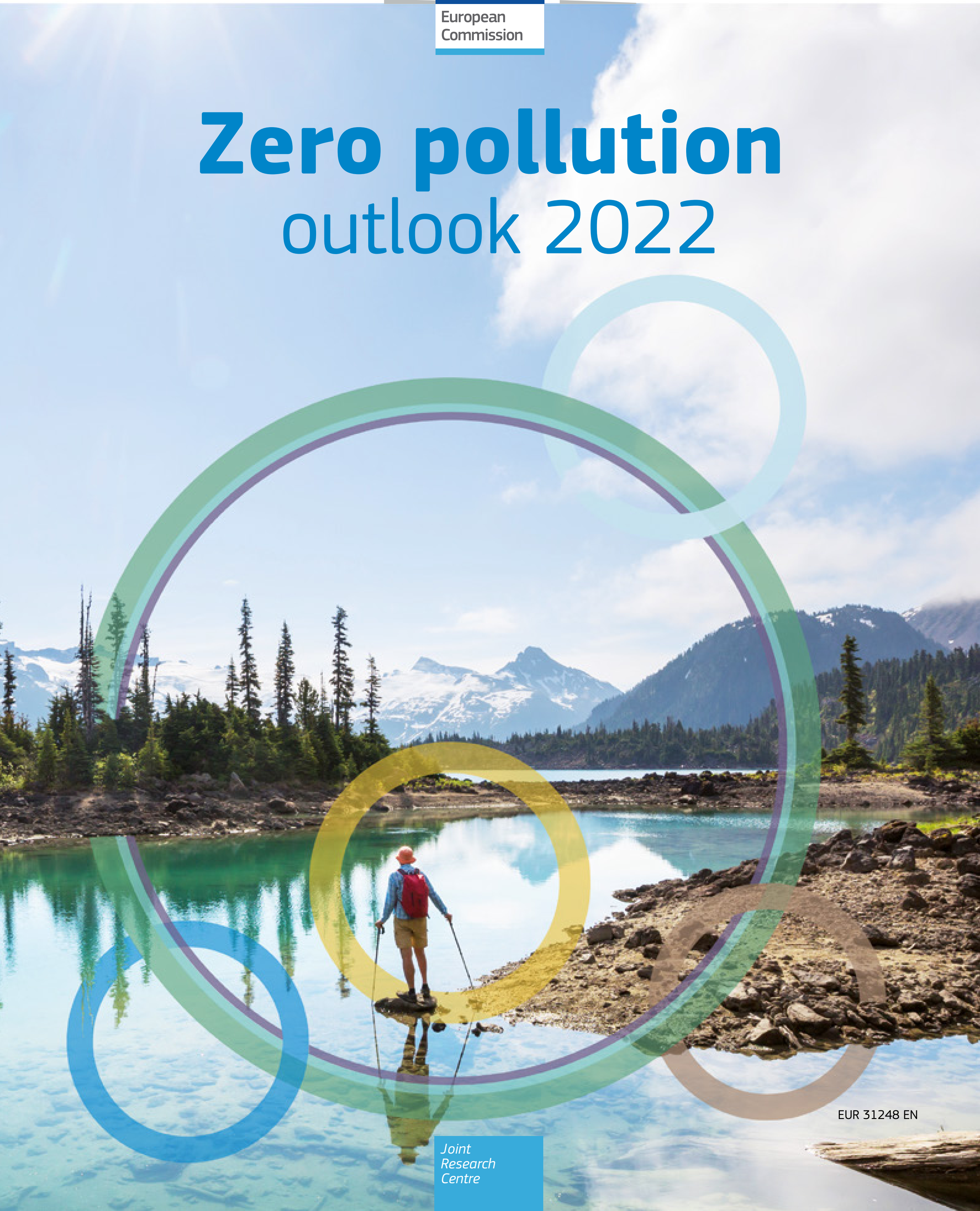
ISSN 1831-9424

European Commission

Zero pollution outlook 2022



EUR 31248 EN

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JRC129655
EUR 31248 EN

Print	ISBN 978-92-76-57575-7	ISSN 1018-5593	doi:10.2760/778012	KJ-NA-31-248-EN-C
PDF	ISBN 978-92-76-57574-0	ISSN 1831-9424	doi:10.2760/39491	KJ-NA-31-248-EN-N

Luxembourg: Publications Office of the European Union, 2022

How to cite this report: Joint Research Centre, *Zero pollution outlook 2022,* Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/39491, JRC129655

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Abstract

Along with climate change and biodiversity loss, pollution constitutes a global issue that threatens the health of our planet, people and societies. With the deployment of the zero pollution action plan, the European Commission acknowledges the importance and urgency of the public health, environmental, moral and socioeconomic case for the European Union (EU) to lead the global fight against pollution.

The zero pollution outlook presents modelling and foresight results that provide a perspective on whether we are on track in terms of the objectives of the EU zero pollution ambitions and the associated EU legislation. This first edition focuses on a selection of objectives and targets for air, water and soil, for which sufficient data and information is available It offers scientific advice to inform decision-makers regarding the actions needed to successfully implement the European Commission's zero pollution action plan.

The report concludes that the first zero pollution target seems to be achievable by 2030 if all planned measures are implemented by Member States - namely the reduction in the number of premature deaths due to air pollution. Reaching the other targets appears more difficult if current trends and developments, such as increased levels of transport, consumption and waste continue.

