# 10. Chemical pollution

# Key messages

- European chemical policies have contributed to improved air and surface water quality and reduced related harm to the environment and people's health. Nevertheless, on-going exposure to chemical pollution continues to negatively affect human health and the environment. Latent and irreversible damage to human health is of particular concern.

- The projected increase in chemical production and continued emissions of persistent and hazardous chemicals suggests that the total chemical burden on health and the environment is unlikely to decrease.

- The large variety of chemicals used in Europe makes it impossible to carry out robust risk assessments for each individual chemical and monitor their presence in environmental media and in people. Significant knowledge gaps remain regarding the impacts of chemicals on health and the environment.

- Current policies mainly address single chemicals and often in separate policy domains. A shift to a more integrated approach for chemicals governance that better fosters innovation within Europe is needed. The current single substance approach is not fit for assessing and managing the risks of the large number of chemicals on the European market in the immediate future. A shift towards tackling chemical groups rather than single substances offers opportunities to accelerate risk management.

- A transition to chemicals and products that are safe by design, as well as using less hazardous chemicals along the entire life cycle of products, offers significant opportunities to reduce chemical pollution and improve circularity and innovation in Europe's economy.

### Thematic summary assessment

| Theme | Past trends and outlook | | Prospects of meeting policy objectives/targets |
|---|---|---|---|
| | Past trends (10-15 years) | Outlook to 2030 | 2020 |
| Emissions of chemicals | Trends show a mixed picture | Deteriorating developments dominate | ☒ Largely not on track |
| Chemical pollution and impacts on ecosystems | Trends show a mixed picture | Deteriorating developments dominate | ☒ Largely not on track |
| Chemical pollution and risks to human health and well-being | Trends show a mixed picture | Deteriorating developments dominate | ☒ Largely not on track |

**Note:** For the methodology of the summary assessment table, see the introduction to Part 2. The justification for the colour coding is explained in Section 10.3, Key trends and outlooks (Tables 10.2, 10.3 and 10.4).

# 10.
# Chemical pollution

## 10.1 Scope of the theme

Society benefits from using chemicals while aiming to minimise risks to the environment and human health. Chemicals are widely used in everyday life and many economic sectors are dependent on chemicals, such as agriculture, manufacturing of consumer products, infrastructure and technology, and energy. Given this widespread and diverse use (Bernhardt et al., 2017; Landrigan et al., 2017; Gross and Birnbaum, 2017), this chapter focuses mainly on synthetic chemicals, such as industrial chemicals, pesticides, biocides and chemicals in products, and particularly on the most hazardous substances or those that accumulate in humans and the environment. It excludes fertilisers and air pollutants from combustion processes, which are addressed in other chapters in this report.

An overview of the 'chemical universe' and emissions is presented, along with an assessment of how chemicals impact on human health and the environment and the responses that have been put in place to deal with key challenges. Given the cross-cutting nature of chemicals, this chapter complements the assessment of pollutants from the perspective of specific media (Chapters 4, 5, 6 and 8) and from the perspective of sources of pollution (Chapters 12 and 13).

Exposure to chemical pollution negatively impacts human health and the environment.

Emissions of chemical pollutants occur across various stages of the chemical or product's life cycle and exposure to chemicals may occur through many routes, including point and diffuse sources (Figure 10.1). Chemicals produced or used in one place may also spread regionally and globally. While chemical accidents at manufacturing facilities can lead to loss of life and severe pollution locally, they are outside the scope of this report. However, data are available in the eMARS database (JRC, 2018).

Risk assessment is a tool used to inform decision-making. It is based on data on the chemical's hazard and level of exposure, which combine to provide a measure of the risk of causing effects (Risk = Hazard × Exposure). Hazards vary by type and the timescale in which they manifest. An example of an acute hazard is pesticide poisoning, whereas chronic hazards may develop over time and result in diseases such as cancer. The toxicity of hazardous substances depends on both the chemical and the vulnerability of humans or ecosystems when exposed. For example, if an organism is exposed during fetal development, or exposed to multiple stresses, this can increase vulnerability, meaning that the chemical is hazardous even at low doses.

**FIGURE 10.1** Point and diffuse sources of emissions and the exposure routes for humans and the environment


**Source:** EEA.

**BOX 10.1 Definitions of key terms**

**Persistent chemicals** have high intrinsic molecular stability and do not easily degrade in the environment or in living organisms or during technical processing. Persistent organic pollutants (POPs) is a specific subcategory, with polychlorinated biphenyls (PCBs), per- and polyfluorinated alkyl substances (PFAS) and organomercury being examples.

**Mobile chemicals** are either very water soluble or very volatile making them difficult to remove with abatement and remediation technologies.

**Accumulation** occurs in the environment or in humans if the rate of input exceeds the rate of removal.

**Bioaccumulation** occurs when chemicals accumulate in living organisms, typically due to a long-term intake of food or water contaminated with chemicals that are not efficiently removed from the organism. Accumulation of fat-soluble chemicals occurs in fatty tissues (e.g. PCBs and dioxins), but chemicals may also accumulate in the blood and organs (e.g. PFAS).

**Endocrine-disrupting chemicals (EDCs)** interfere with the development or the functioning of the hormonal system such as the female sex hormones (oestrogens), male sex hormones (testosterone) or thyroid hormones. Examples include bisphenol A (BPA) and phthalates (e.g. di-(2-ethylexyl) phthalate, DEHP).

**Developmentally toxic chemicals** damage the development and future functioning of the endocrine (hormonal) system, the immune system or the neurological system (affecting brain development). Critical windows of exposure are associated with different stages of the development of an organism. Organotins (e.g. tributyltin, TBT) and perfluorooctane sulfonate (PFOS) are examples of immunotoxic substances, whereas lead, organomercury and organophosphate pesticides are examples of neurotoxic chemicals.

**Substances of very high concern (SVHC)** is a term used in the EU chemicals regulation REACH (registration, evaluation, authorisation and restriction of chemicals), for single or groups of chemicals that are subject to authorisation. EU legislation requires that SVHCs should be substituted with less harmful alternatives and the REACH Regulation provides for risk management processes to achieve this aim. The SVHC criteria target substances that have one or more of the following properties: carcinogenic; mutagenic; toxic for reproduction; persistent, bioaccumulative and toxic (PBT); very persistent and very bioaccumulative (vPvB) or giving rise to equivalent levels of concern. Examples of the substances causing equivalent concern include neurotoxic and endocrine-disrupting chemicals. ■

Overall risks result from the combined exposure to single chemicals released from various sources but also from mixtures of chemicals. High exposure typically happens as a result of repeated exposures and when chemicals accumulate in the environment or in people. Accumulation occurs when the input of chemicals is greater than the rate at which they are degraded or excreted from living organisms. This may occur with chemicals produced at high volume that are continuously released into the environment at a rate that exceeds the removal rate, as well as with lower volumes of persistent chemicals (see Box 10.1 for definitions).

## 10.2 Policy landscape

The Seventh Environment Action Programme (7th EAP) states that Europe aims to achieve, by 2020, the objective that chemicals are produced and used in ways that lead to the minimisation of significant adverse effects on human health and the environment (EU, 2013). Policies to deliver this objective include more than 40 pieces of legislation including horizontal legislation, and legislation covering specific chemical products, consumer products, wastes, emissions to the environment and environmental quality standards.

Risk assessments are not possible for every chemical used in Europe due to the large variety of chemicals that exist.

Table 10.1 presents an overview of selected relevant policy targets and objectives. The 7th EAP also established a mandate for the European Commission (Directorate-General for Environment) to develop 'by 2018 a Union strategy for a non-toxic environment that is conducive to innovation and the development of sustainable substitutes including non-chemical solutions' (EU, 2013).

REACH is the Regulation on registration, evaluation, authorisation and restriction of chemicals (EU, 2006b) and is the key piece of horizontal legislation that aims to protect human health and the environment. The REACH Regulation obliges companies to provide information on the properties and hazards of chemicals they manufacture and market in the EU and to manage the associated risks. The regulation also calls for the progressive substitution of the most hazardous chemicals when economically and functional alternatives have been identified. This is done by restrictions on their uses, or by authorising the chemical uses for defined purposes. The Classification, Labelling and Packaging (CLP) Regulation (EU, 2008b) aims to protect human health and the environment by putting in place the rules for the classification, labelling and packaging of chemicals. In combination with the REACH Regulation, this ensures that information about the hazards of chemicals and mixtures of chemicals are communicated down the supply chain, alerting workers to the presence of a hazard and the need for risk management (EU, 2009b). The CLP legislation also protects the aquatic environment through classification of some types of chemical hazards in line with international standards (Amec Foster Wheeler et al., 2017).

