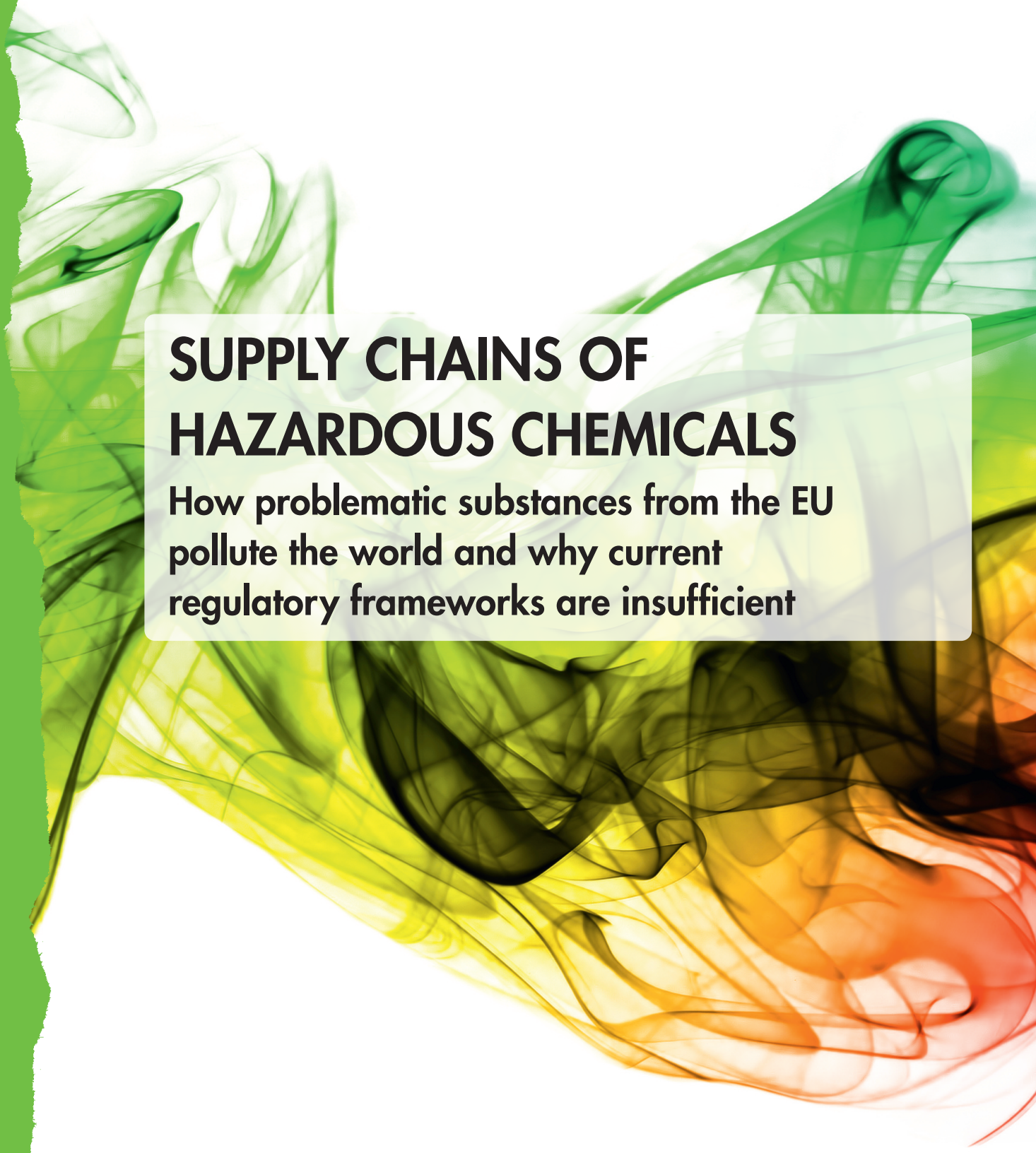
Bund für
Umwelt und
Naturschutz
Deutschland

BUND
FRIENDS OF THE EARTH GERMANY



SUPPLY CHAINS OF HAZARDOUS CHEMICALS

How problematic substances from the EU pollute the world and why current regulatory frameworks are insufficient

This study was conducted on behalf of Friends of the Earth Germany (BUND)

ÖKOPOL GmbH
Institut für Ökologie und Politik
Nernstweg 32–34
D – 22765 Hamburg
www.oekopol.de
info@oekopol.de
+49 40 39 10 02 - 0
+49 40 39 10 02 - 33

Author: Clara Determann
Project coordination: Dr. Olaf Wirth

Client:

Bund für Umwelt und Naturschutz Deutschland

BUND

FRIENDS OF THE EARTH GERMANY

Bund für Umwelt und Naturschutz Deutschland e.V. (BUND)
Kaiserin-Augusta-Allee 5
D – 10553 Berlin
Phone: +49 30 2 75 86 - 40
Fax: +49 30 2 75 86 - 440
E-Mail: bund@bund.net
Responsibility under press law: Petra Kirberger
Cover photo: bedneyimages/Freepik
31 July 2023

The study by ÖKOPOL was commissioned by BUND e.V. and does not necessarily reflect the position of BUND e.V. in all points. It is intended as a discussion paper for a social debate.

Funding information: This project was funded by the Federal Environment Agency and the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. The funds are made available by resolution of the German Bundestag.

Supported by:

Federal Ministry
for the Environment, Nature Conservation,
Nuclear Safety and Consumer Protection

based on a decision of
the German Bundestag

The responsibility for the content of this publication lies with the authors.

TABLE OF CONTENT

1 Introduction

Market actors in the European Union (EU) manufacture substances with hazardous properties and subsequently export them to non-EU countries. This happens even though these hazardous properties mean the substances are carcinogenic, mutagenic and toxic to reproduction (CMR) or persistent, bioaccumulative and toxic (PBT). All these properties and thus substances have serious consequences for human health and the environment, whether they are in direct skin contact, disrupt ecosystems or accumulate in food chains. This does not only occur at the site of exposure. Hazardous chemicals are found in drinking water, in the blood of children and in the most remote places in the world (UBA 2020; Mohapatra et al. 2019; Freudenschuß et al. 2008).

The European Commission (EC) and the governments of the Member States have, in some cases, enacted far-reaching market access restrictions for the substances in question, which ensure that the substances may be used only within very narrow limits or not at all in the EU market. While these restrictions must be complied with when *importing* hazardous substances to the EU, this is not the case when *exporting* them. There is a contradiction between intra-European action and market actors' continued acceptance of risks outside the regulatory area of the EU territory, in order to pursue their economic activities, as it is possible to export substances for purposes for which they are banned in the EU. This can have serious consequences, especially when exporting to countries with less chemical risk assessment. The global target of minimising the environmental and health-related adverse effects of chemicals and waste by 2020 was officially missed (BMUV 2023c).

The restrictions on pesticides and their export from the EU, which nevertheless continues, are a subject of much political discussion (BMEL 2022). Up to 70% of the export volumes of hazardous substances published by the European Chemical Agency are industrial chemicals (ECHA 2023j), and the discussions about these chemicals and weak regulatory stringency are getting louder (PAN Europe 2022). These discussions include voices raised against European double standards and exports of all hazardous chemicals to countries such as Uganda (Parliament of Uganda 2023).

This study, conducted on behalf of Friends of the Earth Germany (BUND), examines the legal framework for industrial chemicals in European law and highlights the substance groups under current debate. Export quantities are analysed, as well as whether they lead to environmental and health impacts in import states. Should the goal be a strict export ban on industrial chemicals? In this context, the negative effects of exporting restricted substances in the EU are illustrated through data evaluation and collection of examples of negative effects in the target countries. In addition, the results of the analysis and proposals for an EU supply chain law will be put into the context of the corporate environmental due diligence of companies that export chemicals.

2 Legal context

Hazardous substances are regulated by various conventions and regulations, both under international law, at United Nations (UN) level, and under European law, at EU level. The jurisdiction of the EU applies between international law of the community of states and national laws of the EU Member States. EU law is bound by international law in that it must implement international law at EU level. The implementation of conventions in the form of regulations provides concrete European rules for its Member States and has direct, legally binding applicability without the need for further transposition into national law (EP 2023; bpb 2021). Conventions and regulations relevant to the supply chains of hazardous substances are discussed below in order of their entry into force.

2.1 Rotterdam Convention

Back in the mid-1980s, the UN Environment Programme (UNEP) and the Food and Agriculture Organization (FAO) raised concerns about increased production, trade and use of chemicals and the resulting potential risks for human health and the environment (ECHA 2014). Knowledge of and infrastructures for measures to avoid hazards from toxic substances were and are very unevenly distributed between a) large producing and exporting countries and b) countries of import with less chemical infrastructure or regulation. The Rotterdam Convention was adopted in 1998 in Rotterdam to promote shared responsibility between exporting and importing countries through mandatory global exchange of information on the properties of hazardous chemicals, assessment of risks associated with their use and possible risk reduction measures (BMUV 2021; ECHA 2014). Entering into force in 2004, the *Rotterdam Convention on the Prior Information Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade* became legally binding for its parties. 165 parties have signed the convention since then, and thus the Rotterdam Convention constitutes an almost globally valid standard for the trade of hazardous substances (Secretariat BRS 2023a). The key pillars of the Rotterdam Convention are described in the following paragraphs.

The Prior Informed Consent (PIC) process is at the heart of the convention. It is designed to ensure that no exports are made to countries against their will. The convention does not ban any hazardous substance in principle, but countries can decide to consent or refuse to import based on the risk information provided in a decision guidance document (DGD) for each listed substance (U.S. Department of State 2023). If a country decides to refuse to import a chemical, this applies to all potential importers, and the country in question must also stop its domestic production for domestic uses. Domestic production for export to countries that have given their consent to import remains permitted (Secretariat BRS 2023c). The PIC procedure is implemented by the submission of export notifications. The exporting companies must prepare these in advance, with details of the intended exports and their risks, and send them via the Designated National Authority (DNA) of the exporting country to the corresponding DNA of the importing country for consent or rejection. In the case of the EU, the European Chemicals Agency (ECHA) acts as an interface between the DNAs of all Member States and those of the importing countries (ECHA 2023g).

All substances subject to the PIC procedure are listed in Annex III to the convention. The initial list of Annex III chemicals consisted of 27 chemicals, based on the prior voluntary PIC procedure (BVL 2023). Now, a total of 54 chemicals are listed: 35 pesticides, 18 industrial chemicals, and one chemical that falls into both use categories (as of July 2023) (Secretariat BRS 2023c). The distinction between use categories is of great importance. Substances are only subject to the PIC procedure for the category under which they are listed in the Rotterdam Convention. If, for example, they are listed only as pesticides in Annex III, no explicit consent needs to be given when they are traded as industrial chemicals. Since the Rotterdam Convention and also the Stockholm Convention (see below) came into force, both have been expanded to include additional chemicals. However, the listing of new chemicals goes through a lengthy process, from nomination by the parties and scientific evaluation by review committees to a political discussion at the Conference of the Parties (COP), where all signed parties must agree to the listing of each new chemical. This process is very demanding and is influenced by the technical and socio-economic capabilities and interests of the individual parties. However, neither convention, Rotterdam or Stockholm, imposes any obligation to include new chemicals in its annexes. This can only happen as a result of the efforts of the parties in lobbying and forcing alliances (IISD 2023; BMU 2012; Secretariat BRS 2023b).

2.2 Stockholm Convention and POPs Regulation

Persistent organic pollutants (POPs) are organic substances with certain toxic properties that pose a global risk of harm to humans and the environment. They persist in the environment for long periods, can accumulate in living organisms, including humans and food chains, and are widely distributed geographically (BMUV 2023a). Therefore, POPs are regulated worldwide by the *Stockholm Convention on Persistent Organic Pollutants (POPs)*, which was adopted in 2001 and entered into force in 2004. This international treaty is signed by 186 parties as of today and implemented in an identical form at EU level by the POPs Regulation (Regulation (EU) 2019/1021). Both aim to ban or restrict the use of POPs but also to prohibit their manufacture and placement on the market. In contrast to the Rotterdam Convention, both the Stockholm Convention and the POPs Regulation also include obligations regarding the release of unintentional by-products (Secretariat BRS 2004). Thus, regulation is very stringent and far-reaching for the entire downstream process (BAuA 2023b). The Stockholm Convention entered into force with 12 POPs, and 29 POPs are now listed in its Annexes A and B (Secretariat BRS 2023b). Due to the convention's high level of legal stringency, any proposed further inclusion is debated even more sharply and for longer than new substances under the Rotterdam Convention (BMU 2012).

2.3 REACH Regulation

The *Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation* standardises chemicals legislation across Europe. The regulation aims to increase knowledge of hazards and risks that can arise from chemicals. The REACH Regulation (EC) No 1907/2006, which came into force in 2007, places the responsibility for registration on manufacturers and importers. They must register with ECHA all substances or mixtures of substances that are manufactured or imported in the EU (ECHA 2023).

If substances are designated as having properties that are carcinogenic, mutagenic or toxic to reproduction (CMR) based on the registration data or further exploration, or if they are identified as PBTs or very persistent and very bioaccumulative (vPvB), then they are included in the REACH candidate list as substances of very high concern (SVHCs) (BAuA 2023c). Substances on the candidate list may continue to be manufactured, used and placed on the market. However, there are additional obligations regarding information and notification. Substances on the candidate list may be included in Annex XIV, the authorisation list, with the participation of ECHA, the EC and the Member States. Manufacturers must then apply for authorisation for certain uses, without which they are no longer allowed to place the substances on the market or use them.

For substances that pose an unreasonable risk to human health or the environment, REACH makes it possible to restrict or even ban their manufacture, placement on the market and use. For this purpose, a risk assessment, as well as a socio-economic analysis, is carried out. Substances can then in principle be restricted for specific applications, but with exceptions, or banned completely. These substances and their restrictions are listed in Annex XVII to the REACH Regulation, which is an important database for the PIC Regulation (BAuA 2023c; ECHA 2023k; BAuA 2023a).

2.4 PIC Regulation

With the Rotterdam Convention entering into force in 2004, the PIC procedure became public international law. Moreover, the convention allows parties to take action that is more stringently protective of human health and the environment than that called for in the PIC procedure. In line with this, the EU decided to include several additional provisions when implementing the convention through the *Prior Informed Consent (PIC) Regulation* within the EU. Germany and the European Community ratified the convention and adopted Regulation (EC) No 649/2012 on the export and

import of hazardous chemicals (BVL 2023); before the PIC Regulation was finally adopted in 2012, Regulation (EC) No 304/2003 was applied temporarily.

At the core of the regulation are two annexes with different parts listing the chemicals it regulates. Annex I Part 3 includes all chemicals listed under Annex III to the Rotterdam Convention and Annex I Part 2 lists the chemicals on the Rotterdam candidate list. For these, export notifications from exporters and the explicit consent of importing countries are required. In addition, Annex I Part 1 includes all chemicals that are already banned or restricted in the EU by other directives or regulations, for example under the REACH Regulation or the Classification, Labelling and Packaging (CLP) Regulation (EC) No 1272/2008. For these, the scope of the PIC Regulation goes beyond the Rotterdam Convention's requirements and is extended by more than 200 substances. As imposed by the EU itself, export notifications must also be prepared for these additional substances. The requirements for the respective substances apply regardless of whether the importing country is part of the Rotterdam Convention. However, for these extra chemicals in Annex I Part 1 to the PIC Regulation, there is no requirement to request explicit consent, and the export notification only provides information about the risks and consequent restrictions of a substance for the EU market. Export of additional chemicals is still allowed for all purposes, regardless of the EU restrictions or the will of the importing party. The importing party must only be provided with an export notification that includes the required information. Accordingly, the substances may only be produced for export, not for the domestic market (ECHA 2023g).

The PIC Regulation is determined not only by the Rotterdam Convention and the REACH Regulation but also by the Stockholm Convention. POPs, mainly banned under the Stockholm Convention, are listed in Annex V to the PIC Regulation. As the POPs Regulation is more far-reaching and bans the manufacture of such substances, they are not subject to any further requirements under PIC.

All relevant regulations and directives, the jurisdiction of their annexes and all relevant dependencies can be understood from Table 1.

Table 1: Annexes of conventions and regulations regarding hazardous substances in the EU

Annex	Subject of regulation
Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	
Entered into force in 2004	
54 chemicals listed in Annex III: 35 pesticides, 18 industrial chemicals, 1 chemical in both categories	
Annex III List of chemicals subject to the PIC procedure	Chemicals banned or severely restricted for health or environmental reasons by two or more parties and which the Conference of the Parties (COP) has decided to subject to the PIC procedure. ➔ PIC procedure ➔ Decision guidance documents (DGDs)
Stockholm Convention on Persistent Organic Pollutants (POPs)	
Entered into force in 2004	
29 chemicals listed in Annex A or B: 18 pesticides, 14 industrial chemicals, 3 chemicals in both categories	
Annexes A and B	POPs eliminated or severely restricted for production and/or use.
Persistent Organic Pollutants (POPs) Regulation	
First version: Regulation (EC) 850/2004, entered into force in 2004; Revision: Regulation (EU) 2019/1021, entered into force in 2019	
31 chemicals: 29 chemicals listed in Annex I	
Annexes I and II	All chemicals listed in the Stockholm Convention Annexes A and B: substances listed in Annex I are subject to prohibition on manufacturing, placement on the market and use; substances listed in Annex II are subject to restriction.

Annex	Subject of regulation
REACH Regulation – Registration, Evaluation, Authorisation and Restriction of Chemicals	
Regulation (EC) No 1907/2006, entered into force in 2007	
Annex XIV List of substances subject to authorisation	Chemicals whose manufacture, placement on the market or use is subject to authorisation.
Annex XVII List of substances restricted under REACH	Chemicals whose placement on the market or use is restricted for certain purposes.
Prior Informed Consent (PIC) Regulation	
Regulation (EU) No 649/2012, entered into force in 2014	
278 chemicals: 208 pesticides, 59 industrial chemicals, 6 chemicals in both categories	
Annex I: Part 1	Comprises all active substances in pesticides or industrial chemicals that are banned or severely restricted within the EU by other regulations, e.g., Annex XVII to the REACH Regulation. ➔ Export notification procedure
Annex I: Part 2	Chemicals qualified for PIC notification under the Rotterdam Convention. ➔ Export notification procedure ➔ Explicit consent by the importing country
Annex I: Part 3	Chemicals subject to the PIC procedure under the Rotterdam Convention: listed in Annex III to the Rotterdam Convention. ➔ Export notification procedure ➔ Explicit consent by the importing country Except where an import response is published in the PIC circular of the Rotterdam Convention.
Annex V: Part 1	POPs listed in the Stockholm Convention Annexes A and B, which are subject to an export ban.
Annex V: Part 2	Chemicals other than POPs listed in the Stockholm Convention Annexes A and B, which are subject to an export ban.

3 Analysis of export data

Companies producing chemicals in the EU that are regulated under the PIC Regulation and exporting to non-EU countries must notify their respective DNAs of estimated exports and their properties. The actual quantities of chemicals exported must then be reported by the companies in the following year and are forwarded in an aggregated form from the DNAs of all EU Member States to ECHA. ECHA summarises the data at EU level and maintains a database of export and import notifications, which is available to the public online under non-confidential conditions. The export notifications are available to the public with origin, destination, use category and year. Not publicly accessible, however, are data on foreseen use, expected export volume or which exports actually took place. In addition, ECHA publishes the reported exports the following year, including exact tonnages. However, these data are aggregated by different origins, destinations and, in some cases, substances, so as not to allow too precise conclusions to be drawn about trade flows.

With such a high level of confidentiality, it is difficult for the public to identify substance flows and supply chains, especially real numbers of exported goods and their destinations. Under the Environmental Information Act, ECHA is obliged to provide further specific export data on request. In practice, however, this may not be feasible for any large data set, depending on the individual consent of the exporters and the capacities of ECHA.

3.1 Statistics

The annexes to the PIC Regulation currently have 287 entries, of which 59 substances are listed as industrial chemicals. The majority of the 261 substances under PIC are subject to Annex I and the procedure of export notification. A minority of 33 substances under PIC are subject to Annex V, which means they are banned from export completely. Most of the listed "chemicals" cover entire substance groups of similar structure and properties, which are summarised for the annexes under one entry. Thus, the almost 300 chemicals listed under PIC stand for countless more compounds and formulations.

In 2021, exports of chemicals under PIC were reported from 532 companies in 24 EU Member States exporting to more than 125 non-EU countries all over the world. As can be seen in Figure 1, a total of 791,000 tonnes of exports were reported. Even though a higher number of pesticides than industrial chemicals are regulated under the PIC Regulation, up to 70% of the exported volumes (560,000 tonnes in 2021) were industrial chemicals. In the previous reporting years, their share was also high (ECHA 2022).

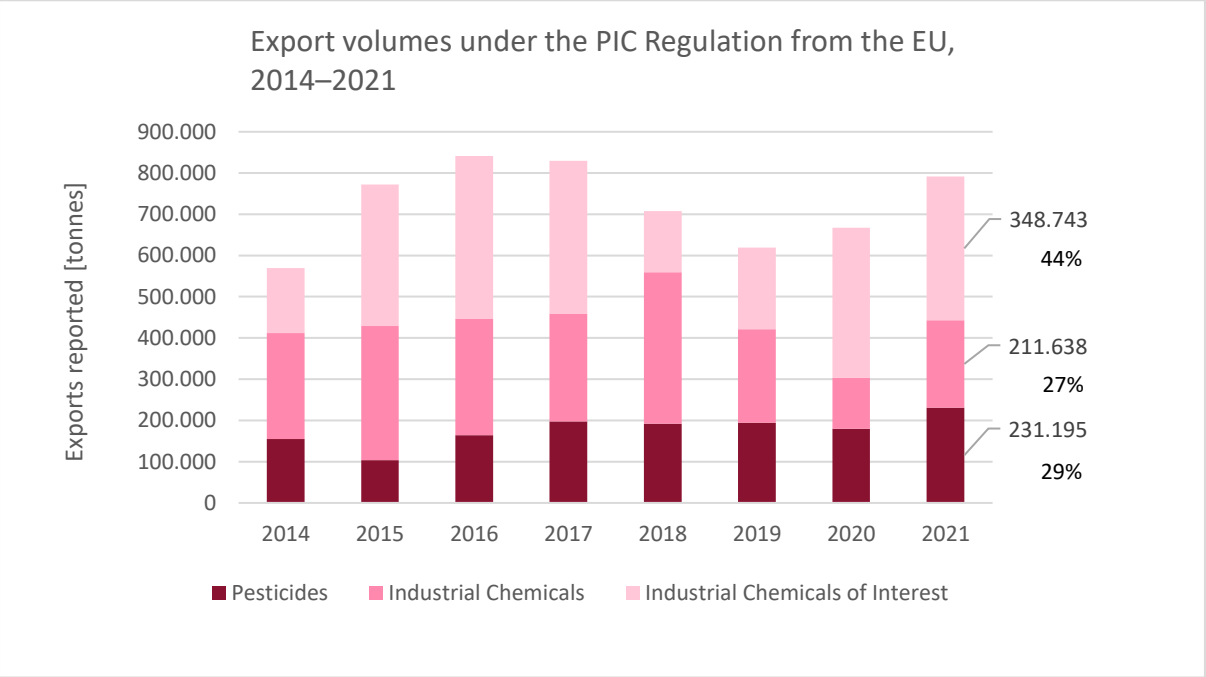


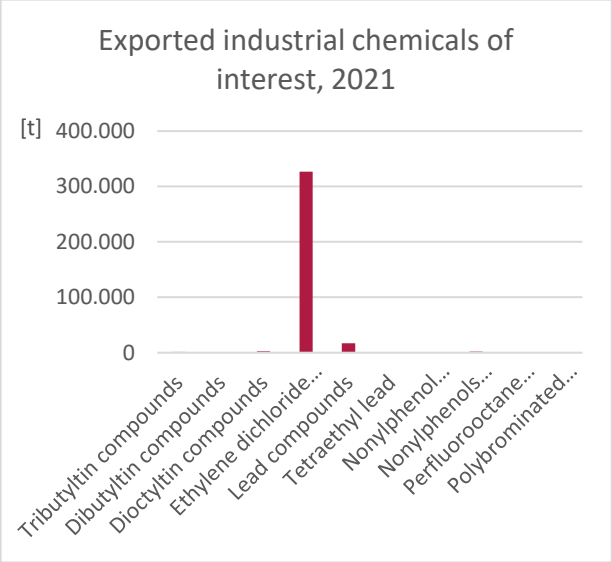
Figure 1: **Analysis based on export volumes reported by companies after exporting chemicals regulated under the PIC Regulation out of the EU. Source: Ökopol analysis by data submitted to ECHA 2015–2022 (ECHA 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023)**

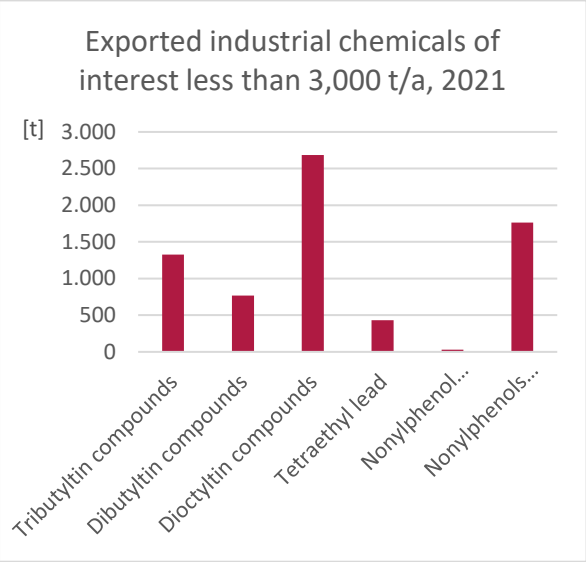
Recently, the reported export volumes and the number of export notifications increased, which is not due solely to a longer list of regulated chemicals. In fact, the reporting system between EU exporters, DNAs and ECHA has improved over time, and the United Kingdom's departure from the EU has also played a crucial role, because exports from EU Member States to the UK now also have to be notified and reported and are included in the weights (ECHA 2022a).

The overall top six exported chemicals related to PIC in 2021 were as follows: 26% ethylene dichloride, 24% benzene, 14% chlorate, 11% creosote and creosote-related substances, 4% carbon tetrachloride and 3% ethylene oxide (others: 18%) (ECHA 2022b). Of these, only ethylene dichloride and ethylene oxide belong to the Rotterdam Convention list of chemicals. The top export substances that the EU has elected to regulate beyond the Rotterdam Convention account for more than half of the total exports.

The top importing countries in 2021 were as follows: 25% UK, 21% Egypt, 16% US, 6% Norway, 4% Japan and 4% Russian Federation (others: 24%). Other top export countries focusing on the industrial chemicals sector included India, Turkey, Switzerland, China and Brazil, among many others.[1] Overall, most industrial chemicals, including those examined below, were exported to at least 10 countries across different regions, often many more. The trade of hazardous industrial chemicals spreads from the EU around the globe (ECHA 2022).

Regarding the substance groups that are of greater interest for this study, it can be seen in figures 2 and 3 that the export quantities of ethylene dichloride are huge. Apart from lead compounds, all other substance exports remained below 3,000 tonnes or even below one tonne.





Figures 2, 3: **Analysis based on export volumes reported by companies after exporting chemicals regulated under the PIC Regulation out of the EU. Source: Ökopol analysis by data submitted to ECHA 2015–2022 (ECHA 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023)**

3.2 Substance groups of interest and their regulatory status

In the last quarter of a century, different conventions and regulations have been enacted to ensure by restriction the safe use of chemicals. It takes time from the passing of a law for it to come into force, and all those introduced in section 2 complement or build on one another. Even after the first successful implementation of each convention or regulation, there remains an ongoing and complex process in which individual substances will be added to it by delegated regulations in the future.

Table 2, which shows the legal regulatory framework of the substance groups, is intended to illustrate which regulations and respective annexes the substance groups of interest for this study are covered by today.

[1] As export volumes are reported in aggregated form, it is neither possible to further specify absolute export volumes for individual countries nor to make a further ranking.

Table 2: Legal regulatory framework of substance groups

Substance (group)	Regulations		Delegated regulations and date of chemicals addition to annexes
Dioctyltin compounds Dibutyltin compounds	REACH	Regulation (EC) No 1907/2006: Entry 20 to Annex XVII	552/2009 22 June 2009
	PIC	Regulation (EU) No 649/2012: Part 1 to Annex I	2229/2015 1 February 2016
Tributyltin compounds	REACH	Regulation (EC) No 1907/2006: Entry 20 to Annex XVII	552/2009 22 June 2009
	Rotterdam	Rotterdam Convention: Annex III	15 September 2017
	PIC	Regulation (EU) No 649/2012: Parts 1+3 to Annex I	330/2019 1 May 2019
Ethylene dichloride (1,2-dichloroethane)	REACH	Regulation (EC) No 1907/2006: Entry 28 to Annex XVII	1907/2006 1 June 2007
	PIC	Regulation (EU) No 649/2012: Part 1 to Annex I	304/2003[2] 7 March 2003
Lead compounds	REACH	Regulation (EC) No 1907/2006: Entry 63 to Annex XVII	1907/2006 22 June 2009
	PIC	Regulation (EU) No 649/2012: Part 1 to Annex I	2220/2015 1 February 2016
Tetraethyl lead	REACH	Regulation (EC) No 1907/2006: Entry 30 to Annex XVII	1907/2006 1 June 2006
	Rotterdam	Rotterdam Convention: Annex III	1 February 2005
	PIC	Regulation (EU) No 649/2012: Parts 1+3 to Annex I	777/2006 23 May 2006
Nonylphenols C6H4(OH)C9H19; nonylphenol ethoxylates (C2H4O)nC15H24O	REACH	Regulation (EC) No 1907/2006: Entry 46 to Annex XVII	1907/2006 1 June 2007
	PIC	Regulation (EU) No 649/2012: Parts 1+2 to Annex I	775/2004 17 May 2004
Polybrominated biphenyls (PBB) except hexabromo-biphenyl	REACH	Regulation (EC) No 1907/2006: Entry 8 to Annex XVII	1907/2006 1 June 2007
	Rotterdam	Rotterdam Convention: Annex III	214/2011 1 May 2011
	PIC	Regulation (EU) No 649/2012: Parts 1+3 to Annex I	649/2012 1 March 2014
Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride	REACH	Regulation (EC) No 1907/2006: Entry 30 to Annex XVII	552/2009 22 June 2009[3]
	POP	Regulation (EU) 2019/1021: Part A to Annex I	757/2010 26 August 2010
	Rotterdam	Rotterdam Convention: Annex III	May 2017
	PIC	Regulation (EU) No 649/2012: Part 1 to Annex V	2022/643 1 July 2022

[2] Where the entry date of a substance is earlier than the entry into force of the PIC or POPs Regulation, this means it was already listed under the respective transitional regulations.
[3] If a substance is included in the Stockholm Convention and thus must be dealt with in EU law by being listed in the POPs Regulation, the substance will be deleted from the REACH Regulation on entry into the POPs Regulation. This excludes double regulation. Due to the differing regulatory areas, this does not apply to the PIC Regulation and REACH.

Substance (group)	Regulations		Delegated regulations and date of chemicals addition to annexes
Perfluorooctane sulfonic acid (PFOS), perfluorooctane sulfonates, perfluorooctane sulfonamides, perfluorooctane sulfonyls[4]	Rotterdam	Rotterdam Convention: Annex III	May 2017[5]
	PIC	Regulation (EU) No 649/2012: Parts 2+3 to Annex I	649/2012 1 March 2014
Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds	REACH	Regulation (EC) No 1907/2006: Entry 68 to Annex XVII	2017/1000 4 July 2017
	POP	Regulation (EU) 2019/1021: Part A to Annex I	2020/784 4 July 2020
	Rotterdam	Rotterdam Convention: Annex III	22 October 2022
	PIC	Regulation (EU) No 649/2012: Parts 1+2 to Annex I	2022/643 1 July 2022

In the following sections, different substance groups are discussed in more detail. In each case, it is shown how toxic they are, what restrictions follow from this and how their export figures have developed throughout PIC reporting from 2014 to 2021.

The figures show the reported export quantities in tonnes, as indicated on the left vertical axis, and the numbers of export notifications issued as a grey line, with units on the right vertical axis. Individual numbers of export notifications do not correspond directly to the quantities exported, since such notifications must be issued regardless of the tonnage exported. Nevertheless, these data indicate how the number of exports has developed over time and may be cross-referenced with the changing regulatory context. Bars in light pink indicate that the export tonnages have been reported aggregated with at least two other substances. This is therefore a maximum value, which may be too high.

3.2.1 Ethylene dichloride (1,2-dichloroethane)

Ethylene dichloride has been the most exported PIC chemical in the recent period. It is mainly used as an intermediate for polymer production of PVC and as a solvent. This substance may cause cancer, is highly flammable as a liquid and a vapour, is harmful if swallowed, causes serious eye irritation and skin irritation and may cause respiratory irritation (ECHA 2023a). It can, for example, lead to organ damage or cause permanent damage to water bodies (UBA 2002). Ethylene dichloride is listed as a pesticide under the Rotterdam Convention and thus under the PIC Regulation (Annex I Part 3). But only a small fraction of the total produced is used for pesticide products. Ethylene dichloride is mainly exported and used as an industrial chemical. It is listed on the REACH Restriction List and thus for use as an industrial chemical under the PIC Regulation (Annex I Part 1). It is restricted to professional users and to certain concentration limits, with derogations, for example for certain medicinal or veterinary products, fuels or artists' paints, each covered by further directives or regulations. From 2017 to 2018, exports shrank by more than 200,000 tonnes, as can be seen in Figure 4. In 2020, however, exports increased again by almost 50% to a reported 262,000 tonnes[6] (ECHA 2021).

[4] These are not regulated as a whole group under REACH.
[5] This relates to decision RC-6/7, regarding inclusion in Annex III, of the 6th COP in May 2017. An exact entry date could not be determined.
[6] Tonnages for the years 2020 and 2021 are reported aggregated with quantities of other substances. Based on the aggregated data, it is unclear to which countries ethylene dichloride was exported, or exported the most.

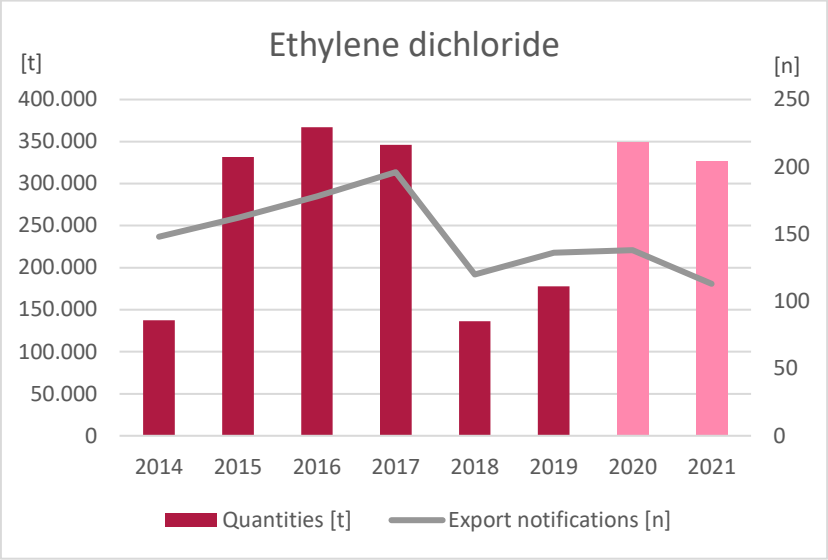


Figure 4: **Analysis based on export volumes reported by companies after exporting chemicals regulated under the PIC Regulation out of the EU. Source: Ökopol analysis by data submitted to ECHA 2015–2022 (ECHA 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023)**

A recently published study by Zou et al. (2023) examined trade data under the PIC procedure. The study concluded that almost half of the Annex III substances traded worldwide from 2004 to 2019 were exported to countries that had explicitly refused to import them. Ethylene dichloride accounted for 55.3 of 64.5 million tonnes of hazardous substances exported during this period, the majority of which were exported from Europe; thus, a large volume of European exports is thought to have undermined global efforts to reduce use of hazardous chemicals. The 2021 data analysed here show that an enormous tonnage of ethylene dichloride is still exported from the EU. However, between 2014 and 2021 only eight export consignments were categorised as pesticides and subject to the PIC procedure. For all export notifications in 2021, ethylene dichloride was categorised as an industrial chemical. This means that, even against the will of the importing country, only an export notification is required for legal import under the Rotterdam Convention.

3.2.2 Nonylphenols and their ethoxylates

Nonylphenols (NPs) are often used for the production of nonylphenol ethoxylates (NPEs), which in turn are mainly used as detergent or as an emulsifying agent in the manufacture of textiles. NP, as a degradation product of NPE, is a hormone toxin. When present in high concentrations, it can prevent male fish from reaching maturity (UBA 2016). It is toxic to aquatic life, causes skin burns and eye damage, is harmful if swallowed and is suspected of damaging fertility or unborn children (ECHA 2023e, 2023d). Therefore, NPE has been severely restricted by REACH in relation to industrial and domestic cleaning, textile processing with release into wastewater and many more applications since 2009. Restrictions on NPE were extended in 2021: as well as NPE being restricted in the processing of textiles, it was no longer permitted to place on the market textiles with NPE that are likely to be washed in water. This EU restriction may have had an impact on the general EU-wide production and its economic viability and therefore may be a cause of the recent sharp decline in NPE exports, which can be seen in Figure 5. Most of the remaining EU exports went from Germany, Poland, Belgium and the Netherlands to Mexico, Russia, the UK, Iran, Taiwan, the United Arab Emirates, Argentina and India.[7]

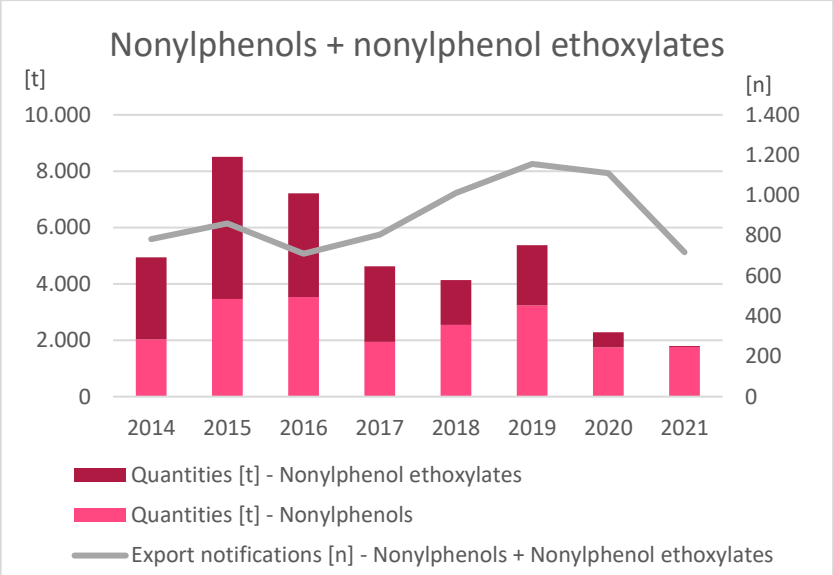


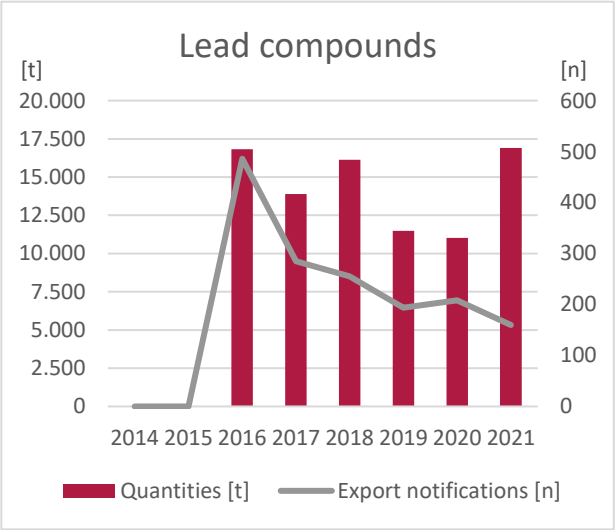
Figure 5: **Analysis based on export volumes reported by companies after exporting chemicals regulated under the PIC Regulation out of the EU. Source: Ökopol analysis by data submitted to ECHA 2015–2022 (ECHA 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023)**

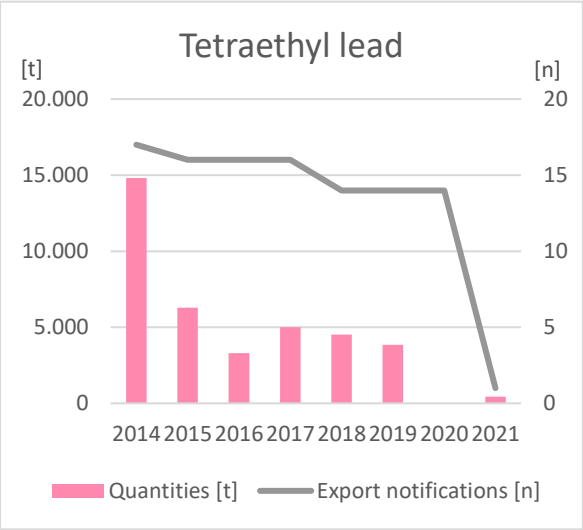
[7] A more precise breakdown of export volumes moved is not possible, as they are only available to the public in an aggregated form.

3.2.3 Lead compounds and tetraethyl lead

Lead is used, among other things, for biocides, plastic additives and wood preservatives. A particularly important lead compound is tetraethyl lead. This is used in anti-knock agents. It is toxic to the extent that it is fatal for humans to swallow or inhale it or to have it in contact with the skin. Tetraethyl lead may damage organs and fertility or unborn children. Furthermore, it is very toxic to aquatic life, with long-lasting effects (ECHA 2023f). A report by UNICEF and Pure Earth states that lead can cause irreparable harm to children's brains, even at low concentrations (UNICEF and Pure Earth 2020).

Lead compounds were included in Annex I to the PIC Regulation in 2016, and since then no discernible trend can be seen in their exports (Figure 6). However, the export of tetraethyl lead (considered separately in Figure 7) has declined drastically. Export of this substance from the EU was already restricted: under Annex III to the Rotterdam Convention since it entered into force, and under Annex XVII to the REACH Regulation since 2006. Use of this substance is restricted to professional users above the concentration limits specified in Part 3 of Annex I to the CLP Regulation. A special derogation applies for use of leaded petrol by collectors of vintage cars. Tetraethyl lead is subject to the authorisation list of REACH and has a sunset date of May 2025. After that, it may only be placed on the European market with explicit approval. Perhaps the declining exports to non-EU countries can also be attributed to the restrictions of the EU market: these can prompt EU manufacturers to switch to production of alternative substances or simply make production uneconomical due to lower demand. Even though tetraethyl lead is exported very little now, Germany, France, Spain and Belgium exported 13,000 tonnes of other lead compounds to a group of 16 countries from all continents in 2021.

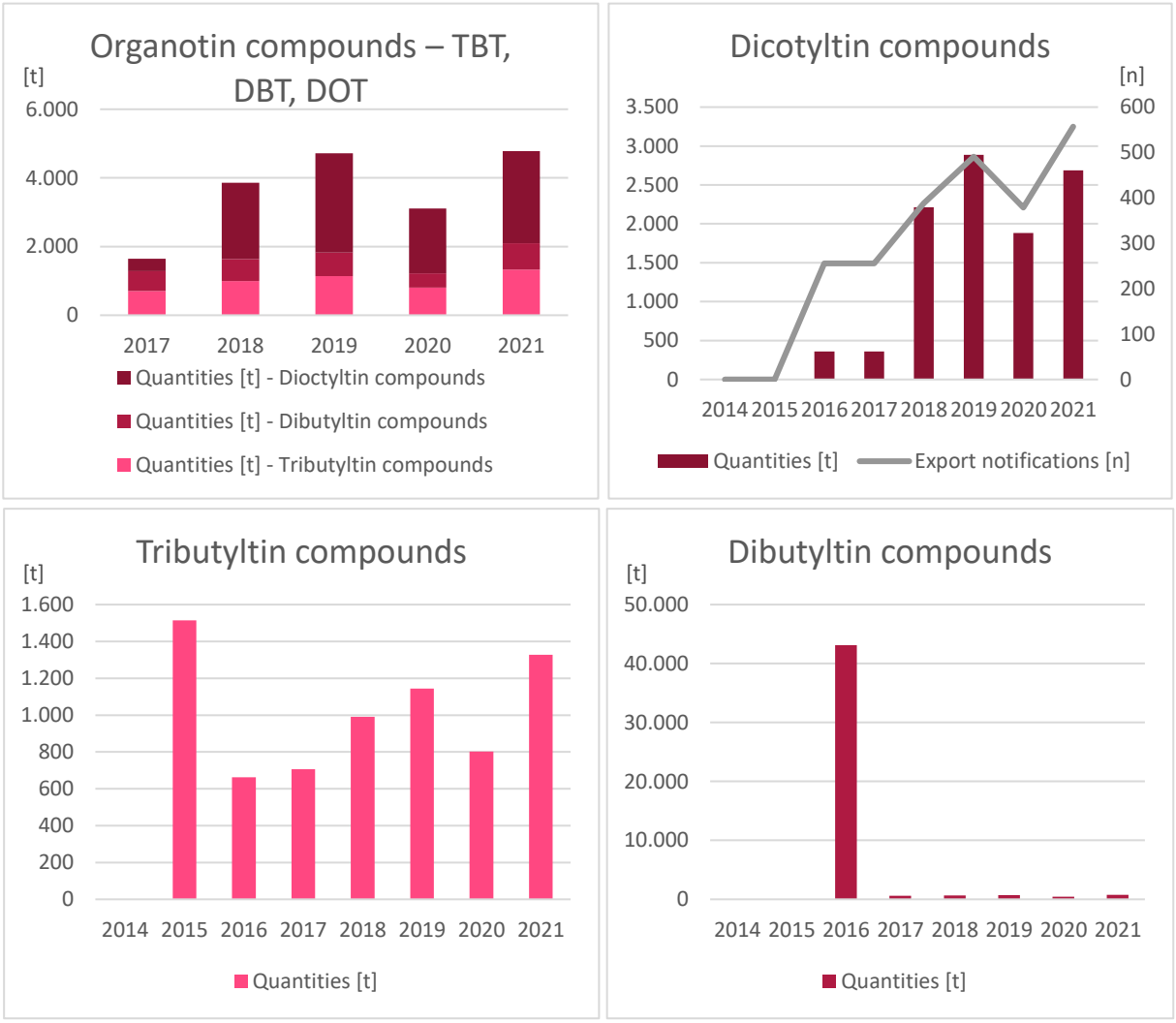




Figures 6, 7: **Analysis based on export volumes reported by companies after exporting chemicals regulated under the PIC Regulation out of the EU. Source: Ökopol analysis by data submitted to ECHA 2015–2022 (ECHA 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023)**

3.2.4 Organotin compounds: Dioctyltin, dibutyltin and tributyltin compounds

Organotin compounds (OTCs) are widely used as additives in plastic materials and as biocides in wood preservatives, marine biocides and industrial wet processes. They persist in the environment, with long-lasting toxic effects to aquatic life such as reproductive disorders in fish, mussels and marine gastropods (UBA 2023; HLNUG 2004). Serious effects on human health include, among others, organ damage, genetic defects and skin irritation (ECHA 2023c). Therefore, three OTCs – dioctyltin (DOT), dibutyltin (DBT) and tributyltin (TBT) – are regulated under REACH and the PIC Regulation. TBT is also included in Annex III to the Rotterdam Convention. No trends in export development can be identified from the data in figures 8 to 11. The export quantities of TBT and DOT per year are in a four-digit tonne range, and DBT has been in a three-digit tonne range since 2017.



Figures 8, 9, 10, 11: **Analysis based on export volumes reported by companies after exporting chemicals regulated under the PIC Regulation out of the EU. Source: Ökopol analysis by data submitted to ECHA 2015–2022 (ECHA 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023)**

3.2.5 Flame retardants: Polybrominated biphenyls

Polybrominated biphenyls (PBBs) are used as flame retardants and as plastics softeners but they are hazardous to the environment. As they are slow to degrade, PBBs are toxic to aquatic life, with long-lasting effects. Also, PBBs cause serious eye, skin and respiratory irritation to humans (ECHA 2023b). Flame retardants such as PBBs leach into the environment and contaminate air, soil and water. This then leads to contamination of the food chain, mainly animal-based products (EFSA 2023).

As they are listed in Annex III to the Rotterdam Convention, PBBs are also included in Annex 1 Part 3 to the PIC Regulation. Furthermore, the PBB hexabromobiphenyl is listed as a POP and subject to the Stockholm Convention. Therefore, it is completely excluded from export and listed in Annex V Part 1 to the PIC Regulation. The PIC Regulation does not require export notifications to be issued for chemicals listed in Annex I Part 3 if explicit consent has already been given by an importing party. Nevertheless, in recent years export volumes have remained in a negligible single-digit tonne range (Figure 12). In 2021, around half a tonne of PBB was exported from Germany to the USA to produce rodenticide, mice and rat poison.[8]

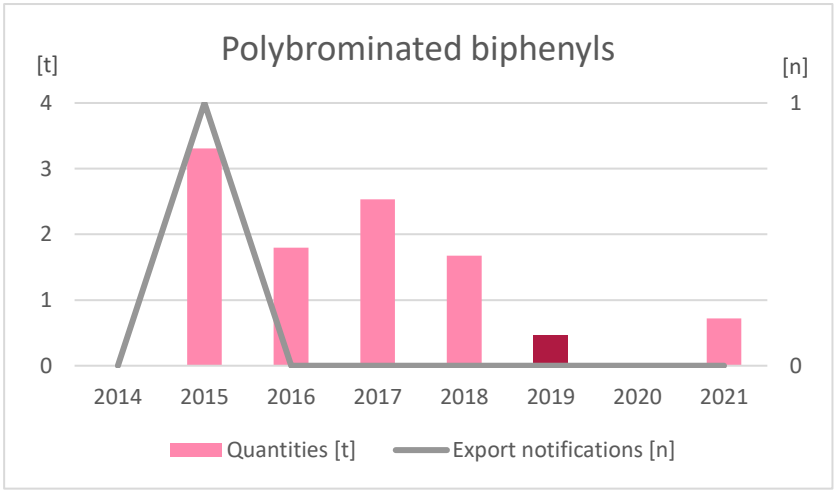


Figure 12: **Analysis based on export volumes reported by companies after exporting chemicals regulated under the PIC Regulation out of the EU. Source: Ökopol analysis by data submitted to ECHA 2015–2022 (ECHA 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023)**

3.2.6 Per- and polyfluoroalkyl substances

Per- and polyfluoroalkyl substances (PFASs) are POPs and are mainly used to impregnate materials to make them grease-, oil- and water-resistant. PFASs are bioaccumulative and toxic, an outcome that is occasionally associated with contamination of drinking water (LANUV 2023). The detection of PFASs in the human body has been linked to concentration difficulties, weakened immune systems in children and thyroid disorders and fertility problems in adults (BfR 2023).

Some PFASs are regulated by the Stockholm Convention, listed in Part A of Annex I to Regulation (EU) No 2019/1021. It follows that these perfluorooctane sulfonic acids (PFOSs) and perfluorooctanoic acids (PFOAs) were added to the list of chemicals in Part 1 of Annex V to the PIC Regulation. Because of this, they are banned from export to non-EU countries. In line with this, no exports of PFOSs or PFOAs have been reported since 2015. Meanwhile, the substance group of PFOSs, perfluorooctane sulfonates,

[8] This information is based on export notifications issued by exporting companies and submitted to ECHA, 2021.

perfluorooctane sulfonamides and perfluorooctane sulfonyls is not subject to the POPs Regulation but is included in Annex I Parts 1 and 3 to the PIC Regulation, and even when restricted may still be exported.

After two years with exports of less than 5 tonnes (2015 and 2016) (ECHA 2016), the latest reported numbers have remained below 100 kg per year (ECHA 2018, 2019, 2020, 2021, 2022b). For 2021, no exports of PFOSs, perfluorooctane sulfonates, perfluorooctane sulfonamides or perfluorooctane sulfonyls were reported, and notifications regarding exports of these substances and of PFOAs to China and Singapore are currently submitted by German companies in a very few individual cases of use for surfactants and in the electronics industry.[9]

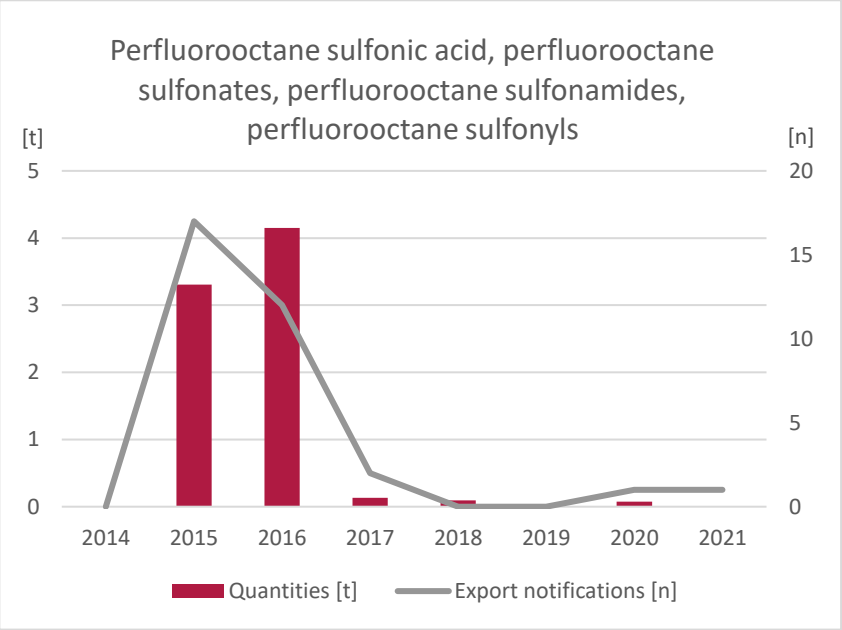


Figure 13: **Analysis based on export volumes reported by companies after exporting chemicals regulated under the PIC Regulation out of the EU. Source: Ökopol analysis by data submitted to ECHA 2015–2022 (ECHA 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022b, 2023)**

3.3 Discussion

Based on the available data analysed in this study, no significant export flows can be identified that do not legally comply with the PIC and POPs regulations. With regard to different regulatory stringencies between the use categories of the same substance, these data cannot confirm the accusation of Zou et al. (2023) that almost half of the chemicals subject to Annex III to the Rotterdam Convention were illegally exported against the will of the importing countries

Nonetheless, it is interesting that non-EU countries generally make use of their right to refuse imports under the Rotterdam Convention and would possibly do so for further substances and use categories. Yet there is nonetheless a gap in the European legal framework as it does not restrict substances for export as strictly as it does those for the European market by, for example, REACH. This is even more interesting when considering that three EU countries – Germany, the Netherlands and Belgium – stand behind China and the USA to form the top five countries for chemical exports (excluding pharmaceuticals). The EU had a foreign trade balance, including all

[9] This information is based on export notifications issued by exporting companies and submitted to ECHA, 2021–2023.

chemical products (but excluding pharmaceuticals), of €35 billion in 2020. Of the rest of the world, only Asia still had a positive balance (of at least 1.6 billion euros). Africa and Latin America, on the other hand, had foreign trade balances of -€25 billion and -€69 billion respectively (VCI 2022). Yet it is in precisely these regions that chemical management is often weaker, and humans and the environment are less protected from the risk and impact of toxic substances. The European chemical industry focuses on the export of chemicals, without handling them as strictly as if they were on the European market.

Compared to the total 279 million tonnes of industrial chemicals produced in the EU in 2021, the share of exported chemicals regulated under PIC is rather small. And also, quantities of illegally exported pesticides, such as the much-discussed neonicotinoids – bee poison – are much higher than those of most of the substance groups examined in this study. Nevertheless, each of these industrial chemicals is subject to restrictions because of its potentially serious consequences for human health and the environment, and this applies to all quantities of substances, even if they are lower.

4 Effects and pathways of exported chemicals

Although most of the chemicals under consideration are not currently exported in huge quantities to non-EU countries, each chemical has its risks, because of which it is restricted or banned altogether for the EU market. And even though PIC and exchange of DGDs are intended to ensure that all countries have the same level of knowledge about chemicals and their risks to human health and the environment, it is questionable how much this helps in countries whose own regulations are not yet as far-reaching as, for example, those of Europe. In the following sections, two of the groups of substances are examined in more detail to determine the possible consequences of their export from the EU to non-EU countries – consequences for the countries, their people and the local environments. Also examined are the risks and consequences entailed in turn for the EU and its Member States, which no longer produce the substance groups for their own purposes but only trade them across borders.