Integrated nutrient management needs to deliver nitrogen (N) and phosphorous (P) reductions together to maintain a natural N:P balance. This is needed to ensure a healthy aquatic ecosystem and to avoid a worsening of the eutrophication of marine waters.

Soil and water quality suffer from historical pollution with persistent industrial chemicals and heavy metals, a kind of "pollution legacy". In these cases, it could take some time for measures to show effect.

Tackling plastic litter in the seas surrounding the EU depends on international collaboration and coordination as litter, once in the sea, is transported by ocean currents to regions and shores, including those far from their country of origin.

An international view on pollution is also needed, since the EU imports goods whose production causes environmental impacts in their country of origin.

Climate change may also have an impact on the achievability of the targets, could geopolitical developments such as the economic and energy crises which may affect the results of the outlook.

The results provided in this first zero pollution outlook are mainly derived from modelling and foresight studies. In some cases, results are subject to uncertainty as not all necessary data and knowledge is currently available. Results and conclusions therefore give an indication of the direction we are taking, but need to be interpreted in light of inherent uncertainty. We trust that future editions of the zero pollution outlook report, which will be published every two years, will benefit from increasingly solid data availability.

Key interlinkages between different policies (e.g. addressing clean air, soil, water, nutrient management and biodiversity) can mutually contribute to each other's objectives. Synergies and spillover effects should be considered by all actors when implementing policies in order to maximise benefits for the environment, health and society.

The first zero pollution outlook report presents modelling and foresight results that provide a perspective on whether we are on track in terms of the objectives and targets of the European Union's (EU) zero pollution ambitions and the associated EU legislation. It offers scientific advice to inform decision-makers regarding the actions needed to successfully implement the European Commission's zero pollution action plan. Importantly, the report does not cover all objectives and targets for air, water and soil, but a selection based on data and information availability.

Foreword
by Commissioner Gabriel

Dear reader,

The zero pollution action plan (ZPAP) recognises the need for swift action to address the challenges of climate change in an integrated way, by reducing pollution, protecting biodiversity and fostering a circular economy.

We must address pollution at both the EU and global levels. The ZPAP provides a roadmap for achieving its ambitious goals by 2030 and its vision for 2050.

This means that we need to reduce the pollution of air, water and soil to levels that are safe for our health and help preserve natural ecosystems.

Research plays a key role in helping us to make informed decisions and improve the current pollution reduction measures.

The Joint Research Centre has prepared this first zero pollution outlook report, which assesses where we stand with respect to our zero pollution goals for 2030. The outlook will be updated every two years to ensure a reliable overview based on the most up-to-date and accurate information. It will help us to see whether we are on the right track, and what adjustments may be needed in order to achieve the zero pollution targets.

Reducing pollution through the implementation of current policies is a good basis from which to start, but one that requires coordinated efforts in planning, implementation and monitoring.

As our societal actions and consumption patterns influence EU policymaking, we must examine them based on the best available data and state-of-the-art research.

This first edition of the zero pollution outlook, published together with the zero pollution monitoring report and and the zero pollution monitoring and outlook report 2022*, presents a comprehensive roadmap for a future toxic-free environment.

I wish you an enriching read,

Mariya Gabriel

Commissioner for Innovation, Research, Culture, Education and Youth

* (COM(2022 674)

Foreword to the zero pollution monitoring and outlook report 2022 (COM(2022) 674) by Commissioner Sinkevičius

In her mission letter President Von der Leyen asked me to *"lead on delivering on our zero-pollution ambition. This will require a wide-ranging approach looking at air and water quality, hazardous chemicals, emissions, pesticides and endocrine disruptors."* I have been very committed to deliver on this, as the Eurobarometer surveys clearly show that these are precisely the pollution concerns that citizens want us to address. In December 2019 the European Green Deal set the trajectory to bring the EU towards climate neutrality and restored biodiversity by 2050, thanks to a more circular economy, an accelerated deployment of cleaner energy, smarter and more sustainable transport, and a revamped food system, to mention a few.

In May 2021, with the zero pollution action plan, we built on the ongoing climate and environmental sustainability efforts, complementing and integrating them to put the EU on a path towards cleaner air, cleaner water and cleaner soil.

In that action plan we defined the long-term objective that, by 2050 and across the EU, *"air, water and soil pollution is reduced to levels no longer considered harmful to health and natural ecosystems and that respect the boundaries our planet can cope with, thus creating a toxic-free environment."* And we agreed to set six concrete zero pollution targets for 2030 which build upon ongoing decarbonisation and/or depollution efforts in different sectors and policies. These targets cover air, water and noise pollution as well as nutrients, pesticides, antimicrobial and plastics pollution, all of which have a significant impact on our health and biodiversity. The targets also tackle our excessive generation of waste and help us moving towards a circular economy.

This first zero pollution monitoring and outlook report is therefore an important milestone for zero pollution efforts. It answers a number of questions, e.g.: How polluted is the EU? What are the pollution trends over the past years? Can we achieve the 2030 zero pollution targets?

The report underlines once more that the three environmental crises - pollution, climate change, biodiversity loss - are deeply intertwined. Moving to a clean, circular and climate-neutral economic model becomes increasingly pressing – also beyond the EU. The EU is striving to offer global solutions, and at the same time to lead the way. Our efforts are also crucial to address inequalities, as pollution often impacts most on vulnerable groups such as children and the elderly.

This report helps us make the case for our drive towards the zero pollution ambition by showing 'Pathways towards Cleaner Air, