ch/roe/publications/assessment/02_chemicals.pdf
a methodology for generating a list of substances of possible concern from the universe of chemicals on the market; then, from this, a more focused list of substances for priority action. The listing of these substances is based on a precautionary approach. That means it uses indicative (published) evidence of a substance’s intrinsic hazardous properties, eg if a substance has PBT properties or properties of equivalent concern (see box below for more information).

In order to prioritise the substances of highest concern for immediate action, OSPAR has developed a selection and prioritisation mechanism. This is the **Dynamic Selection and Prioritisation Mechanism for Hazardous Substances (DYNAMEC)**.

DYNAMEC identifies certain hazardous substances on the basis of their intrinsic hazardous properties of persistence, liability to bioaccumulate and toxicity (P, B and T) and has a safety net procedure to also capture other substances that show properties of equivalent concern – namely endocrine disruptors, metals and others. Typically, experimental data on P, B and T is used, and DYNAMEC defines cut-off values to determine PBT classification. However, when experimental data are not available, substances have been identified by employing different models (QSARs: Quantitative Structure Activity Relationships), which estimate these values on the basis of their chemical structure.

By being precautionary and using published experimental and predictive data from modelling, the classification process is relatively straightforward and does not rely on extensive research and data on exposure and the levels of risk before a substance is listed for priority action.

The EU Water Framework Directive also bases its priority listing on a hazards-based approach and establishes the EU Priority Hazardous Substances list, creating a binding legislative tool with which to implement the obligation to implement the phase-out at the European regional level.

In response to the EU chemical management law REACH, NGOs have established their own SVHC list – based on the criteria laid down in REACH – the Substitute it Now (SIN) list – see: [http://www.sinlist.org/](http://www.sinlist.org/).

The project focuses particularly on chemicals that consumers might be exposed to. This includes chemicals used everywhere in our daily life, such as detergents and paints, in electronics, in residential buildings, toys, apparel and clothes. The SIN List is also supported by the market-leading companies in the ChemSec Business Group.

The SIN List 1.0 was launched in September 2008 and the SIN List 2.0 now lists 378 (updated in May 2011) substances that fulfil the criteria of Substances of Very High Concern, as laid out within REACH.
Right to Know – a win-win tool

Q6 Why is public disclosure of hazardous chemical use and releases by facilities so important?

One of the ways of providing information to the public is to establish Pollutant and Release and Transfer Registers (PRTRs). PRTRs are based on reported quantities of releases of hazardous chemicals to the environment, facility by facility, year by year, ideally made available in searchable online databases freely accessible to the general public. From 1988 to 2007, manufacturing facilities decreased their on- and off-site disposal or other releases by 61% based on chemicals that have been consistently reported since 1988 according to the US Toxics Release Inventory. Downward trends have also been observed in Japan under the Japanese Pollutant Release and Transfer Register (PRTR), which was established in 2001. Covering 462 hazardous chemical substances in 23 sectors and 34,830 facilities, the Japanese PRTR has shown a reduction of 24.5% (2001-2009) in releases (and waste transfers) of hazardous substances. Equally revealing is that for industrial facilities that are not required to disclose their releases (just maintain data sheets) no significant reduction was observed.

Results like this have lead to a Dow Chemical executive saying that ‘mandatory disclosure has done more than all other legislation put together in getting companies to voluntarily reduce emissions’.

Some regions show less dramatic but still downward trends. For example, data from the EU PRTR found that just over half the facilities that reported between 2001 and 2004 saw a decrease of over 10% in emissions.

Background: Public access to information and public participation in decision-making is a powerful tool to prevent chemical pollution. Producers and product designers are made more accountable when communities and workers can find out what an industry or a factory is emitting into the environment or when consumers can find out what is in a product.

The Aarhus Convention, the UNECE’s response to the Rio Principle 10 of Agenda 21 commitment on access to information, came into force on October 31, 2001. In May 2003, 36 nations and the European Union signed the Kiev PRTR Protocol, widely considered the most significant expansion of mandatory disclosure requirements to date anywhere. Participating countries are committed to establishing compatible registers that report pollution emissions and transfers of a core list of 86 pollutants from major point sources. The EU E-PRTR, originally established in 2000 to fulfill requirements established under the Directive on Integrated Pollution Prevention and Control, is an example of the implementation of this commitment. All 26 EU member states have to produce annual reports on the emissions of industrial facilities into air and waters. This PRTR does however only cover the 86 Kiev Protocol pollutants, plus five additional pollutants (Octylphenols and Octylphenol ethoxylates, Fluoranthene, Isodrin, Hexabromobiphenyl, Benzo(g,h,i)perylene).

---

82 The US Toxic Release Inventory is a mandatory requirement on companies, who meet a certain threshold of toxic chemicals used, to report the quantities of (currently) 667 chemicals designated as toxic that are released to the environment.
86 Aarhus Clearinghouse at http://aarhusclearinghouse.unece.org
87 UNECE is the Economic Commission for Europe, consisting of 41 members including the European Union.
88 The Rio Declaration established 27 principles to govern sustainable development and conservation of the world’s natural resources; Principle 10 of Agenda 21 called on nations to adopt improved access to information and participation: ‘... At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities...’
90 The revised European Pollutant Release and Transfer Register (European PRTR) was adopted on 18 January 2006. see http://prtr ec.europa.eu/Home.aspx [accessed 15 December 2010].
91 For example thermal power stations, mining and metallurgical industries, chemical plants, waste and waste-water treatment plants, paper and timber industries, http://www.unece.org/env/pp/prtr ng.htm [accessed 18 January 2011].
Another way other countries became active in providing information to the public was an OECD initiative to establish PRTRs modelled after the Toxics Release Inventory in the US. PRTR.net provides a global portal to PRTR information and activities from countries and organisations around the world. The OECD has an interactive website that allows users to access data from each of the participating countries. PRTRs continue to be implemented in ‘economies in transition’ in Central and Latin America, Africa and Asia.

The US Toxics Release Inventory: How US citizens can track hazardous emissions

The US Toxic Release Inventory (TRI) was the first globally available public database of information about the toxic emissions of individual companies into the environment.

Members of the public and also some in industry were shocked when the US Environmental Protection Agency (EPA) published its first TRI data on emissions in 1987: US industry reported releasing over 9.6bn pounds (4.4bn kilos) of toxics to the air, water and land. The effect of public pressure on the companies involved prompted the EPA to declare that ‘the impact of TRI has far exceeded our expectations as a tool for improving environmental management’ and that the TRI data ‘should be considered to be among the most important weapons in efforts to combat pollution’.

An example of this is the IBM - Silicon Valley Case. After an analysis of 1987 TRI data revealed that an IBM company in the Silicon Valley area discharged the largest quantities of ozone-depleting CFCs in California, a public interest group organised a campaign to reduce those emissions. Within months, senior management at IBM had pledged to completely eliminate the use of CFCs in their products and processes at the plant by 1993.

The US Toxic Release Inventory is a mandatory requirement on companies that meet a certain threshold of toxic chemicals used to report the quantities of (currently) 667 chemicals designated as toxic that are released to the environment. Since 1991, companies also have to report what types of pollution prevention techniques they are using to reduce emissions.

By requiring that data be made public, PRTRs and TRIs make businesses more accountable for the pollution they cause. But the TRI also has other important uses. The US federal government uses the data to track trends and to assess the effectiveness of their regulations. Increasingly, TRI data are being used in financial decision-making. Insurance companies look to TRI data as one indication of potential environmental liabilities. NGOs use the data to raise the capacity of people to understand the types of hazardous chemicals being discharged into their communities for example Pollution Watch in Canada or the Toxic Watch Network in Japan.

The data can also reveal corporate double standards and pressure companies to practice the same level of prevention as in their headquarter countries. While not its main purpose, regulators can also use the data to set emission permit limits, measure compliance with those limits, and target facilities for enforcement activities.
Going upstream – Recognition of the need for a direct focus on chemical use and producer responsibility

‘Over the past few decades, control of the chemical industry has evolved from regulation and litigation to a diverse set of instruments including information disclosure and incentives. Yet even today only 55% of chemicals on the Toxic Release Inventory list have full testing data. Of the 3,000 high production volume chemicals (more than 1m lb/year) 43% have no testing data on basic toxicity and only 7% have a full set of basic test data. For 38,000, of the more than 45,000 chemicals listed by the EPA, fewer than 1,000 have been tested for acute effects and only about 500 have been tested for cancer-causing, reproductive, or mutagenic effects.’


‘The number of existing chemicals on the market is large, but the exact number is unknown. Over 100,000 were registered in the European Inventory of Existing Commercial Chemical Substances (EINECS) in 1981, but the current estimate of marketed chemicals varies widely, from 20,000 to as many as 70,000 (Teknologi-Rådet, 1996). Little is known about the toxicity of about 75% of these chemicals (NRC, 1984; EDF, 1997).’


Q7 Who has the greatest power to eliminate hazardous chemicals?

It is the producer who decides to produce and market the chemicals companies and citizens use. The chemical manufacturers, together with their customers (ie product manufacturers), can make the choice to shift from using hazardous to non-hazardous chemicals. In other words, it is producers that have the greatest power to eliminate the use of hazardous chemicals. Based on this logic, some policy makers have taken up the approach of increasing producer responsibility, shifting the duty of environmental protection from the impacts of hazardous chemicals from authorities and wider society to a greater responsibility for those who make and sell chemicals.

The EU has several well-known laws that use producer responsibility and directly focus on chemical use, in particular in products – for example the Restriction of Hazardous Substances in Electrical and Electronic Equipment Directive. These laws have and still are driving substitution of hazardous chemicals such as brominated flame retardants and heavy metals in the Electronics sector.

In 2006, the European Institutions took their strongest action yet to force the change in practice needed for tackling the use of hazardous chemicals, with the adoption of Regulation No. 107/2006 – the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

REACH has set the global benchmark for the new precautionary producer responsibility paradigm for chemicals management. Companies trading in the EU are now fully responsible for providing safety information for all chemicals regulated by REACH, shifting the burden from authorities to producers. More precisely, chemicals in use with certain tonnage thresholds should be proven safe and companies that

100 Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC.
produce or trade them should bear their responsibility in proving they are safe, in a fully transparent manner, requiring the submission of information to a new European Chemicals Agency. In short: ‘No data, no market’.

In addition to this reversal of burden of proof, REACH requires that substances of very high concern shall be eventually substituted by safer alternatives. To achieve this, companies should evaluate the availability of alternatives if the chemicals they are placing on the EU market are classified as Substances of Very High Concern (SVHC). REACH follows the OSPAR and WFD intrinsic (or inherent) hazards approach in its prioritisation of Substances of Very High Concern based on PBT\(^{103}\) and CMR\(^{104}\) properties and others of equivalent concern.\(^{105}\)

**Article 55 of REACH**

“The aim of … authorisation and considerations for substitution [author’s edit] … is to ensure the good functioning of the internal market while assuring that the risks from substances of very high concern are properly controlled and that these substances are progressively replaced by suitable alternative substances or technologies where these are economically and technically viable. To this end all manufacturers, importers and downstream users applying for authorisations shall analyse the availability of alternatives and consider their risks, and the technical and economic feasibility of substitution.”\(^{106}\)


Q8a Will chemical manufacturers be able to find alternatives to hazardous chemicals?

Substitution of hazardous chemicals requires, of course, that equally performing non-hazardous alternatives are available. After decades of innovation with little concern for hazardousness, these alternatives will not be available overnight. As the EU regulation on chemicals management (REACH) recognises, what is important to drive the process of finding alternatives is the requirement for companies to undertake assessments of alternatives when a chemical they mark is identified as hazardous (in the case of REACH, when it is identified as a Substance of Very High Concern – SVHC).\(^{107}\)

Research in the field recognises that the chemical industry should supply the alternatives to hazardous chemicals but that it is slow to make breakthrough product innovations. According to researchers in Green Chemistry (such as Warner et al.), ‘Much of the chemical industry is capital-intensive, based on economies of scale, and thus large companies are typically slow to convert to new technologies. The dynamics of advance in the chemical industry, as for non-assembled products in general, is dominated by increasing scale, reducing costs, and increasing demand that spurs process innovation rather than breakthrough product innovations.’\(^{108}\)

In other words, the market will not produce the innovations on its own. Government regulation is necessary to make it happen. This can happen through a combined strategy of regulation, education, tax incentives and also cooperative work, research funding and demonstration. One part of the solution for empowering the search for alternatives is Green Chemistry.

The researchers Anastas and Warner define Green Chemistry as “the utilisation of a set of principles”\(^{109}\) that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and

---

\(^{103}\) Abbreviation for persistent, bioaccumulative and toxic properties – ie substances that can accumulate in our bodies and in the ecosystem.

\(^{104}\) Abbreviation for carcinogenic, mutagenic and reprotoxic properties - ie substances that can cause cancer, are toxic to reproduction or alter genes.

\(^{105}\) For example and endocrine disrupting (ED) properties ie substances that interfere with hormone systems.


\(^{109}\) There are typically 12 principles underlying the Green Chemistry initiative – including principle 3. Less Hazardous Chemical Syntheses - Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment, and principle 10. Design for Degradation - Chemical products should be designed so that at the end of their
Green Chemistry is based on the approach that with a thorough understanding of the molecular basis of a chemical’s properties the chemist designer should be able to construct molecules that reduce or eliminate the chemical and/or physical properties of hazard, allowing the designer to eliminate hazards at the design stage.

However, as its proponents stress, 'unlike regulatory requirements for pollution prevention, Green Chemistry is an innovative, non-regulatory, economically driven approach [...] targeting in particular the chemical industry. Rather than regulatory restrictions for controlling hazards, Green Chemistry challenges innovators to design and utilise matter and energy in a way that increases performance and value while protecting human health and the environment.'

Green Chemistry case study

Argonne National Laboratory (ANL) transformed the economics of producing Ethyl Lactate that allows it to compete with existing solvents. Ethyl lactate has been known for years as a technically effective alternative solvent to hazardous chlorinated solvents used in many sectors. Potential substitution of green/bio-based solvents could be foreseen for up to 80% of the 30 billion pounds (13.6 million tonnes) of environmentally damaging solvents employed in the world.

Q8b What if the alternative, less hazardous chemical is nowhere to be found?

It is important to recall (as stressed in the definition of precaution in Q2 above) that to meet the precautionary objective of reducing the burden of a hazardous chemicals load, the decision to prevent the discharge of a certain chemical may require a fundamental re-evaluation of a need for a product or process and may not always imply simple substitution with an alternative. Options such as a product re-design – while maintaining the same functionality – or the re-examination of its functionality – while still meeting its needs – can be considered. A recent report from the UK Chemicals Stakeholder Forum Guide to Substitution outlines four possible approaches (see box).

Identifying the Opportunities

When identifying the level of innovation required for substitution, the Guide lists four possible approaches:

- Improve the existing product. Direct substitution of a single ingredient under pressure is the simplest approach. The product, manufacturing process and functionality remain basically the same, but the effort involved effectively leaves you were you started.

- Redesign the product. The product purpose concept and functionality stay the same, but the way the product is put together changes completely. For example a reformulation with a new mix of ingredients replacing the functionality of the substituted material.

- Provide new functionality. Rather than improving the existing product concept, find new ways of meeting the customer needs. For example, by converting the product into a service.

- Redesign the business system. Create a new business model in which product, production system, delivery system, supply chain and customer care may all be changed.
As the authors of the Guide to Substitution note: ‘Each approach is progressively more complex and more risky. However, there is evidence that the potential environmental and commercial benefits increase dramatically with more radical innovation. As a guideline, incremental improvements to an existing product can only deliver a reduction in impact of a factor of 2; whereas a complete redesign of the business system can reduce impact by factors of 20 or more.’\textsuperscript{115}

Policy makers also need to be aware of the risks of so-called ‘shallow innovation’. As the authors of the Guide to Substitution also stress, ‘The costs and risks of shallow, incremental innovation can be as high as deeper, more fundamental innovation. Shallow innovation still appears to be an attractive strategy; particularly where a specific ingredient is a cause for concern and needs to be substituted. A fast reformulation project looks cost and time efficient. The EPA in the US and in Denmark have collated tables of known substitutes for materials where the environmental or health and safety profile have caused concern. This approach is particularly widely used for solvents, where it has been very effective.

‘However, the cost of simple substitution and shallow innovation can be substantial. REACH regulations are expected to result in a large number of chemicals that are currently freely available to vanish from the market. Formulated commercial products such as inks, adhesives and paints can contain up to 60 individual chemicals in one formulation. If one of these is withdrawn as a result of REACH, the potential costs of reformulation can be very high.’\textsuperscript{116}

**The best of both worlds – targets and transition tools**

**Q9 Are priority lists, disclosure and producer responsibility requirements enough for shifting to non-hazardous chemicals?**

A 2006 study of 15 pollution prevention programmes showed that although all programmes had significant positive impacts, those with mandatory requirements, such as reporting chemical input and documenting the good faith completion of a pollution prevention plan, had greater indicators of success than voluntary programmes.\textsuperscript{117} The European Environment Agency (EEA) also assessed the effectiveness of voluntary environmental agreements and concluded that the setting of clear targets or quantified objectives was a necessary framework condition for such tools.\textsuperscript{118}

More recently a report prepared for the UK Department of Environment, Food and Rural Affairs (DEFRA) and its Chemicals Stakeholder Forum on the impact of EU controls on the Voluntary Agreement (VA) to phase out the use of nonylphenols (NP) concluded that ‘the marketing and use restrictions on NP/Es appear to have made a significant difference to industry’s perception of the acceptability of a VA for NP/Es. This shows that a VA backed up by some sort of regulatory action is more likely to be taken up by industry.’ The report notes furthermore that ‘VA is a risk management option, the success of which will depend on several parameters. Underpinning a VA with legislation perhaps offers the safest way of ensuring success.’\textsuperscript{119}

There is an important lesson here. Effective chemicals policies must balance carefully mandatory targets and requirements with more cooperative or voluntary transformation or ‘transition tools’ such as the technical assistance and education programmes that can assist in the transition to safer chemicals. In other words, without a clear driver – such as a timeline for cessation of use or substitution – the efficiency of cooperative voluntary tools depend on the good will and opportunism of market innovators, or the education of the innovating chemists, or the stick and carrot of disclosure.\textsuperscript{121}

\textsuperscript{115} op cit.

\textsuperscript{116} op cit.


\textsuperscript{120} Transition tools is used here to mean policies and processes that facilitate transition to non-hazardous chemicals use.

In addition to long term macro-targets, such as the OSPAR cessation of releases in one generation, other government regulatory drivers, such as media-based effluent and emission standards and restrictions on the manufacture, use or disposal of priority chemicals set the legal context for the chemicals market and create incentives for the innovation necessary to create the safer alternatives required to replace dangerous chemicals.

Ken Geiser, one of the authors of the Massachusetts Toxics Use Reduction Act, notes that, 'An ideal chemical management strategy must set a framework where regulatory timelines and goals drive the need for chemical substitution, science is encouraged to develop safer alternatives, market incentives reward successful substitutions, and there is sufficient government capacity and technical assistance to assure that the results are "preferable" (ie really non-hazardous) rather than "regrettable".' 122

In other words, the OSPAR, the EU Water Framework Directive and REACH-style obligations and targets, the precautionary and simple priority substance listing (based on intrinsic hazards), together with the tools of the TURA plans and the Green Chemistry initiative knowledge base, are all necessary parts of an effective hazardous chemicals management framework.

Prevention and substitution – saving the environment while reducing costs

Q10 Is prevention at source and substitution of hazardous chemicals (too) expensive?

This a common perception but experience indicates that prevention at source, both through substitution of hazardous chemicals with non-hazardous alternatives and through source reductions, can actually save companies money.

Programmes that have assessed the costs and benefits of toxics use reduction in companies, such as the Massachusetts Toxics Use Reduction Act (MTURA) programme, have reached the conclusion that companies save more than the measures cost them. Overall the MTURA has reduced toxic chemical use in the state by several hundred million pounds (100m pounds = 45,000 tonnes).123

Overall results (see Figure 2) of the Toxics Use Reduction Programme, 1990-2004124 show reductions of:

- toxic chemical use by 41%;
- toxic byproducts by 65%;
- toxics shipped in product by 58%;
- on-site releases of toxics to the environment by 91%; and
- transfers of toxics off-site for further waste management by 56%.

122 Quote from interview, personal communication, 12 December 2010.
124 Data normalised to an economic index.
Recent reports show reductions are less dramatic (some years there are small increases, followed by decreases), but the trend is still continuing to be downwards overall, and still substantial, showing reductions of:

- 20% in toxic chemical use;
- 33% in toxic byproducts;
- 19% in toxics shipped in product;
- on-site releases of toxics to the environment by 52%; and
- transfers of toxics off-site for further waste management by 39%

over the eight year period (2000-2008). See Figure 3. Note that this data covers a different Core Group as some companies dropped out and some new ones joined.

In 1997, the MTURA programme commissioned an independent evaluation that found that companies total costs were $76m US dollars, and savings were $90m. On an individual company level, cases that have been evaluated often show payback times in zero to three years.
The Office of Technical Assistance (OTA) at the Massachusetts Executive Office of Energy and Environmental Affairs has visited nearly two thousand facilities and has published dozens of case studies (see box 1 for some examples). Not one company was forced to receive OTA’s assistance; this aspect of the programme is entirely voluntary.

Table 1. MTURA case studies.

<table>
<thead>
<tr>
<th>Name of firm</th>
<th>Type of industry / product</th>
<th>Process</th>
<th>Hazardous chemicals</th>
<th>Properties</th>
<th>Quantities eliminated</th>
<th>Alternatives used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackinton</td>
<td>Metalworking</td>
<td>Chemical plating</td>
<td>Freon, Trichloroethylene</td>
<td>Neurotox / carcinogenic, mutagenic and reprotoxic</td>
<td>13.6 tonnes TCE</td>
<td>Deionised water, aqueous cleaner</td>
</tr>
<tr>
<td>Cranston</td>
<td>Textile</td>
<td>Finishing – mercerising</td>
<td>Sulphuric acid</td>
<td>Musculoskeletal / respiratory / skin toxicant</td>
<td>1,209 tonnes sulphuric acid</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>Acushnet</td>
<td>Rubber components</td>
<td>Parts degreasing</td>
<td>Trichloroethylene</td>
<td>Carcinogenic, mutagenic and reprotoxic</td>
<td>18 tonnes</td>
<td>Aqueous cleaner</td>
</tr>
</tbody>
</table>

Economic benefits – savings and payback

Company savers over $25,000 per annum (not specific to TCE substitution, also includes energy savings)

$115,000 US dollars cost, $80,000 savings per annum. 1.5 years payback

$100,000 US dollars savings per annum

Sources: State of Massachusetts, Office of Technical Assistance case studies.

In 1997, the programme commissioned an independent evaluation by Abt Associates of Cambridge, MA, which found that companies saved more than TURA cost them. Total costs were $76m US dollars, and savings were $90m.

No company was forced to make any particular changes, only to consider them through mandatory planning. Plans had to be certified by Toxics Use Reduction Planners at the Toxics Use Reduction Institute (TURI). However, once companies realised the cost savings due to the opportunities for toxics use reduction, most implemented the plans.


130 Note: $27m US dollars of this is investment by the companies in voluntarily improving their own operations. These would not even be counted as costs in some analyses, but as benefits. Rick Reibstein, OTA, personal communication.


132 Rick Reibstein, OTA, personal communication.
onsite, confidential, one-on-one assistance), analysed the effectiveness of its assistance efforts, concluding that the companies visited by OTA performed far better than those not visited.\textsuperscript{133} This showed that assistance is a critical factor in creating a programme that works.

Furthermore, the toxics use reduction planning and consequent self auditing and investigative processes, ie the careful examination of what is being used, and what could be used, to accomplish a task; and by constant consideration of ways to improve how things are done, that are required by MTURA, and are necessary to implement substitution and source reduction, often lead to process innovations.\textsuperscript{134} One example are closed-loop processes (see Blackinton case study below).

**Blackinton case study**

One example in process innovation is the shift to closed-loop systems that create savings in overall process efficiency. The TURA case study on the metal working company Blackinton (see Table 1) is one such case: The closed-loop plating process has resulted in the elimination of wastewater discharges. 7,400 pounds (\(= 3363.6 \text{ kg}\)) of annual sodium hydroxide use, 1,200 pounds (\(= 545.5 \text{ kg}\)) of cyanide use, and almost 30 tons (27.2 tonnes) of annual hazardous waste sludge generation has been eliminated. The company no longer has to report under TURA, or pay TURA fees. In addition, the efficiency gains of the new systems have saved the company more than $20,000 US dollars a year. The company also saves $5,000 a year in water charges.\textsuperscript{135}

Other examples of process innovation and cost savings while eliminating hazardous chemicals through substitution are:

- Substitution of solvent-based metal cleaning surfactants with non-hazardous aqueous metal surface cleaners (see Acushnet case study in Table 1 above and the use of ethyl lactate-based alternatives to solvent cleaners\textsuperscript{136});
- Substitution of hazardous alkyl phenol surfactants with non-hazardous surfactants (see substitution of nonylphenol ethoxylates surfactants with linear alcohol ethoxylates in the North Carolina textile industry case study, below); and
- Substitution of toxic sodium sulphide in the sulphur black textile dyeing processes with glucose and the replacement of the hazardous chemical dichromate with the sodium perborate or with hydrogen peroxide in Egyptian textile companies.\textsuperscript{137}

When total chemical use is reduced by one-third (the approximate amount of reductions in Massachusetts relative to total use), it is likely that toxic accidents, contamination, exposures and the loss of resources, and the impacts on health and the environment are also reduced significantly. Companies that eliminate toxics use eliminate storage costs and the concerns of neighbours and local emergency responders, and the need to prepare for accidental releases, as well as costly litigation. This is a growing ‘economic risk’ companies are facing globally.\textsuperscript{138} Companies that reduce toxics input to their process reduce the need to authorise transport of hazardous materials, and thus the responsibility for spills.
The Massachusetts story is not unique – many other jurisdictions have had successes with pollution prevention programmes, but because Massachusetts requires the reporting of chemical inputs, it is possible to measure success. The state uses many of the tools of governance to promote pollution prevention and has had a relatively large and strong programme, so it provides a good example of what can be accomplished if the best of the policy measures are combined.

How preventive policies can help avoid closing companies down

The cost savings and competitive advantages of prevention and substitution are evident not only at the company level, but also at the state level.

In the 1980s, a large portion of the discharges sent to publicly owned waste water treatment works (POTWs) in the state of North Carolina in the US came from a thriving textile industry that has now relocated to India and China. The discharges from these companies were causing the POTWs to fail tests that evaluate whether aquatic organisms can survive in the discharge from the facility. Furthermore, the POTWs were having a difficult time operating – breaking down the sewage and processing sludge – because of the toxicity of the discharges they were receiving. The Pollution Prevention programme, working with consultants and academics, formed a collaborative effort to find the source of the problem and to investigate alternatives. Many meetings were held with the industry to establish a cooperative relationship, and many tests were performed to determine which chemicals were primarily at fault.

One class of chemicals that emerged as a focus from this effort was the surfactants known as alkyl phenol ethoxylates, and the subclass nonylphenol ethoxylates (APEs and NPEs). These chemicals are excellent detergent and wetting agents, cleaning the fibres and wetting them so that they quickly take up dye when processed. However, NPEs are highly toxic to aquatic organisms, persistent in the aquatic environment, and moderately bioaccumulative.

Linear alcohol ethoxylates (LAEs) also perform the same function, and had been adopted by detergent manufacturers after concerns were raised about toxic surfactants in the 1970s, but had not been adopted for use by textile companies because they cost about 30% more.

The project demonstrated that replacing APEs and NPEs with LAEs could solve the problem of the aquatic toxicity of facility discharges. Dozens of companies switched to LAEs, and the POTWs began passing their toxicity tests.

Authorities at the North Carolina Pollution Prevention Programme estimate that the case of substituting NPEs with LAEs in the textile sector in North Carolina in the 1990s allowed over 100 companies to stay in business (due to staying competitive through costs savings) for more than a decade. The value of helping to keep more than a hundred companies in operation for more than a decade is difficult to estimate. In 1992, the textile industry in the state represented about 16% of total manufacturing in the state (the national average was 2%), a substantial portion of which involved wet processing potentially using toxic surfactants. Hundreds of thousands of jobs were at stake.

According to Sam Moore, formerly of Burlington Research Incorporated, the primary consulting firm working with the state on the project, the first strategy employed by POTWs was to attempt to control discharges through extended aeration treatment, then with activated carbon. Expensive systems were built, and did not effectively prevent discharges. If the strategy of material input substitution had not been adopted, ‘the level of treatment

---

139 See, for example, http://www.cleanerproduction.com/directory/sectors/industries.htm, which lists resources such as the UN Environment Management Center, (with 441 case studies), the Pollution Prevention Resource Exchange, http://www.p2rx.org/, which combines six regional US centers gathering case studies, fact sheets and guidance from US state and local programs; and P2 Gems.

140 The Toxics Release Inventory, required by the federal Emergency Planning and Community Right to Know Act, requires reporting of toxic releases (discharges) throughout the US, and many other countries have adopted what is termed ‘Pollutant Release and Transfer Registers’. But only Massachusetts and New Jersey, and the city of Eugene, Oregon, have comprehensive requirements for the reporting of chemical input, enabling the comparison of what is used in process to what results. Without input information, it is impossible to calculate a ‘mass balance’ of chemical use in a facility that accurately tells you how efficiently the chemical is used.


required would have been so costly that the companies would not have been able to stay in business.” As a result of the success, the cities of Burlington and Concord in North Carolina banned the use of NPEs and APEs.\textsuperscript{143}

Beyond North Carolina, another interesting example of cost savings from substitution can be found in Canada. Environment Canada, the state environmental agency, placed all wet processing textile mills on notice in 2004 that they were required to prepare and implement pollution prevention plans for reducing the use of NPEs by 97% relative to the annual use for 1998 by 2009, and in 2006 they reported the mills had already surpassed this reduction target.\textsuperscript{144}

The largest Canadian manufacturer of furniture fabric and stretch knitted fabric, Hafner Inc., reduced its discharges from 6,800 kilograms in 2001 to 68 kilograms in 2003, and as a result also cut the chemical oxygen demand (COD) of the wastewater in half, which reduced their annual effluent disposal costs by $15,000 US dollars.\textsuperscript{145}

The latest results from the US EPA P2 programme indicate that prevention not only led to environmental improvements, but has also been very cost-effective, saving a total of approximately $6.4bn between 2004 and 2006.\textsuperscript{146}

Authors: Rick Reibstein, Melissa Shinn

With special thanks for valuable oversight and contributions from Beverly Thorpe and Ken Geiser.

For more information, contact:
enquiries@greenpeace.org

Greenpeace International
Otto Heldringstraat 5
1066 AZ Amsterdam
The Netherlands
Tel: +31 20 7182000

greenpeace.org

\textsuperscript{143} According to an interview with Moore, industry claims that APEs have not been shown to be as toxic do not use data from North Carolina, where discharges were at a level high enough to affect local POTW operations, but use data from cities where textile operations are a far smaller percentage of discharges and are thus diluted.