4.1 Case study: Nonylphenols and nonylphenol ethoxylates

NPs and NPEs are subject to the PIC Regulation but treated differently by the REACH Regulation. Since 2009, NPEs and NPs have been severely restricted by REACH regarding industrial and domestic cleaning, textile processing with release into wastewater and many more purposes. The restriction of NPEs was extended in 2021: as well as restrictions being applied in relation to the processing of textiles, it is no longer permitted to place on the market textiles that contain NPEs and are likely to be washed in water (ECHA 2023h). The substances are removed from contaminated textiles after several washes. However, they then enter the environment via wastewater and have therefore also been detected in food (Wolff 2007). The EU classifies the chemical as a PBT as well as endocrine-disrupting (ECHA 2023d). Since 2013, NPEs have been included in the REACH candidate list as substances of very high concern and may only be used with authorisation. Authorisation applies only for spare parts and repair of products that came onto the market before the application restriction. NPs are so far less restricted and only included in the candidate list for authorisation. But it is still not permitted to place them on the EU market for the purposes stated above. And yet both substances are exported from the EU to non-EU countries. In 2021, more than 1,700 tonnes of NPs were exported to 57 non-EU countries. The countries with the highest imports from the EU included Russia, Mexico, the UK and Switzerland, but also Taiwan, USA, India and Turkey. The export of NPEs was kept to 28 tonnes in total (ECHA 2022b).

However, despite the earlier domestic EU restrictions on NPEs and NPs, concentrations continued to be measured in water bodies and the air in the EU. Various studies by Greenpeace International and

the UK Environment Agency investigated the chemical contamination of clothing imported to the EU. Of the garments sampled, between one and two thirds had NPE concentrations in the range of concern, which can be related to the concentrations of the environmental compartments. Garments that tested positive had been produced in countries including India, Mexico, Egypt, China and Turkey (Greenpeace International 2012; Greenpeace International 2015; EA UK 2013). These are all countries to which the EU itself exports NPs and NPEs. To address the problem of NP contamination locally, the import of textile articles contaminated with NP into the EU was banned in 2021. And indeed, measured concentrations of NP in the EU have decreased over the last 10 years (Ringbeck et al. 2022).

The question remains, however, of what the situation is like on the other side – that is, in countries that import NPs and NPEs. In 2021, an Indian study carried out a detailed assessment of the presence of NPs in detergent as well as in river water samples in India. In recent years, India has consumed about 40,000 to 60,000 tonnes of NPEs a year. Of this, more than 3,000 tonnes was imported between 2018 and 2019, mainly from Taiwan and Korea but also from the EU (Mohapatra and Gaonkar 2021). The EU in turn exported NPs and NPEs not only to India but also to Taiwan and Korea (ECHA 2022b).

The study by Mohapatra and Gaonkar (2021) revealed that the chemical is widely used in detergents, and a high NP concentration was found in river water. The highest concentration of NPs was detected in Bandi River (41.27 ppm) in Pali, Rajasthan, which is a known textile hub, indicating excessive use of NPs in the textile industries. India already bans the use of NPs in cosmetics but does not regulate other uses (such as use in surfactants or other consumer products or in manufacturing), as the EU itself does (Mohapatra and Gaonkar 2021). Thus, exports from the EU promote the presence of NPs, and increase both environmental and health impacts of this substance, in India. And the EU's actions also increase the quantities in which NPs are present in the EU, as NPs can be transported a long distance, for example through the air or via the contaminated textiles that are still imported.

4.2 Case study: Organotin compounds

OTCs are among the most widely used organometallic compounds (compounds containing organic groups bound to metal) for agricultural, industrial and biomedicinal applications. They are widely used as polyvinyl chloride (PVC) stabilisers, biocides or anti-fouling (AF) paints. Organotin contamination has been reported in textiles, food and potable water subject to industrial effluents, and via leaching from PVC water pipes (Button 2022; Shaikh et al. 2019). OTCs that are widely restricted in the EU under REACH Annex XVII and regulated for export under the PIC Regulation Annex I are DOT compounds, DBT compounds and TBT compounds.

TBT has been used in AF paints on ship hulls since the 1960s to prevent organisms from attaching to the hull and hindering navigation (Dai et al. 2022). Due to the high toxicity of TBT, and its degradation products such as DBT, to non-target species, in 2001 the International Maritime Organization (IMO) adopted the *International Convention on the Control of Harmful Anti-Fouling Systems on Ships (AFS)*. The convention proposed a global ban on TBT, which was enforced for all ships from September 2008. Today, more than 80 parties have signed and ratified the convention, representing more than 90% of the gross tonnage of the world's merchant fleet (IMO 2023a, 2023b). But contamination by TBT and its degradation products has still been detected, representing a serious environmental issue in coastal areas affected by maritime activities, such as in Asia, Europe, Africa and South America (Dai et al. 2022). The degradation processes of TBT are slow but concentrations are nonetheless decreasing. Much of the TBT contamination in water transport hotspots such as ports and coasts is attributed to contamination from AF paints that occurred before the major ban (Abreu et al. 2020).

Nevertheless, AF paints containing TBT as an active ingredient are still being registered for commercialisation. Although the identification of active registrations does not by itself guarantee that

the paints are actually being produced and used, these products do seem to be available in some markets. The commercialisation and use of TBT-based paints still seem to be among the main current sources of fresh inputs to the aquatic environment. By hosting these markets, some of the signatory countries of the Rotterdam and AFS conventions in the Caribbean (e.g., Mexico, Saint Martin, French St Martin, St Lucia and Grenada, where these paints are still marketed) are indirectly in disagreement with global initiatives seeking to reduce TBT impacts worldwide. In addition, this trading of TBT-based AF paints is likely to produce more cause for alarm in countries with no or poor implementation of national or international restrictions. Even though the EU has not recently exported TBT directly to these countries, these substances have been exported to the USA, where products for the AF paints market are manufactured (ECHA 2022; Paz-Villarraga et al. 2022). And with every product, the occurrence of hazardous substances is promoted, no matter how long the downstream value chain is.

5 Corporate Sustainability Due Diligence Directive

Companies in the EU trade with business partners all over the world. This results in long, often complex supply chains, which companies have so far felt little incentive to supervise. This is set to change with a European supply chain law, the *Corporate Sustainability Due Diligence Directive (CSDDD)* (BMUV 2023). The directive will stipulate due diligence obligations on both EU-based companies and those companies that generate a significant share of their turnover within the EU with regard to their value chains. The directive's objective is to combat child labour, slavery and labour exploitation as well as environmental pollution and degradation (European Commission (EC) 23.02.2022). An important step in the due diligence process is to map, assess and mitigate the impact of value chain partners on these areas. It is important to note that these are not only suppliers of imported goods in so-called upstream value chains: downstream value chains out of the EU should also be included if the production origin is in the EU and subsequent use, recovery or disposal takes place outside the EU (Denter et al. 2023).

Currently, the CSDDD is in trialogue. Regarding the focus of this study – the export of hazardous substances and its regulation – the positions by the EC, Council, and Parliament each offer a different material scope. The EC and the EU Council both include provisions from the Stockholm Convention and the Rotterdam Convention. However, within the framework of the Rotterdam Convention, the EC refers to a ban on only the import of Annex III chemicals of the Convention under the PIC procedure, not on exports, as the EU Council does. Concerning section 2, it must be added that there are no general bans on imports or exports of individual substances under the PIC procedure. However, individual Member States can decide against imports of hazardous substances. Nevertheless, it is noteworthy that the EU Council refers to both the import and export of chemicals under Annex III to the Rotterdam Convention. Whereas the EC refers to the value chain as a whole, consisting of upstream and downstream elements, the Council's position weakens the "value chain" to a "chain of activities", which on the downstream side covers only distribution, transport, storage and disposal of the product, not its use (see article 3 (g)). The European Parliament, on the other hand, is following the EC's approach. However, it proposed a deletion of the reference to the Rotterdam Convention's PIC procedure and refers only to a ban on POPs under the Stockholm Convention.

Despite the current proposals, and even if the entire value chain were covered and both the Stockholm and Rotterdam Conventions were included, the level of protection of these due diligence obligations would still be very low. This is because, as discussed in section 2 regarding gaps in EU regulation, both conventions only cover a fraction of possible hazardous substances, and the Rotterdam Convention only includes an information obligation. This information obligation in the form of export notifications completely ignores other requirements, such as those that apply in the EU under REACH. As further explained in section 2.3, REACH requires that all substances be registered by companies from the

outset and assessed for potential hazards before they can be placed on the market, and that these are restricted for certain applications or authorised only for explicit applications, depending on their hazard potential. These requirements could be incorporated into equivalent due diligence requirements in the CSDDD. Companies would then have to ensure that sufficient protective measures were listed with the risk information, in terms of both the environment and health, and try to ensure that these measures were implemented. These are measures against exposure to pollutants in the air, water and soil or resulting health risks, as defined under REACH; they also include occupational health and safety measures, such as provision of personal protective equipment or comprehensive training and information on health hazards for workers.

Regardless of the extent to which hazardous substances are covered by the CSDDD, regulation must apply equally upstream and downstream in the value chain. Upstream or downstream, the environmental and health-related effects remain the same. Exported hazardous substances are highly relevant for the EU population in terms of environmental due diligence: these substances may return to the EU via re-imports or enter the EU via transport through the environment by air or water. Also, harming the global ecosystem outside the EU affects the EU population.

6 Conclusion

This study shows that a complex regulatory framework for hazardous substances is already in place in the EU. However, there are still large gaps in this system in relation to exports from the EU to non-EU countries. First, the number of hazardous substances listed under the strict Stockholm Convention and the corresponding POPs Regulation (EU) No 2019/1021 is very small and requires cumbersome political discussions for each addition. Second, although the PIC Regulation (EU) No 649/2012 covers a larger number of hazardous substances, for the substances going beyond the Rotterdam Convention the PIC Regulation only requires producing companies to inform exporting companies and countries about their hazards. In principle, companies can still legally export hazardous substances, even though they are subject to strong application-related regulations in the EU, without identifying what the export substances are used for in the importing countries or ensuring that protective measures are implemented for the known risks.

This study has shown that export volumes may be reduced by reference to intra-EU regulations and bans. However, an absolute export ban on all harmful chemicals listed under PIC is not realistically feasible. In the EU, many chemicals have exemptions under REACH through which their use within the EU is still allowed. There is therefore a need for a ban on exports for these uses. These uses would include, for example, the export of NPEs and its ethoxylates for the textiles industry, among others. Many countries to which various pollutants continue to be exported have weaker chemical management practices, putting workers, users and the environment at risk. Harmful chemicals restricted in the EU should only be exported when the exporting company can guarantee that all risk measures are in place, instead of only giving risk information, as risks and damage do not stop at the EU border. The case studies on NPs, NPEs and OTCs show that the chemicals market causes further hazard exposure for the environment and humans – globally, but also leading back to the EU – and that EU exports contribute to this.

Producers must monitor their entire downstream value chain and ensure protective measures, just as they are obliged to do within the EU. This applies equally to the further development of the PIC Regulation and the development of the CSDDD.

Publication bibliography

Abreu, Fiamma; Da Lima Silva, Juliane Natália; Castro, Ítalo Braga; Fillmann, Gilberto (2020): Are antifouling residues a matter of concern in the largest South American port? In *Journal of hazardous materials* 398, p. 122937. DOI: 10.1016/j.jhazmat.2020.122937.

Association of the German Chemical Industry (VCI) (2022): Chemiemärkte Weltweit. Umatz, Verbrauch, Handel und Investitionen. Frankfurt am Main, Deutschland. Available online at https://www.vci.de/services/publikationen/broschueren-faltblaetter/chemiewirtschaft-in-zahlen.jsp, retrieved on 19.07.2023.

Button, Jenny (2022): Investigating the Environmental Impact of Organotins. In *Column* 18 (11), pp. 14–18. Available online at https://www.chromatographyonline.com/view/investigating-the-environmental-impact-of-organotins.

Dai, Qi; Chen, Ling; Li, Pan; Xia, Shengji; Wang, Yanyan; Huang, Qinghui (2022): Occurrence and risk assessment of organotin compounds in the surface water of the upper Yangtze River Estuary. In *Front. Environ. Sci.* 10, Article 964486. DOI: 10.3389/fenvs.2022.964486.

Denter, Luisa; Jungus, Charlotte; Vervynckt, Mathieu; Wilde-Ramsing, Joseph (2023): Downstream due diligence. A must-have for the EU's Corporate Sustainability Due Diligence Directive. Germanwatch e.V. Available online at https://www.germanwatch.org/en/87962, retrieved on 19.07.2023.

Environmental Agency Germany (UBA) (2002): Integrierte Vermeidung und Verminderung der Umweltverschmutzung (IVU). Referenzdokument über die besten verfügbaren Techniken für die Herstellung organischer Grundchemikalien. Available online at https://www.umweltbundesamt.de/sites/default/files/medien/419/dokumente/bvt_organische-grundchemikalien_vv.pdf, retrieved on 23.07.2023.

Environmental Agency Germany (UBA) (2016): Nonylphenol und seine Ethoxylate. Available online at https://www.umweltbundesamt.de/nonylphenol-seine-ethoxylate, retrieved on 24.07.2023.

Environmental Agency Germany (UBA) (2020): Kinder und Jugendliche haben zu viel PFAS im Blut. Available online at https://www.umweltbundesamt.de/presse/pressemitteilungen/kinder-jugendliche-haben-zu-viel-pfas-im-blut, updated on 06.07.2020, retrieved on 23.07.2023.

Environmental Agency Germany (UBA) (2023): Seeschifffahrt. Available online at https://www.umweltbundesamt.de/themen/wasser/gewaesser/meere/nutzung-belastungen/schifffahrt#bewuchsschutzsysteme-antifouling, retrieved on 20.07.2023.

Environment Agency UK (EA UK) (2013): Nonylphenol ethoxylates (NPE) in imported textiles. With assistance of Chemical Compliance Team. Sheffield, UK.

European Chemical Agency (ECHA) (2014): Guidance for implementation of Regulation (EU) No 649/2012 concerning the export and import of hazardous chemicals.

European Chemical Agency (ECHA) (2016): Report on exports and imports in 2015 of chemicals listed in Annex I to the Prior Informed Consent (PIC) Regulation.

European Chemical Agency (ECHA) (2018): Report on exports and imports in 2017 of chemicals listed in Annex I to the Prior Informed Consent (PIC) Regulation.

European Chemical Agency (ECHA) (2019): Report on exports and imports in 2018 of chemicals listed in Annex I to the Prior Informed Consent (PIC) Regulation.

European Chemical Agency (ECHA) (2020): Report on exports and imports in 2019 of chemicals listed in Annex I to the Prior Informed Consent (PIC) Regulation.

European Chemical Agency (ECHA) (2021): Report on exports and imports in 2020 of chemicals listed in Annex I to the Prior Informed Consent (PIC) Regulation.

European Chemical Agency (ECHA) (2022a): Reported trade of hazardous chemicals increased following Brexit. ECHA/NR/22/21 (All news). Available online at https://echa.europa.eu/de/-/reported-trade-of-hazardous-chemicals-increased-following-brexit, retrieved on 05.07.2023.

European Chemical Agency (ECHA) (2022b): Report on exports and imports in 2021 of chemicals listed in Annex I to the Prior Informed Consent (PIC) Regulation.

European Chemical Agency (ECHA) (2023a): Brief Profile: 1,2-dichloroethane. Available online at https://echa.europa.eu/de/brief-profile/-/briefprofile/100.003.145, updated on 18.07.2023, retrieved on 28.07.2023.

European Chemical Agency (ECHA) (2023b): Brief Profile: 2-(4-Phenylbenzoyl)benzoic acid. Available online at https://echa.europa.eu/de/brief-profile/-/briefprofile/100.223.653, updated on 23.05.2023, retrieved on 28.07.2023.

European Chemical Agency (ECHA) (2023c): Brief Profile: Bis(tributyltin) oxide. Available online at https://echa.europa.eu/de/brief-profile/-/briefprofile/100.000.244, updated on 16.06.2023, retrieved on 28.07.2023.

European Chemical Agency (ECHA) (2023d): Brief Profile: Nonylphenol, ethoxylated. Available online at https://echa.europa.eu/de/brief-profile/-/briefprofile/100.105.533, updated on 18.03.2023, retrieved on 28.07.2023.

European Chemical Agency (ECHA) (2023e): Brief Profile: Phenol, 4-nonyl-, branched. Available online at https://echa.europa.eu/de/brief-profile/-/briefprofile/100.076.631, updated on 20.07.2023, retrieved on 28.07.2023.

European Chemical Agency (ECHA) (2023f): Brief Profile: Tetraethyllead. Available online at https://echa.europa.eu/de/brief-profile/-/briefprofile/100.000.979, updated on 04.07.2023, retrieved on 28.07.2023.

European Chemical Agency (ECHA) (2023g): PIC. Available online at https://echa.europa.eu/regulations/prior-informed-consent/, retrieved on 28.06.23.

European Chemical Agency (ECHA) (2023h): PIC Factsheet: Nonylphenol ethoxylates (C2H4O)nC15H24O. Available online at https://echa.europa.eu/de/pic-factsheet/-/pic-detail/100.239.200, retrieved on 28.07.2023.

European Chemical Agency (ECHA) (2023i): Understanding REACH. Available online at https://echa.europa.eu/regulations/reach/understanding-reach, retrieved on 03.06.2023.

European Chemical Agency (ECHA) (2023j): Annual reporting on PIC exports and imports. Reports on PIC chemicals exported and imported under Regulation 649/2012. Available online at https://echa.europa.eu/regulations/prior-informed-consent/annual-reporting-on-pic-exports-and-imports, updated on 27.06.2023, retrieved on 27.06.2023.

European Chemical Agency (ECHA) (2023k): Understanding REACH. Available online at https://echa.europa.eu/regulations/reach/understanding-reach, updated on 18.07.2023, retrieved on 18.07.2023.

European Food Safety Authority (EFSA) (2023): Brominated flame retardants. Available online at https://www.efsa.europa.eu/en/topics/topic/brominated-flame-retardants, retrieved on 24.07.2023.

European Parliament (EP) (2023): Quellen und Geltungsbereich des Rechts der Europäischen Union | Kurzdarstellungen zur Europäischen Union | Europäisches Parlament. Available online at

https://www.europarl.europa.eu/factsheets/de/sheet/6/quellen-und-geltungsbereich-des-rechts-der-europaischen-union, retrieved on 18.07.2023.

European Parliament (EP) (01.06.2023): Unternehmen sollen Menschenrechte und Umweltnormen in Lieferketten berücksichtigen. Available online at https://www.europarl.europa.eu/news/de/press-room/20230524IPR91907/lieferketten-unternehmen-sollen-menschenrechte-und-umweltnormen-berucksichtigen, retrieved on 05.07.2023.

Eurostat (2022): Production and consumption of chemicals up in 2021. Available online at https://ec.europa.eu/eurostat/de/web/products-eurostat-news/-/DDN-20221216-3, retrieved on 30.06.2023.

Federal Agency for Civil Education (bpb) (2021): Völkerrecht. Available online at https://www.bpb.de/kurz-knapp/lexika/politiklexikon/18430/voelkerrecht/, updated on 06.10.2021, retrieved on 18.07.2023.

Federal Institute for Occupational Safety and Health (BAuA) (2023a): Beschränkungsverfahren. helpdesk reach-clp-biozid. Available online at https://www.reach-clp-biozid-helpdesk.de/DE/REACH/Verfahren/Beschraenkungsverfahren/Beschraenkungsverfahren_node.html, retrieved on 19.07.2023.

Federal Institute for Occupational Safety and Health (BAuA) (2023b): POP. Available online at https://www.baua.de/DE/Themen/Anwendungssichere-Chemikalien-und-Produkte/Chemikalienrecht/POP/POP_node.html, retrieved on 19.07.2023.

Federal Institute for Occupational Safety and Health (BAuA) (2023c): REACH – Die REACH-Verordnung. Available online at https://www.baua.de/DE/Themen/Anwendungssichere-Chemikalien-und-Produkte/Chemikalienrecht/REACH/REACH.html, retrieved on 18.07.2023.

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety (Ed.) (2012): Development of a List of Potential POP Candidates for the Stockholm Convention and Refinement of the POP Criteria. Which Strategy is to be Adopted for a Successful Identification of potential POP candidates? Öko-Institut e.V.; Institut für Chemie- und Biowissenschaften ETH Zürich (ICH).

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (2023a): POPs – (Persistent organic pollutants). Federal Ministry for the Environment, Nature Conservation Nuclear Safety and Consumer Protection (BMUV). Available online at https://www.bmuv.de/themen/gesundheit-chemikalien/chemikalien/pops, updated on 26.05.2023, retrieved on 17.07.2023.

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) (2021): Rotterdamer Übereinkommen. Available online at https://www.bmuv.de/themen/gesundheit-chemikalien/chemikalien/rotterdamer-uebereinkommen-pic, updated on 21.06.2021, retrieved on 28.06.2023.

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) (2023b): Europäische Lieferkettenrichtlinie (CSDDD). Available online at https://www.bmuv.de/themen/nachhaltigkeit-digitalisierung/wirtschaft/wirtschaft-und-umwelt-worum-geht-es/mehr-umwelt-und-menschenrechtsschutz-in-lieferketten/europaeische-lieferkettenrichtlinie-csddd, updated on 04.05.2023, retrieved on 05.07.2023.

Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) (2023c): Internationales Chemikalienmanagement. Available online at https://www.bmuv.de/themen/gesundheit-chemikalien/chemikalien/internationales-chemikalienmanagement, updated on 27.07.2023, retrieved on 15.06.2023.

Federal Ministry of Food and Agriculture (BMEL) (2022): Exportverbot gesundheitsschädlicher Pestizide kommt. Available online at https://www.bmel.de/SharedDocs/Pressemitteilungen/DE/2022/119-vo-exportverbot-pestizide.html, updated on 12.09.2022, retrieved on 14.06.2023.

Federal Ministry of Labour and Social Affairs (BMAS) (2023): EU-Lieferkettengesetz. In einer globalisierten Wirtschaft braucht es eine europäische Strategie, um Menschenrechte und Umwelt in Liefer- und Wertschöpfungsketten wirksam zu schützen. With assistance of Referat "CSR" – Gesellschaftliche Verantwortung von Unternehmen. Available online at https://www.csr-in-deutschland.de/DE/Wirtschaft-Menschenrechte/Europa/Lieferketten-Gesetzesinitiative-in-der-EU/lieferketten-gesetzesinitiative-der-eu-art.html, retrieved on 05.07.2023.

Federal Office of Consumer Protection and Food Safety Germany (BVL) (2023): Background information on the Rotterdam Convention (PIC Procedure). Available online at https://www.bvl.bund.de/EN/Tasks/04_Plant_protection_products/03_Applicants/13_LegalRegulations/03_InternationalAgreements/02_PIC_Rotterdam/ppp_intern_agreements_PIC_Background_node.html, retrieved on 28.06.2023.

Freudenschuß, Alexandra; Obersteiner, Erik; Uhl, Maria (2008): Organische Schadstoffe in Grünlandböden. Environmental Agency Austria (UBA AT). Wien, Austria. Available online at https://www.umweltbundesamt.at/fileadmin/site/publikationen/rep0158.pdf, retrieved on 23.07.2023.

German Federal Institute for Risk Assesment (BfR) (2023): Gekommen, um zu bleiben: Per- und polyfluorierte Alkylsubstanzen (PFAS) in Lebensmitteln und der Umwelt – BfR. Available online at https://www.bfr.bund.de/de/gekommen__um_zu_bleiben__per__und_polyfluorierte_alkylsubstanzen__pfas__in_lebensmitteln_und_der_umwelt-242936.html, retrieved on 24.07.2023.

Greenpeace International (2012): Toxic Threads: The Big Fashion Stich-Up. How big brands are making consumers unwitting accomplices in the toxic water cycle. Amsterdam, Netherlands.

Greenpeace International (2015): You did it! Toxic chemical banned in EU textile imports. Available online at https://www.greenpeace.org/international/story/7615/you-did-it-toxic-chemical-banned-in-eu-textile-imports/, retrieved on 05.07.2023.

Hessian Agency for Nature Conservation, Environment and Geology (HLNUG) (2004): Zinnorganika. Available online at https://www.hlnug.de/fileadmin/dokumente/wasser/fliessgewaesser/gewaesserbelastung/orientierende_messungen/6.08Zinnorganika.pdf, retrieved on 15.07.2023.

International Institute for Sustainable Development (IISD) (2023): Summary report 24–28 January 2022. 17th Meeting of the Persistent Organic Pollutants Review Committee to the Stockholm Convention (POPRC-17), updated on 12.05.2023, retrieved on 18.07.2023.

International Maritime Organization (IMO) (2023a): Anti-fouling systems. Available online at https://www.imo.org/en/OurWork/Environment/Pages/Anti-fouling.aspx, retrieved on 22.06.2023.

International Maritime Organization (IMO) (2023b): International Convention on the Control of Harmful Anti-fouling Systems on Ships. Available online at https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-the-Control-of-Harmful-Anti-fouling-Systems-on-Ships-(AFS).aspx, retrieved on 22.06.2023.

Mohapatra, Piyush; Gaonkar, Omkar (2021): Toxic – An Overview of Chemicals in Textiles. Toxics Link. New Delhi, India.

North Rhine-Westphalia Agency for Nature, Environment and Consumer Protection (LANUV) (2023): PFAS in Wasser. Available online at https://www.lanuv.nrw.de/umwelt/gefahrstoffe/pfas/pfas-im-wasser, retrieved on 24.07.2023.

Parliament of The Rebublic of Uganda (Parliament of Uganda) (2023): Stop exporting cancer causing products to Africa – Tayebwa tells EU. Kampala, Uganda. Available online at https://www.parliament.go.ug/news/6481/stop-exporting-cancer-causing-products-africa-tayebwa-tells-eu, retrieved on 05.07.2023.

Paz-Villarraga, César Augusto; Castro, Ítalo Braga; Fillmann, Gilberto (2022): Biocides in Antifouling Paint Formulations Currently Registered For Use. In *Environmental Science and Pollution Research* (29), pp. 30090–30101. DOI: 10.1007/s11356-021-17662-5.

Pesticide Action Network (PAN) Europe (2022): European Commission mustn't abandon promise on hazardous chemical exports ban made in EU Green Deal. Available online at https://www.pan-europe.info/press-releases/2022/11/european-commission-mustn%E2%80%99t-abandon-promise-hazardous-chemical-exports-ban, updated on 01.12.2022, retrieved on 07.07.2023.

Mohapatra, Piyush; Arora, Tripti; Rajankar, Prashant (2019): Dirty Trail: Detergent to Water bodies. A study on the presence of Toxic Nonylphenol. Toxics Link. New Delhi, India.

Ringbeck, Benedikt; Weber, Till; Bury, Daniel; Kasper-Sonnenberg, Monika; Pälmke, Claudia; Brüning, Thomas; Koch, Holger M.; Kolossa-Gehring, Marike (2022): Nonylphenol (NP) exposure in Germany between 1991 and 2021: Urinary biomarker analyses in the German Environmental Specimen Bank (ESB). In *International Journal of Hygiene and Environmental Health* (245), 114010. DOI: 10.1016/j.ijheh.2022.114010.

Secretariat of the Basel, Rotterdam and Stockholm Conventions (Secretariat BRS) (2023a): History of the negotiations of the Rotterdam Convention. Available online at https://www.pic.int/TheConvention/Overview/History/Overview/tabid/1360/language/en-US/Default.aspx, retrieved on 28.06.2023.

Secretariat of the Basel, Rotterdam and Stockholm Conventions (Secretariat BRS) (2004): Guide on the Development of National Laws to Implement the Rotterdam Convention.

Secretariat of the Basel, Rotterdam and Stockholm Conventions (Secretariat BRS) (2023b): All POPs listed in the Stockholm Convention. Available online at https://chm.pops.int/TheConvention/ThePOPs/AllPOPs/tabid/2509/Default.aspx, retrieved on 17.07.2023.

Secretariat of the Basel, Rotterdam and Stockholm Conventions (Secretariat BRS) (2023c): Annex III Chemicals. Available online at https://www.pic.int/TheConvention/Chemicals/AnnexIIIChemicals/tabid/1132/language/en-US/Default.aspx, updated on 28.06.2023.

Shaikh, Muhammad Mansoor; Hanafiah, Marlia Mohd; Basheer, Alfarooq O. (2019): Leaching of Organic Toxic Compounds from PVC Water Pipes in Medina Al-Munawarah, Kingdom of Saudi Arabia. In *Processes* 7 (10), p. 641. DOI: 10.3390/pr7100641.

UNICEF and Pure Earth (2020): The Toxic Truth: Children's Exposure to Lead Pollution Undermines a Generation of Future Potential.

U.S. Department of State (2023): Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. Available online at https://www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/rotterdam-convention-on-the-prior-informed-consent-procedure-for-certain-hazardous-chemicals-and-pesticides-in-international-trade/, retrieved on 28.06.2023.

Wolff, Reinhard (2007): Schmutzige Tücher. Schwedische Umweltschützer haben Hormongift in importierten Badezimmertextilien gefunden. In *taz. die tageszeitung*, 13.09.2007 (8377), p. 8. Available online at https://taz.de/!237117/, retrieved on 05.07.2023.

Zou, Hongyan; Wang, Tao; Wang, Zhong-Liang; Wang, Zhanyun (2023): Continuing large-scale global trade and illegal trade of highly hazardous chemicals. In *Nat Sustain*. DOI: 10.1038/s41893-023-01158-w.

Legal acts

European Parliament and the Council (23.01.2003): Regulation (EC) No 304/2003 of the European Parliament and of the Council of 28 January 2003 concerning the export and import of dangerous chemicals (Text with EEA relevance), revised 17.06.2008. Source: EUR-Lex. Available online at http://data.europa.eu/eli/reg/2003/304/oj, retrieved on 30.06.2023.

European Parliament and the Council (18.12.2006): Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC. REACH, revised 29.06.2023. Source: EUR-Lex. Available online at http://data.europa.eu/eli/reg/2006/1907/oj, retrieved on 30.06.2023.

European Parliament and the Council (16.12.2008): Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (Text with EEA relevance). CLP Regulation, revised 20.04.2023. Source: EUR-Lex. Available online at http://data.europa.eu/eli/reg/2008/1272/oj, retrieved on 30.06.2023.

European Parliament and the Council (04.07.2012): Regulation (EU) No 649/2012 of the European Parliament and of the Council of 4 July 2012 concerning the export and import of hazardous chemicals (recast) Text with EEA relevance. PIC Regulation, revised 07.01.2022. Source: EUR-Lex. Available online at http://data.europa.eu/eli/reg/2012/649/oj, retrieved on 30.06.2023.

European Parliament and the Council (20.06.2019): Regulation (EU) 2019/1021 of the European Parliament and of the Council of 20 June 2019 on persistent organic pollutants (recast) (Text with EEA relevance.). POPs Regulation. Source: EUR-Lex. Available online at data.europa.eu/eli/reg/2019/1021/2023-06-10, retrieved on 30.06.2023.

United Nations Environmental Programme (2004): Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade. PIC Convention, revised 2019. Available online at https://www.pic.int/TheConvention/Overview/TextoftheConvention/tabid/1048/language/en-US/Default.aspx, retrieved on 30.06.2023.

United Nations Environmental Programme (2004): Stockholm Convention on Persistent Organic Pollutants (POPs). POP Convention, revised 2019. Available online at https://chm.pops.int/TheConvention/Overview/TextoftheConvention/tabid/2232/Default.aspx, retrieved on 30.06.2023.

Corporate Sustainability Due Diligence Directive

European Commission (EC) (23.02.2022): Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Corporate Sustainability Due Diligence and amending Directive (EU) 2019/1937. Available online at https://commission.europa.eu/publications/proposal-directive-corporate-sustainability-due-diligence-and-annex_en, retrieved on 15.07.2023.

European Commission (EC) (23.02.2022): Annex to the proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Corporate Sustainability Due Diligence and amending Directive (EU) 2019/1937. Available online at https://commission.europa.eu/publications/proposal-directive-corporate-sustainability-due-diligence-and-annex_en, retrieved on 15.07.2023.

Council of the European Union (Council) (30.11.2022): Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Corporate Sustainability Due Diligence and amending Directive (EU) 2019/1937 – General Approach. Available online at https://data.consilium.europa.eu/doc/document/ST-15024-2022-REV-1/en/pdf, retrieved on 15.07.2023.

European Parliament (EP) (01.06.2023): Corporate Sustainability Due Diligence. Amendments adopted by the European Parliament on 1 June 2023 on the proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Corporate Sustainability Due Diligence and amending Directive (EU) 2019/1937 (COM(2022)0071 – C9-0050/2022 – 2022/0051(COD)). Available online at https://www.europarl.europa.eu/doceo/document/TA-9-2023-0209_EN.html, retrieved on 15.07.2023.

I Appendix

Table A1: European regulations on hazardous substances

Regulation	Relation	Entry into force
Regulation (EU) 2019/1021	POPs Regulation: Persistent Organic Pollutants Recast of Regulation (EC) No 850/2004 Based on the Stockholm Convention	20 June 2019
Regulation (EU) No 649/2012	PIC Regulation: Prior Informed Consent Based on the Rotterdam Convention	4 July 2012
Regulation (EC) No 1272/2008	CLP Regulation: Classification, Labelling, Packaging Based on the Globally Harmonized System of Classification and Labelling of Chemicals (GHS)	20 January 2009
Regulation (EC) No 1907/2006	REACH Regulation: Registration, Evaluation, Authorisation and Restriction of Chemicals	1 June 2007
Regulation (EC) No 304/2003	Regulation concerning the export and import of dangerous chemicals applying on a mandatory basis the PIC procedure Transitional regulation between Rotterdam Convention and PIC Regulation	28 January 2003– 17 June 2008