Regarding chemical products, the EU has directives and regulations in place (with amendments) to restrict various uses, occurrences and emissions of chemicals. Some examples include detergents (EU, 2004a), biocides (EU, 2012), plant protection products, including pesticides (EU, 2009d), and pharmaceuticals (EU, 2001b). Furthermore, policies limit some use and presence of hazardous chemicals in consumer products to ensure consumer safety and protect the environment from diffuse emissions, including personal care products, cosmetics, textiles, electronic equipment and toys (Amec Foster Wheeler et al., 2017), as well as food contact plastics (EU, 2011a), food (EU, 2002) and drinking water (EU, 2001a, 2006a).

European chemical policies have contributed to improved air and surface water quality.

Efforts to close material cycles under the action plan for the circular economy have implications for the chemical life cycle, with the potential for recycled material flows to contain and even magnify legacy chemicals as well as other hazardous chemicals that are not restricted or authorised (EC, 2015). The circular economy, and its benefits of reducing pressures on resources, nature and the climate, could therefore be supported if clean and non-toxic material cycles were ensured. A 2018 Commission communication sets out options for addressing the interface between chemical, product and waste legislation (EC, 2018c).

European policies also control emissions of chemicals to the environment and set maximum thresholds for the presence of certain chemicals in air and in water bodies. Legislation addresses point source emissions from industrial installations and from urban waste water treatment plants (Chapter 12). Legislation also addresses emissions of chemicals that are hazardous and of global concern due to the transboundary nature of their transport and impacts, such as persistent organic pollutants (POPs). Typically, policies regulate use, emissions or occurrences of single substances. Increasingly authorities seek to manage the risks of substances as groups when those substances share similarities in their chemical characteristics (ECHA, 2018d).

In addition to policies at European level, several of the Sustainable Development Goals (SDGs) (UN, 2015) address the risks from chemicals. SDG 12 on sustainable consumption and production patterns calls for the environmentally sound management of chemicals and waste throughout their life cycle. SDG 3 on ensuring healthy lives and promoting well-being for all at all ages sets the goal of substantially reducing the number of deaths and illnesses from hazardous chemicals. Finally, SDG 6 identifies the need to minimise releases of hazardous chemicals to water to achieve sustainable management of water and sanitation for all. The SDGs' objectives on chemicals are supported at the global level by implementation of the *Strategic approach to international chemicals management*, a policy framework to promote chemical safety (UNEP, 2006).

## 10.3 Key trends and outlooks

### *10.3.1 The chemical universe*

The chemical universe captures the wide range of chemical products in use today: chemicals that are deliberately or unintentionally emitted from agriculture, industrial processes and urban areas, and legacy chemicals that persist in the environment from previous emissions. Two aspects of this universe create concern: the sheer volume of chemicals in use and the potential combined toxicity of these diverse chemicals.

**TABLE 10.1 Overview of selected policy objectives and targets**

| Policy objectives and targets | Sources | Target year | Agreement |
|---|---|---|---|
| **Chemical pollution** | | | |
| Improve the protection of human health and the environment through registration, evaluation, authorisation and restriction of chemicals | REACH Regulation (EU, 2006b) | N/A | Binding |
| Develop a strategy for a non-toxic environment | 7th EAP (EU, 2013) | 2018 | Non-binding commitment |
| Risks for the environment and health associated with the use of hazardous substances, including chemicals in products, are assessed and minimised | 7th EAP (EU, 2013) | 2020 | Non-binding commitment |
| Policy response in place for endocrine disrupters, and for combination effects of mixtures of chemicals | 7th EAP (EU, 2013), EC (2012) | 2015 | Non-binding commitment |
| To prevent or, where that is not practicable, to reduce emissions to air, water and land and to prevent the generation of waste in order to achieve a high level of protection of the environment taken as a whole | IED (EU, 2010) | N/A | Non-binding commitment |
| Develop a strategy on pharmaceuticals in water | 2000/60/EC and 2008/105/EC | 2015/2017 | Binding |
| The use of plant protection products does not have any harmful effects on human health or unacceptable influence on the environment, and such products are used sustainably | 7th EAP (EU, 2013) | 2020 | Non-binding commitment |
| Minimise the use/emissions of listed POPs, following addition of a POP to the list | EC 850/2004, EC 96/59, CLRTAP (UNECE, 1979) | New facilities: 2 years, existing facilities: 8 years after entry into force | Binding |
| Priority hazardous substances under Directive 2008/105/EC are eliminated from surface waters in accordance with the WFD | WFD (2000/60/EU) | N/A | Binding |
| Contaminants are not at a level giving rise to pollution effects | MSFD (2008/56/EC) | 2020 | Binding |
| All relevant substances of very high concern, including substances with endocrine-disrupting properties, are placed on the REACH candidate list | 7th EAP (EU, 2013) | 2020 | Non-binding commitment |
| Reduce cancers/deaths from workplace exposures to chemicals | EU Roadmap on carcinogens (EU-OSHA, 2017a), 2009/104/EC | N/A | Non-binding commitment |
| Reduce mercury levels in the environment and human exposure and protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds | EU Mercury strategy (EC, 2005), Minamata Convention on Mercury (Council of the European Union, 2013) | N/A | Non-binding commitment |
| Restriction of the use of certain hazardous substances in electrical and electronic equipment | RoHS Directive (EU, 2011b) | 2019 | Binding |

**Note:** 7th EAP, Seventh Environment Action Programme; CLRTAP, Convention on Long-range Transboundary Air Pollution; IED, Industrial Emissions Directive; MSFD, Marine Strategy Framework Directive; POP, persistent organic pollutant; RoHS Directive, Directive on restriction of hazardous substances; WFD, Water Framework Directive; N/A, non-applicable.

Between 2000 and 2017, the production capacity of the global chemical industry increased from 1.2 to 2.3 billion tonnes (UNEP, 2019). In terms of diversity, 22 600 chemical registrations were registered under the REACH legislation in August 2019. This number omits chemicals on the market at volumes of below 1 tonne, as well as polymers, and those already regulated under existing regulation such as pesticides and pharmaceuticals. The total number of synthetic chemicals on the market has been estimated at 100 000 substances (Milieu Ltd et al., 2017) and 600 000 substances can be searched in toxicological databases (DTU, 2019). There are also an unknown number of transformation products from chemicals during their life cycles (Ng et al., 2011). At the same time, the volume and diversity of chemicals continues to increase (CEFIC, 2018).

Thoroughly assessing how the chemical universe constitutes a risk to human health and the environment requires information on the toxic (hazardous) effects of each substance, its potency and the extent to which the environment and people are exposed to each chemical, whether as a single substance or in mixtures. This in turn requires an understanding of how chemicals are used and altered throughout their life cycles, how they end up in various environmental media and how they combine in the environment. The main challenge in assessing the overall risk, is that the majority of substances in the chemical universe lack either a full hazard characterization and/or exposure estimates across ecosystems and in humans.

Different approaches to registering, assessing and monitoring chemicals create challenges in estimating how well chemical risks are assessed. As shown in Figure 10.2, it is estimated that robust information exists for about 500 chemicals and by April 2019, ECHA considered 450 substances as being sufficiently regulated (ECHA, 2019b). Another 10 000 substances are considered to have their risks fairly well characterised, while limited risk information is available for around 20 000 substances. The majority, around 70 000 substances have hardly any information on their hazards or exposures. While these may be present in small volumes, they contribute to the overall chemical risk and a fuller characterisation of hazards may be warranted. Given the diversity of substances, it is however unrealistic in terms of time and resources to comprehensively test all chemicals to identify their hazardous properties and to monitor for their presence in environmental media, in biota and in humans. This suggests that in addition to the existing tools, additional regulatory and other means are required, to enable effective management of the risks posed by chemicals, regardless of their source. In addition, improved information on volumes of specific chemicals could also enable modelling of exposures.

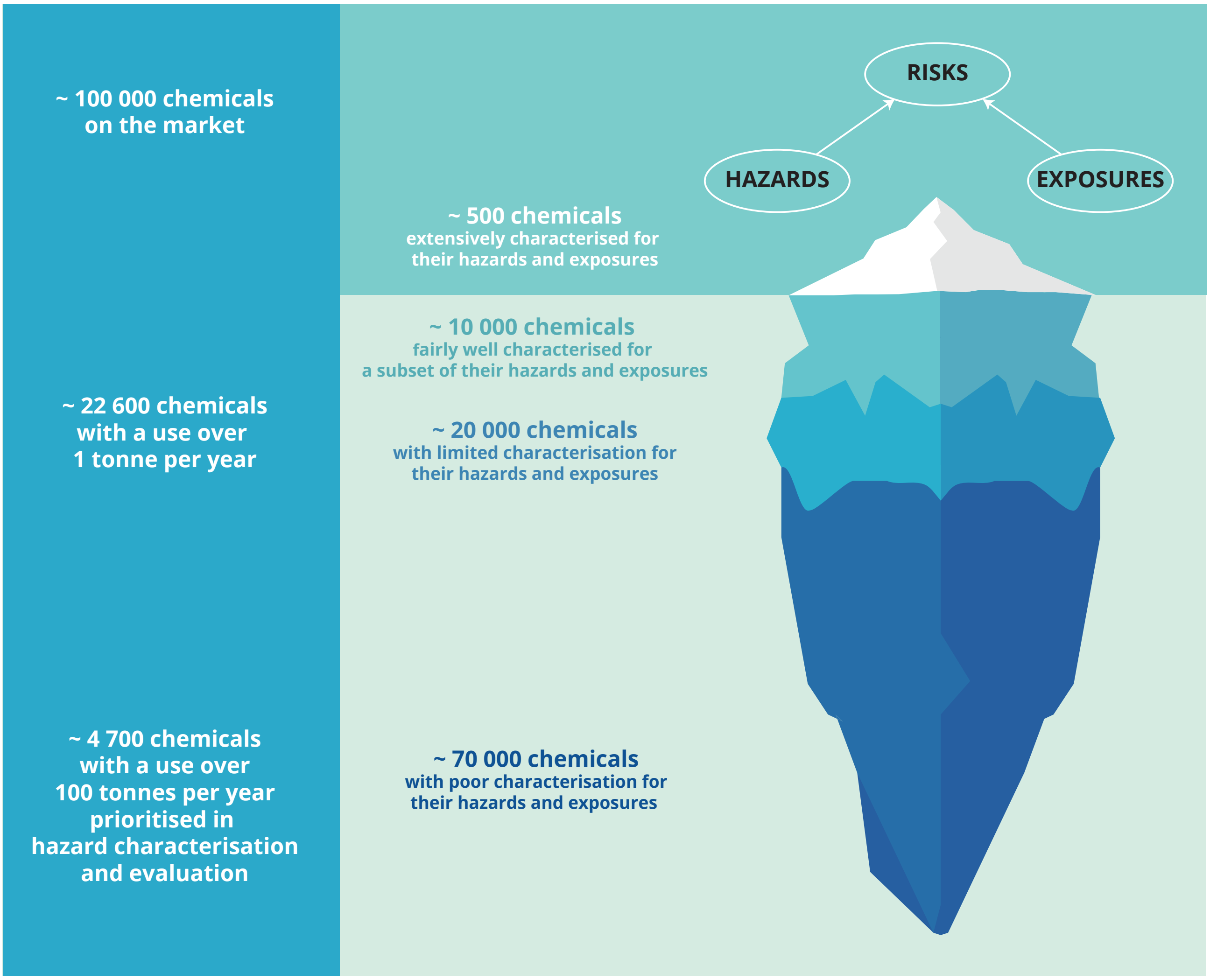
> Two aspects of the chemical universe create concern: the sheer volume of chemicals in use and the potential combined toxicity of these diverse chemicals.

To get a rough estimate of how chemical risks are evolving in Europe, trends in the production and consumption of chemicals and changes in the proportion of chemicals on the market that are classified as hazardous to the environment and/or human health can be evaluated. In the EU, 282 million tonnes of industrial chemicals were produced in 2017. Of these, 28 %, or 75 million tonnes, were hazardous to the environment and 75 %, or 209 million tonnes, were hazardous to health. The proportions of chemicals hazardous to the environment and/or hazardous to health remained stable from 2008 to 2017 (Eurostat, 2019).

The consumption of industrial chemicals in the EU in 2017 was 304 million tonnes. Of these, 22 % were hazardous to the environment and 71 % were hazardous to health, similar proportions to those for chemical production. The proportion of consumed chemicals hazardous to the environment declined by 5 % from 2008 to 2017, with a decline of 6 % for chemicals hazardous to health, suggesting a downward trend in the overall hazard posed (Eurostat, 2019). However, the information available on chemical hazards is incomplete and the classification criteria under the CLP Regulation do not effectively capture certain health impacts, in particular long-term developmental toxicities associated with endocrine disruption, neurotoxicity and immunotoxicity, as well as certain categories of chemicals hazardous to the environment, such as persistent, bioaccumulative and toxic (PBT) and very persistent, very bioaccumulative (vPvB) substances. The approach is based on the hazard profile of individual substances and does not account for the combined effects of chemical mixtures. These issues imply that the associated risk to human health and the environment from chemical production and consumption is likely to be understated.

Production and consumption data provide a weak proxy for exposure to chemicals for several reasons. Actual exposure is determined by emissions during the chemical's life cycle, including use and waste phases and possible reuse, and not by the tonnage produced or consumed. Certain very hazardous chemicals are used in closed systems, reducing opportunities for exposure. Data for industrial chemicals also exclude important chemical sectors, such as pharmaceuticals and pesticides,

**FIGURE 10.2** **The unknown territory of chemical risks**




**Note:** The numbers in the figure do not include impurities, transformation products or structural variants (isomers) of chemicals placed on the market. ~ 500 chemicals: Chemicals which are considered sufficiently regulated (ECHA, 2019b), typically legacy and well-known chemicals characterised for most known hazards, which have limit values and are regularly are monitored by quantitative methods in most media. ~ 10 000 chemicals: Chemicals on EU or national legislation lists which are characterised for some but not for all known hazards, which have specific limit values, and are monitored quantitatively, but irregularly across time, media or space. ~ 20 000 chemicals: Chemicals with hazards characterised mainly by modelling, or where exposure data are based on qualitative screenings done occasionally and in few media. ~ 70 000 chemicals: typically low volume chemicals for which usually no or very few hazards characteristics are available and information on uses and exposure is scarce, not characterised or measured in very few media.

**Sources:** EEA based on Danish EPA (2019); EC (2009); ECHA (2019a, 2019b, 2019c); EFSA (2012); EU (2009a, 2009c, 2011a, 2015); Geiser (2015); JRC (2016); Ng et al. (2011); OECD (2018); Sobek et al. (2016); UNEP (2018).

in which there are significant emissions to the environment. In addition, trends in the production and consumption of chemicals in Europe have been affected by the shift in manufacturing of goods requiring chemical inputs, such as textiles and electronics, to outside the EU (CEFIC, 2018). Chemicals used in manufacturing outside Europe are imported in finished products and emissions along the product's life cycle occur in Europe. Emissions outside Europe may also be transported long distances, adding to the total burden of chemicals in the European environment. Finally, any assessment of the chemical burden on the environment must also account for legacy chemicals already present in the environment, held in old products still in circulation or present in recycled materials.

Persistent emissions and expected growth in chemical production make a reduction in the chemical burden on health and the environment unlikely.

Looking ahead, society's reliance on chemicals is projected to grow. In Europe, the consumption of pharmaceuticals is projected to increase as a result of the ageing population (Moritz et al., 2017). Global chemical production is projected to triple between 2010 and 2050, mainly outside Europe (OECD, 2012). European chemical production is also projected to increase up to 2030 (CEFIC, 2018). The projected increase in the production and consumption of chemicals and the complexity of the chemical universe creates significant challenges for efforts to reduce the risk to human health and the environment from chemical pollution.

### 10.3.2 *Emissions of chemical pollutants to the environment*

►*See Table 10.2*

Emissions of chemicals into the environment are governed by legislation addressing specific sources (e.g. the Industrial Emissions Directive, 2010/75/EU, and Urban Waste Water Treatment Directive, 91/271/EEC), receiving media (e.g. the Convention on Long-range Transboundary Air Pollutants, CLRTAP, and Water Framework Directive, 2000/60/EC) and specific types of chemicals (e.g. the POP Regulation, 850/2004/EC, which is currently being revised).

#### *Emission trends*

Very few chemicals are regularly monitored in flows of emissions to the environment in Europe. The number of substances monitored and reported at EU level in various emission sources are set out below.

- Emissions of 91 single or groups of substances to water, air and soil from about 30 000 industrial facilities, including waste water treatment plants, are reported in the European Pollutant Release and Transfer Register (E-PRTR) (Chapter 12; EEA, 2019b).

- Emissions to water of 45 priority substances reported under the Water Framework Directive's inventory of emissions, discharges and losses, covering both diffuse and point emissions. Data on industrial emissions are drawn from E-PRTR reporting, while diffuse emissions are estimated.

- Emissions to water of several groups of hazardous substances, including pesticides, metals and metalloids, organic substances and other determinants, voluntarily reported to the EEA by member countries under the Water Information System for Europe (WISE) SoE emissions dataflow (Chapter 4). The substances reported vary for each country.

- Emissions of 26 single and groups of substances to air reported under the CLRTAP (EEA, 2018c) covering estimated volumes from several sources (Chapter 8).

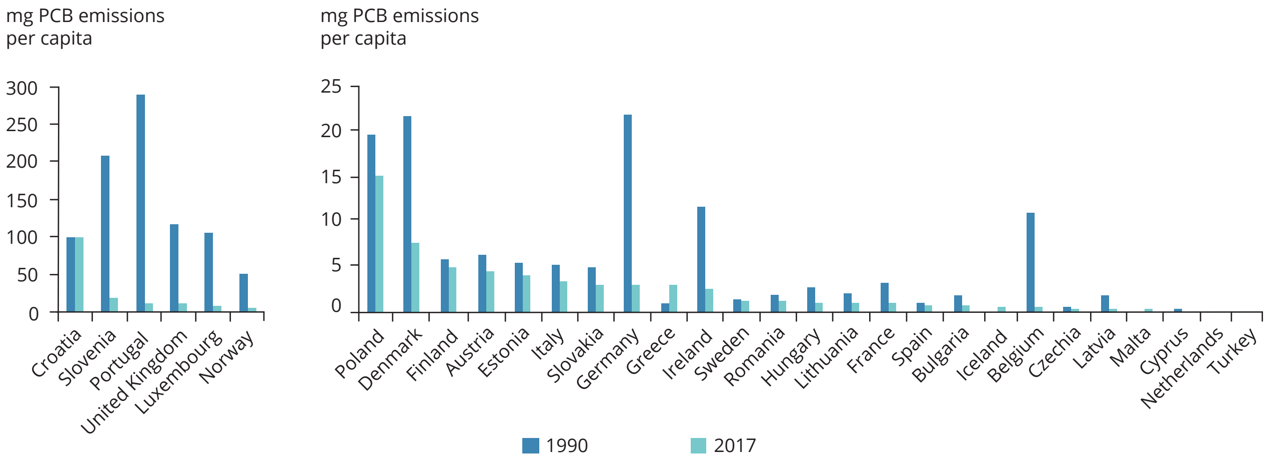
**Chemical emissions to air** There have been reductions in emissions to air of polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB) — two groups of POPs — as well as mercury, with declines of 83 %, 96 % and 72 %, respectively, in the period 1990-2017 and little improvement over the last decade (EEA, 2019a). Emissions of 23 chemicals from industrial installations reported to the E-PRTR with sufficient data coverage (not including heavy metals and pollutants formed during combustion) decreased by between 37 % and 93 % in the period 2007-2016, with the highest decreases in the first half of this period. Many of them are SVHCs that should be subject to substitution where there are suitable alternatives. Emissions of toluene and hydrogen cyanide increased by 13-22 % (EEA, 2019c), while emissions of seven heavy metals decreased by more than 17 % (Chapter 12). Emissions of ozone-depleting substances have been reduced as a result of partial substitution with hydrochlorofluorocarbons, which are potent greenhouse gases — an example of a regrettable substitution.

**Chemical emissions to water** Emissions of chlorinated substances from industrial installations and waste water treatment plants showed mixed trends, while emissions of heavy metals and other organic substances

## BOX 10.2 Emissions of persistent organic pollutants

Persistent organic pollutants (POPs) are persistent, bioaccumulative and toxic. Certain POPs are targeted by a range of policies. Polychlorinated biphenyls (PCBs) are a group of POPs whose use has been prohibited since 2004 (EU, 2004b). However, stocks of PCBs in existing buildings and industrial facilities continue to result in emissions. In 2017, Croatia, Slovenia and Poland emitted the highest amounts of PCB per capita, associated with the legacy use of these substances, and there has been little progress in reducing emissions in Croatia and Poland since 1990 (Figure 10.3). However, in Croatia, leaks from electrical transformers and capacitors are the main sources of emissions, and these are estimated using highly uncertain emission factors (MoEE, 2019). Portugal, Slovenia, the United Kingdom and Luxembourg have been very successful in decreasing emissions. Removal of sources such as electrical (capacity) insulators has been one of the more efficient ways to cut emissions (EEA, 2019a), but more focus is needed on PCBs in the existing stock of buildings. There is some uncertainty in the data. For example, emissions from buildings — which can be significant — are not routinely included in emission inventories, and emissions are calculated using emission factors that most probably underestimate the actual emissions (BiPro et al., 2017; Glüge et al., 2017). ■

**FIGURE 10.3 Country comparison — reductions in PCB emissions to air per capita in EEA member countries**




**Note:** The figures are at different scales. No data available for Liechtenstein and Switzerland. Emissions reported by Cyprus, Malta and the Netherlands are close to zero. Turkey did not report data. Main emission sources are the industry, energy and waste sectors as well as the commercial, institutional and households sector.

**Source:** EEA (2019a).

decreased in the period 2008-2016 (EEA, 2019b). However, comparable data are limited to only a few substances, and emissions reported under different reporting mechanisms are partly inconsistent, while data on emissions from diffuse sources to water are largely lacking. Few countries report pesticide emissions to water, and for only a few selected pesticides, so no picture is available for European trends in pesticide emissions (EEA, 2018b). Emissions of SVHCs and POPs, which have been restricted in their use, are likely to have decreased, although these are not directly monitored (EEA, 2017b).

Current EU policies mainly address single chemicals and often in separate policy domains.

**Chemical emissions to soil** Some information on contamination of soils

**TABLE 10.2 Summary assessment — emissions of chemicals**

| | | |
|---|---|---|
| **Past trends and outlook** | | |
| Past trends (10-15 years) | | There are mixed trends, as emissions to air of a few well-known, regulated, persistent and hazardous chemicals (e.g. many substances of very high concern, polychlorinated biphenyls (PCBs), hexachlorobenzene, mercury) have decreased whereas emissions to water of selected chlorinated and organic chemicals from industrial installations and waste water treatment plants remained rather stable. However, the large majority of chemicals that are emitted are not monitored, including more than 2 500 persistent and mobile chemicals. |
| Outlook to 2030 | | Continuous progress is expected regarding emissions of the few chemicals that have been banned or restricted in use, e.g. PCBs and some pesticides. However, even reduced emissions will still contribute to further accumulation of persistent chemicals in the environment, presenting challenges regarding environmentally sound management of chemicals throughout their life cycles. Policies governing emissions of chemicals lag behind the challenge of addressing the large amount of chemicals of unknown fate and properties. |
| **Prospects of meeting policy objectives/targets** | | |
| 2020 | ☒ | Europe is making progress towards the objective to minimise the use and emissions of listed persistent organic pollutants. However, Europe is not on track to meet the objective to minimise the release of hazardous chemicals to air, water and land, given the lack of information about emissions of thousands of persistent chemicals. |
| **Robustness** | | Emissions data to air, water and soil cover very few chemicals out of the thousands released to the environment. Monitoring methods and reference chemical substances are lacking for the majority of chemicals in use. Data on emissions to water from different reporting mechanisms are in many cases inconsistent, and little information is available on diffuse emissions. Outlook information on emissions of chemicals is largely absent. The assessment of past trends, outlooks and prospects for meeting policy objectives relies primarily on expert judgement. |

by chemicals is available through the Land Use and Coverage Area Frame Survey (LUCAS) soil programme — mainly heavy metals and in the future also pesticide residues (Chapter 5). However, data on emissions to soils are not available at European level because of a lack of a common policy regarding the monitoring and managing of such emissions. At country and regional levels, monitoring of emissions may take place. Mapping and targeted monitoring of sites contaminated with past or present industrial activities using hazardous chemicals can help to identify potential risks, such as contamination of drinking water (EEA, 2019b).

Looking ahead, available outlook information on emissions of chemicals is largely absent. Restrictions on use should result in a decrease in emissions. However, because of accumulated stocks in products and the environment, decreasing emissions will not necessarily result in similar decreasing trends in the concentrations in the environment. Accumulated persistent chemicals may continue to be released from products and buildings, and stocks in soil, sediment and ice may be re-mobilised due to storms, ice melting or flooding of contaminated soils (Wöhrnschimmel et al., 2016; Newkirk II, 2017). With the increasing frequency and magnitude of such events due to climate change, the risk of re-mobilising hazardous chemicals will increase (Moritz et al., 2017). Therefore, humans and the environment are exposed to emissions from both current activities and historical emissions accumulated in the environment (Gabbert and Hilber, 2016; Brack et al., 2017).

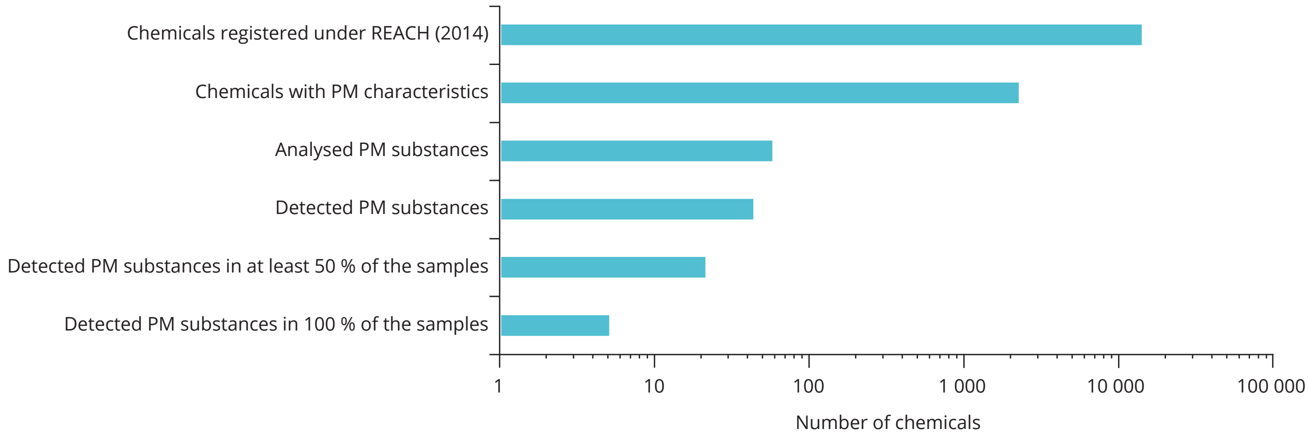
### *Emerging concerns*

Out of the thousands of industrial chemicals produced and released to the environment, emissions are monitored and reported for only a few. Very limited emissions data are available at the European level for diffuse emissions from pesticides, biocides, pharmaceuticals, detergents, products and materials present in consumer goods and buildings (Bolinius et al., 2018). A group of persistent, highly water soluble and mobile chemicals are generating increasing concern and have been

**BOX 10.3 Persistent and mobile chemicals in European surface water**

The European research project on chemicals in water — PROMOTE (Helmholtz Centre for Environmental Research, 2018) — found that of the 14 076 chemicals registered under REACH legislation in 2014, 2 520 were (very) persistent and (very) mobile. Only 57 of them could be measured, because methods were lacking for the rest. 75 % (43) of the measured chemicals were found at least once in the 14 water samples from three European countries. Half of the water samples contained 21 of the substances measured. All of the water samples contained five of these substances (melamine, 2-acrylamino-2-methylpropane sulfonate, p-toluenesulfonic acid, 1,3-diphenylguanidine, 1,3-di-o-tolylguanidine). Concentrations ranged from nanograms per litre to micrograms per litre, raising concerns, as several of these substances resist even advanced drinking water treatment processes (Brendel et al., 2018; Arp et al., 2017). However, emissions and occurrences of the 43 substances are not monitored under current EU regulations. ■

**FIGURE 10.4 Fraction of REACH chemicals that are persistent and mobile and found in water**




**Note:** The scale is logarithmic, PM substances classified as persistent and mobile.

**Sources:** Schulze et al. (2018, 2019), Brendel at al. (2018); Arp et al. (2017); Arp and Hale (forthcoming).

found in European freshwaters (Box 10.3). In response, Germany has recently proposed that such chemicals be treated under the REACH Regulation as chemicals of equivalent concern to substances classified as (very) persistent, (very) bioaccumulative and toxic (Neumann and Schliebner, 2017; Arp, 2018). More generally it has been proposed that persistency itself may be the property to avoid (Cousins et al., 2019) for chemicals that are safe by design (Kümmerer, 2018).

A large majority of emitted chemicals remain unmonitored in the environment.

### *10.3.3 Impacts of chemical pollution on the environment*

► *See Table 10.3*

There is a lack of knowledge of the impacts of many individual chemicals and chemical mixtures on the environment. Not all chemicals or their transformation products have been assessed, and ecotoxicity assessments focus on very few species and ecosystems. This means that knowledge about the presence of chemicals is not enough to explain observed effects, while ecological impact information alone is similarly not sufficient to identify the chemicals causing that impact. Instead, multiple lines of evidence are needed as well as precautionary approaches (EEA, 2018a). Assessments of environmental impacts based on monitoring data for the commonly known legacy pollutants are likely to underestimate the risks (Sobek et al., 2016).

The EU aims to achieve the objective that the use of plant protection products does not have any harmful effects on human health or unacceptable influence on the environment and that such products are used sustainably. Recently, the risks posed by pesticides, in particular neonicotinoids and their effects on pollinators, have been widely demonstrated. Decades of pesticide use is also a factor in the substantial decline in insects populations in Europe and in the related decline in insect-feeding birds (Hallmann et al., 2017, 2014) (Chapter 3).

The European Food Safety Authority (EFSA) has recently increased its efforts to include environmental risks in its risk assessments, for example to understand how using pesticides affects pollinators and sensitive ecosystems. A recent EFSA study developed a procedure for identifying potential emerging chemical risks to health via the food chain due to REACH-registered substances. Of the approximately 15 000 substances registered under the REACH Regulation at the time of the study, 2 336 unique substances were selected for assessment. In terms of emerging risks to health via the food chain, 212 chemicals were identified as being released to the environment and/or poorly biodegraded, bioaccumulating in food/feed and representing a chronic human health hazard. Carcinogenic/mutagenic substances and surfactants dominated the top 10 list of substances (Oltmanns et al., 2019).

With the increasing frequency and magnitude of storms, flooding and ice-melting due to climate change, the risk of re-mobilising hazardous chemicals will increase.

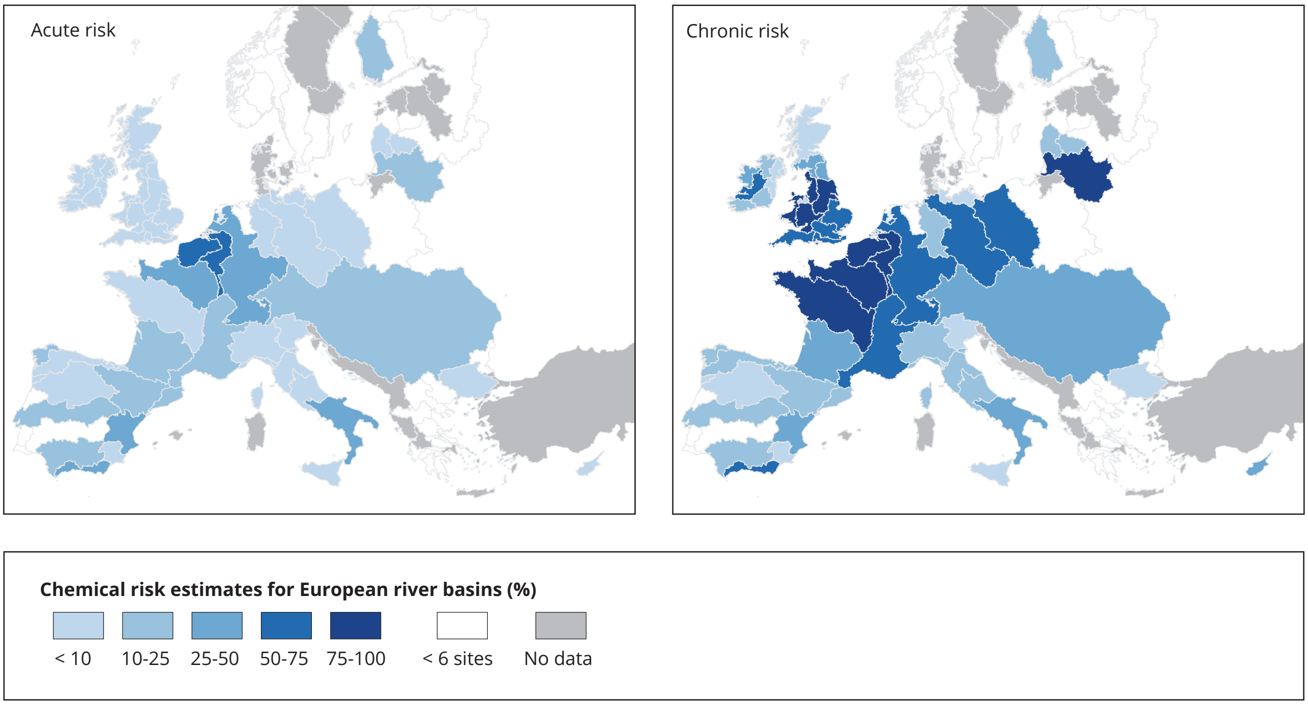
The use of chemicals can also have an impact on ecosystem services, for example clean soils for food production. Chemical pollutants may build up in soil through the application of pesticides, inorganic fertilisers containing metals, and sludge, and manure and waste water for irrigation containing pharmaceuticals, biocides, detergents and microplastics. In 2018, it was estimated that potentially 2.8 million locally contaminated sites exists in the EU-28 Member States, mainly from waste disposal and treatment, and that this is a significant environmental hazard for terrestrial and aquatic ecosystems (Payá Pérez and Rodriguez Eugenio (2018). Legacy pesticides threaten drinking water in Denmark and Spain. Soil pollutants affect both invertebrates and microbes and decrease their capacity to break down plant matter to nutrients, affecting the productivity of soils (Chapter 5).

The Water Framework Directive sets maximum thresholds for a range of chemicals in surface and groundwater bodies. In the second river basin management plans, 38 % of Europe's surface water bodies achieved good chemical status (EEA, 2018d). A relatively small number of substances are responsible for the failure to achieve good chemical status, with mercury responsible for causing failure in a large number of water bodies (Chapter 4). Brominated flame retardants (the polybrominated diphenyl ethers, pBDEs), tributyltin, polycyclic aromatic hydrocarbons and heavy metals were the most frequently found in freshwater in Europe (EEA, 2018d).

Significant knowledge gaps remain regarding the impacts of the total burden of chemicals on human health and the environment.

A pioneering study analysing risk from chemicals used monitoring data on chemical concentrations, reported in the WISE SoE database (Malaj et al., 2014). A total of 223 substances monitored in European freshwater systems were evaluated, and the study found that single chemicals were likely to exert acute lethal and chronic long-term effects on sensitive fish, invertebrate or algae species. They reported an acute risk at 14 % and a chronic risk at 42 % of the sites investigated using an individual chemical risk assessment approach (Map 10.1). Increasing chemical risk was associated with deterioration in the quality status of fish and invertebrate communities. Pesticides, tributyltin, polycyclic aromatic hydrocarbons and brominated flame retardants were the major contributors to the chemical risk and were related to agricultural and urban areas in the upstream catchments (EEA, 2018d). The study also found that the expected risk increases with the availability of chemical monitoring data, confirming that current monitoring underestimates risks. The sources of these chemicals are a mixture of point source emissions from waste water treatment plants, industrial facilities, contaminated sites and diffuse emissions from agrochemicals and sludge (Huber et al., 2016; Kümmerer, 2018).

**MAP 10.1** **Acute and chronic chemical risk estimates in European river basins**




**Note:** The map displays the fraction of sites where the maximum chemical concentration exceeds the *acute risk* threshold, and the mean chemical concentration exceeds the *chronic risk* threshold for any organism group. The calculations are based on reported chemical monitoring data and calculated using risk estimates for individual compounds. The colours indicate low chemical risk (light blue) to high chemical risk (dark blue). Direct comparisons between river systems are potentially biased by the ecotoxicologically relevant compounds analysed and the limit of quantification of the compounds. See Malaj et al. (2014) for further discussion of potential bias in the data (maps have been adapted).

**Source:** Malaj et al. (2014).

However, there are no cases in which only a single substance occurs in the environment. More recently, systematic efforts have demonstrated that mixtures of chemicals affect ecosystem integrity in aquatic ecosystems to the extent that simultaneous exposure to pesticides, along with other forms of stress, can render aquatic organisms up to 100 times more vulnerable to pesticides (Liess et al., 2016; Posthuma et al., 2016). The EU projects SOLUTIONS and MARS found that on average 20 % of aquatic species are lost due to exposure to chemical mixtures, with increasing exposure reducing the integrity of aquatic ecosystems (Posthuma et al., 2019).

In the marine environment, the Marine Strategy Framework Directive's objective of achieving good environmental status for contaminants will not be achieved by 2020, as contaminants continue to give rise to pollution (Chapter 6).

The Marine Strategy Framework Directive objective regarding contaminants will not be achieved by 2020.

However, success has been achieved in reducing the levels and effects of specific chemicals that are banned such as tributyltin, which has been used in antifouling paint (AMAP, 2018). While there has been a reduction in PCB emissions, air levels remain high (Wöhrnschimmel et al., 2016), as do PCB levels in fish and other marine organisms in the North-East Atlantic and the Baltic and Black Seas. Meanwhile, PCB levels have decreased in northern seas but increased in the Mediterranean (EEA, 2015). Long-lived organisms high up the food chain are particularly vulnerable because of their high accumulation of POPs. Killer whales

**TABLE 10.3 Summary assessment — chemical pollution and impacts on ecosystems**

| | | |
|---|---|---|
| **Past trends and outlook** | | |
| Past trends (10-15 years) | | There are mixed trends, as the occurrence of some individual substances and their related impacts on ecosystems have decreased. However, the effects of most chemicals in the environment have not been assessed, and many of them are likely to have substantial impacts on biodiversity and ecosystems. |
| Outlook to 2030 | | The accumulation of persistent chemicals and continued emissions of hazardous and persistent chemicals into the environment mean that it is likely that impacts of chemical pollution on ecosystems will not decrease. Legacy and emerging pollutants in soil are a particular concern considering the lack of a European policy on soil. Overall, current policies lag behind in addressing a large number of chemicals, and procedures do not keep up with the pace of developments, such as increasing production, new chemicals entering the market, chemicals in imported articles, and gaps in the evidence base. |
| **Prospects of meeting policy objectives/targets** | | |
| 2020 | ☒ | Europe is not on track to minimise the significant adverse effects of chemicals on the environment by 2020. Only 38 % of Europe's water bodies are in good chemical status, and the Marine Strategy Framework Directive objective regarding contaminants will not be achieved. |
| **Robustness** | | The availability of monitoring data on chemicals in the environment influences the assessment of risk, and the risks appear higher where information is available than where it is lacking. The risks are likely greatly underestimated, as only a fraction of chemicals are monitored and assessed, and mixture effects and multiple stressors are not included in risk assessments. Knowledge of the impacts of chemical pollution on ecosystems is very scattered, and outlook information is absent; therefore, the assessment of these impacts relies primarily on expert judgement. |

now risk extinction because PCBs are impairing their reproduction and health (Desforges et al., 2018).

### *Emerging concerns*

Continuous and high-volume releases of bioactive biocides, fungicides, plant protection products, surfactants and pharmaceuticals into the environment affect ecosystems and pose risks for the development of wider antibiotic and fungal resistance. In 2017, the European Commission issued an action plan on antimicrobial resistance (EC, 2017), which will complement existing laws such as the Biocidal Product Regulation (EU, 2012). A strategy for pharmaceuticals in the environment was adopted in March 2019 (EC, 2019a), as called for in the Water Framework Directive and reiterated by a European Council decision in December 2016 (Council of the European Union, 2016). The rapid development and use, and emissions of nanomaterials into the environment, which may pose different and less well-understood risks, is another area of concern (EEA, 2013; EU, 2013; Hansen, 2018).

## *10.3.4 Human exposure to chemical pollution and impacts on human health*

► *See Table 10.4*

The overarching policy goal regarding the impacts of chemicals on health is to minimise significant adverse effects from the production and use of chemicals. There is evidence that human exposure to a complex mixture of hazardous chemicals via environmental pollution generates a range of negative health outcomes (WHO, 2016; Landrigan et al., 2017; Bopp et al., 2018;). The range of chronic diseases associated with exposure to hazardous chemicals includes allergies, asthma, reproductive disorders, neurological disorders such as Parkinson's disease and autism, immune system and cardiovascular disorders, diabetes and cancer. These health impacts may shorten life expectancy (mortality) and/or may lead to increased illness (morbidity) over the course of a lifetime or in later generations (WHO, 2016).

People are exposed to mixtures of chemicals via their diet, the environment and contact with a wide range of consumer products. Some groups of people in society are more vulnerable, either because they are exposed to higher concentrations of hazardous chemicals or to mixtures of chemicals or because their bodies are more sensitive to the impacts of hazardous chemicals. Workers handling chemicals are typically exposed to the highest levels (EU-OSHA, 2017a). Young children and pregnant women are particularly sensitive, as exposure to chemicals that cause developmental toxicity to the endocrine, neurological and immune systems during fetal development and early childhood can result in chronic diseases later in life or in later generations (Grandjean and Bellanger, 2017).

There is a lack of robust data on the actual exposure of the European population to hazardous chemicals to feed into an understanding of the risks to human health. In order to better understand exposure to chemicals, human biomonitoring can be used to measure the concentrations of chemicals in blood, breast milk, urine or hair. The European human biomonitoring initiative, HBM4EU, is currently gathering human exposure data for 17 groups of chemicals, as well as mixtures and emerging substances, and exploring links to health impacts. The aim of the initiative is to produce coherent, comparable exposure data for the European population in order to evaluate existing measures and support the development of targeted policy measures to deliver chemical safety.

In terms of exposure to pesticide residues in food, in 2015 more than 97 % of food samples collected across the EU contained pesticides within the legal limits, with just over 53 % free of quantifiable residues (EFSA, 2017). Concerns remain regarding human exposure to neurotoxic pesticides (Grandjean and Landrigan, 2014; Mie et al., 2018) and mixtures of pesticides (Hass et al., 2017). Regulation 396/2005/EC on the maximum residue levels of pesticides in or on food and feed of plant and animal origin highlights the importance of further work to develop a methodology to take into account cumulative and mixture effects. EFSA is undertaking a number of activities to deliver on this mandate.

Current evidence suggests that POPs and certain metals are responsible for a substantial proportion of the chemical burden on health, both as individual substances and in mixtures (Evans et al., 2016). Under the global monitoring plan conducted by the World Health Organization and UN Environment in support of the Stockholm Convention on Persistent Organic Pollutants, hundreds of POPs have been identified in human breast milk, including PCBs and brominated flame retardants (Fång et al., 2015), as well as per- and polyfluorinated alkyl substances, or PFAS (Nyberg et al., 2018; EFSA, 2018). Due to their bioaccumulation properties, POPs that have been phased out continue to be a significant source of exposure (Evans et al., 2016).

Minimising the signficant adverse impacts of chemicals including pesticides in Europe by 2020 is unlikely.

Methylmercury is an example of a developmental neurotoxicant that affects the brain development of fetuses and young children. The most significant route of human exposure to mercury is diet, with the highest blood mercury concentrations found in communities that consume lot of predatory fish (e.g. species such as marlin, swordfish and tuna). It is estimated that a minority of European fish consumers reach mercury levels considered hazardous by the World Health Organization (WHO) (Castaño et al., 2015). However, children are more vulnerable, and it has been estimated that every year throughout Europe, nearly 1.8 million babies, approximately one third of all births, are born with methylmercury levels above a safe limit (Bellanger et al., 2013). Countries with higher levels of large predatory fish consumption were estimated to have proportionately more babies born with mercury levels above the limit. The potential impact on children's brain development is lifelong and can result in significant cognitive impairment with related economic costs (Grandjean and Bellanger, 2017). Pregnant women can continue to follow official dietary guidelines and consume fish while avoiding large predatory species to lower mercury intake.

People are exposed to mixtures of chemicals via their diet, the environment and contact with a wide range of consumer products.

Concerns have been growing in Europe for many years regarding the risks to health from endocrine-disrupting chemicals, for example bisphenols, phthalates, benzophenones and some pesticides (Kortenkamp et al., 2012; EC, 2018b). Endocrine disruptors interfere with natural hormone systems, can have affects at very low doses and can result in health effects long after the exposure has stopped. Exposure to endocrine disruptors in the womb may disturb the development of the child causing irreversible health effects, and it can even have consequences for the next generation. Endocrine disruption is also associated with health outcomes including lower fertility, obesity and diabetes. The increased incidence of testicular cancer over a short time scale has been linked to exposure to endocrine disruptors (Skakkebaek et al., 2015). A recent study estimated the cost of health impacts from exposure to endocrine disruptors in the EU to be EUR 157 billion annually as a result

**TABLE 10.4 Summary assessment — chemical pollution and risks to human health and well-being**

| | | |
|---|---|---|
| **Past trends and outlook** | | |
| Past trends (10-15 years) | | Despite reduced emissions of some known hazardous substances, concerns remain regarding daily human exposure to chemicals and their health effects, including allergies and premature death of workers. Exposure to legacy pollutants remains a health concern despite emission reductions, as does exposure to developmentally toxic substances, such as endocrine-disrupting, neuro- and immunotoxic chemicals. |
| Outlook to 2030 | | The impact of accumulated chemicals, and continued emissions of hazardous and persistent chemicals, suggests that human exposure to complex mixtures of chemicals will continue to increase. Increased imports of articles and recycling of materials may increase exposure to chemicals of concern. Current policies lag behind in assessing and regulating the risks of exposure to the large majority of chemicals in use. It is therefore unlikely that the negative effects of chemicals on human health will decrease. |
| **Prospects of meeting policy objectives/targets** | | |
| 2020 | ☒ | Europe is not on track to meet the objective of minimising risks to health from hazardous chemicals by 2020. However, progress has been made, and the REACH Regulation has been successful in identifying a number of substances of very high concern and putting risk management measures in place. |
| **Robustness** | | There is a lack of data on exposure and toxicity for a large number of chemicals, as well as knowledge gaps regarding several types of toxicities and mixture toxicity. There are no coherent time trends in exposure data at European level with which to assess trends, and there are data gaps regarding emerging substances. The assessment of past trends, outlooks and prospects of meeting policy objectives relies primarily on expert judgement. |

of disease and dysfunction across the human life course (Trasande et al., 2016). A number of substances in the chemical group phthalates, the most widely used plasticisers, have been found to have endocrine-disrupting properties (DEHP, BBP, DBP and DiBP). These along with bisphenol A are subject to risk management measures under the REACH Regulation (EU, 2016, 2018b).

Exposures to hazardous chemicals and their corresponding health risks are likely to increase in the future.

### *Emerging concerns*

There are growing concerns regarding a large number of emerging substances that are not included in routine monitoring at the European level and for which impacts on environment and health are poorly understood. An example is the group of PFAS which includes more than 4 700 chemicals that are or degrade to very persistent compounds (OECD, 2018). They are widely used as surfactants, stain and water repellents, emulsifiers and lubricants in consumer products, pharmaceuticals, pesticides and industrial processes (Scheringer et al., 2014; Ritscher et al., 2018). As a consequence, PFAS have been found everywhere, even in the most remote parts of the world. Those PFAS that bioaccumulate have been found in high levels in biota and in the blood, organs and breast milk of humans (Nyberg et al., 2018). This generates concern, as several PFAS have been associated with decreased immune system function, increased cholesterol levels, and kidney and testicular cancer (Rappazzo et al., 2017), and some are suspected of being endocrine disrupters (Kar et al., 2017; EFSA, 2018).

In terms of regulatory control, some PFAS are listed as POPs under the Stockholm Convention and are subject to phasing out. Perfluorooctanoic acid (PFOA) is restricted under the REACH legislation, and other PFAS are classified as SVHCs under REACH. Based on new evidence on the harmful effects of PFAS on humans, EFSA has recently provisionally lowered the tolerable intake for PFOA and perfluorosulfonic acid (PFOS) in food and water and estimated that a significant proportion of Europeans are exposed above the health-based limits (EFSA, 2018). A recent study estimated the annual health-related costs due to exposure to PFAS at 2.8-4.6 billion EUR for the five Nordic countries and 52-84 billion EUR for all EEA countries. The costs related to environmental remediation were estimated to be 46 million-11 billion EUR over the next

20 years for the five Nordic countries (Nordic Council of Ministers, 2019).

Antimicrobial resistance is a worldwide, increasing threat to human health (UNEP, 2017). Health and food sectors are heavily involved in action to mitigate the risk (WHO, 2017) but understanding of the significance of the environment as an exposure pathway lags behind (EEA, 2016, 2018b). Major potential areas for transmission are in discharges from industry and urban waste water treatment plants and in the use of biocides and antibiotics in agriculture for veterinary use.

While a range of evidence is presented here for substances known to be hazardous, there are considerable uncertainties regarding the total burden of disease related to chemical exposure and it is likely to be underestimated (Landrigan et al., 2017; Gross and Birnbaum, 2017; Grandjean and Bellanger, 2017). Looking ahead, the projected growth in consumption of chemicals, the rather stable proportion of those known to be hazardous and the accumulation of persistent chemicals together suggest that human exposure to hazardous chemicals is likely to increase, with corresponding impacts on health.

## 10.4 Responses and prospects of meeting agreed targets and objectives

### *10.4.1 Relevance, effectiveness and coherence of current policies*

Chemicals legislation encompasses different policy domains. The REACH Regulation addresses industrial chemicals, while pesticides, pharmaceuticals, food contact materials and others are addressed separately. This complexity of chemicals legislation creates some challenges in terms of coherence and effectiveness, and its relevance is challenged by the frequency with which new chemicals are introduced, the regulation and monitoring of relatively few and mainly single substances and the expansion of our knowledge of the risks of chemicals (EEA, 2013).

up to 70 %

of REACH registration dossiers were found to be noncompliant.

The main drivers for the introduction of the REACH legislation (EU, 2006b) were to address the information gap regarding chemicals and to accelerate risk assessment and the implementation of risk management for existing chemicals to protect human health and the environment (EC, 2019c). Some 10 years after its entry into force, the REACH Regulation is fully operational, although progress towards the objectives is lagging behind initial expectations. The second REACH review (EC, 2018a) identified shortcomings in its implementation that hamper the achievement of its objectives, including up to 70 % of registration dossiers not being compliant (ECHA, 2018b; BFR, 2018) and the need to simplify the authorisation process, ensure a level playing field for non-EU countries and ensure policy coherence between REACH and other legislation. In addition, the time required for substances of potential concern to human health to be evaluated under the REACH legislation has been estimated at 7-9 years, during which time exposure continues. Only after evaluation is complete are risk management measures put in place through processes that also take considerable time. In a context in which over 22 600 chemical substances are registered under REACH, many with unknown properties and impacts, the current substance-by-substance approach involving an extended period until risk management measures are put in place is not fit for purpose. Despite these shortcomings, the REACH Regulation has positioned the EU as a frontrunner in this area and influenced legislation in other countries.

Alongside REACH, the CLP Regulation, the POPs Regulation and the Directive on restriction of hazardous substances (RoHS) have contributed significantly to managing the risks and reducing exposure to hazardous chemicals, such as SVHCs (EC, 2019c). Legislation has, however, not effectively prevented occupational diseases (EC, 2016; EU-OSHA, 2017b), but a roadmap to reduce occupational cancers in Europe has been developed (EU-OSHA, 2017a).

Risk assessments used within chemicals legislation were reviewed as part of the European Commission's fitness check of the most relevant chemicals legislation (EC, 2019c). Risk assessment processes require significant amounts of data as input, but when there are gaps in the evidence base it may lead to a trade-off between decision-making in the context of uncertainty or delaying decision-making to generate more data. When data do not permit a complete evaluation of the risk but the potential risks could be severe, the Treaty on the Functioning of the European Union, Article 191 (EU, 2008a), allows for the application of the precautionary principle. The principle enables a rapid response through preventive decision-taking to protect human, animal or plant health (EC, 2000). However, the precautionary principle is not used to its full potential, as is highlighted in the REACH review (EC, 2018a).

### 10.4.2
### *Cross-cutting challenges*

Although humans and the environment are generally exposed to mixtures of chemicals, the current approach to risk assessment in chemicals legislation is generally based on single substances. Understanding of the risks of exposure to mixtures is growing, and efforts have been made to review available methodologies for risk assessment of mixtures (Bopp et al., 2015, 2016). EFSA has prepared guidance on harmonised methodologies for human and animal health and ecological risk assessment of combined exposure to multiple chemicals (EFSA Scientific Committee et al., 2019). The HBM4EU project will gather and produce data on actual human exposure to mixtures of chemicals as a basis for risk assessment.

Regulating groups of chemicals rather than single substances is being considered by the European Commission and the European Chemicals Agency (ECHA) as a means of speeding up risk assessment, hazard assessment and risk management (ECHA, 2018a, 2018b). Recent examples include the restriction of four phthalates (EU, 2018a) and the proposal to have a PFAS group limit in EU drinking water (European Parliament, 2018). Another argument for regulating groups of substances is avoiding regrettable substitutions, whereby a banned hazardous chemical is replaced by a similar chemical subsequently found to be harmful. In implementing the REACH legislation, ECHA now pays increasing attention to the structural similarity between substances and has also started to consider substances in groups to avoid regrettable substitutions (ECHA, 2018d).

Legacy chemicals that are now strictly regulated but that persist and accumulate in the environment, such as PCBs and heavy metals, remain an issue for both ecosystems and human health.

Designing safer chemicals and products for circular use would support the transition to a circular economy and a non-toxic environment.

Looking ahead, this raises concerns regarding substances currently in use or produced that are persistent, accumulating or mobile. As knowledge on hazards increases, some of these substances are likely to be found to be toxic after they have already been released into the environment. As cleaning up is often not feasible or too costly, this calls for a preventive regulatory focus on such substances.

The 7th EAP calls for safety concerns related to endocrine disruptors to be effectively addressed in EU legislation by 2020 (EU, 2013). In response, the EU published scientific criteria for the identification of active substances in pesticides (EC, 2018b) and biocides (EU, 2017) that have endocrine-disrupting properties. The EU is investing in research on endocrine disruptors to produce evidence and develop methods to support decision-making. The Commission will also launch a comprehensive screening of the legislation applicable to endocrine disruptors, which will include a public consultation (EC, 2018b).

In the 7th EAP, it was anticipated that a non-toxic environment strategy would be developed by 2018, which was intended to address some of these cross-cutting challenges. A future initiative on sound management of chemicals and waste would need to link to the broader international policy agenda, including the strategic approach to international chemicals management and the SDGs.

### 10.4.3
### *Looking ahead to a non-toxic, circular economy*

The transition to a non-toxic environment will require different approaches to managing hazardous chemicals in products and in the environment. The systematic application of the precautionary principle, a stronger focus on preventing emissions, reducing the use of hazardous chemicals in products and regulating groups of substances could all effectively reduce exposure while keeping up with the rapid introduction of new chemicals (EEA, 2018a; EC, 2019c). Establishing inventories of chemicals of concern in products may enable more frequent enforcement and lead to increased levels of compliance (ECHA, 2018c). Early warning systems to detect mixtures of emerging contaminants in air, water and sensitive biota close to emission points could support faster action. An important future task is devising better controls to prevent banned substances from entering Europe as chemicals or in manufactured products (EC, 2019b)

At the same time, Europe aims to develop into a circular economy that maximises the value and use of products and materials through reuse, repair, refurbishment and recycling (Chapter 9). Moving towards a circular economy will therefore require a high level of traceability and a risk management approach that deals with legacy substances and long-term risks (Pivnenko and Fruergaard, 2016; EEB, 2017). Risk assessment needs to consider not only the first life of a product but also all potential future lives and hence different exposure scenarios from those considered in a linear economy. One of the key areas for action will be to ensure the safe disposal of toxic substances at the end of the product's life cycle. Efforts to clean up material flows can enhance the long-term potential for circularity.

Ensuring greater future use of chemicals and products that are safe and circular by design would support the transitions to both a circular economy and a non-toxic environment. Their development requires education of chemists and material designers in how to design and develop safer chemicals and products (Warner and Ludwig, 2016; Kümmerer, 2018), as well as targeted and interdisciplinary innovation support, as highlighted in ECHA's recent strategy (ECHA, 2018d). Moreover, Best Available Techniques conclusions under the Industrial Emissions Directive (Chapter 12) can promote safe-by-design chemicals. A reduction in material and chemical complexity and a focus on ecodesign and on the function delivered by a product will help facilitate the transition to clean material cycles, with good performance and competitive prices compared with using virgin materials (EEA, 2017a). Their uptake can be speeded up through the use of clean procurement (Box 10.4), and considering essential versus non-essential uses. While a transition to a non-toxic and circular economy based on safer chemicals may not be simple to achieve, it could nevertheless provide systemic solutions, which would support environmental sustainability and progress towards the SDGs and boost innovation in Europe.

**BOX 10.4**
**The NonHazCity project: regional knowledge building and public procurement to reduce emissions of hazardous chemicals into the Baltic Sea**

Eleven cities in eight countries (Belarus, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden) joined efforts to reduce emissions of hazardous chemicals into the Baltic Sea. The project addresses small-scale emitters, including municipalities, small and medium-sized enterprises, and households and aims to reduce the use and emissions of hazardous chemicals. Substances selected from the list of priority substances under the Water Framework Directive and substances of very high concern under the REACH Regulation were screened in urban waste water and storm water, in waste water treatment plant influents and effluents and in sewage sludge. Potential upstream sources were identified using maps and data on chemicals in everyday old and new products.

Hazardous chemicals were widely detected. Waste water treatment plants cannot completely remove all chemicals, implying that emissions must be tackled at source. In terms of sources, diffuse sources related to product emissions, such as indoor dust and laundry waste water, are more important than industrial point sources for some chemicals. Old products frequently contain higher levels of hazardous chemicals than new products.

The project recommended public awareness campaigns and dialogue with small and medium-sized enterprises to guide purchasing choices and behaviour. Municipalities can develop and implement clean chemicals strategies and reduce their use of hazardous chemicals through public procurement. Procurement criteria should include hazardous substances and address compliance with relevant legislation. ■

**Source:** Gercken et al. (2018).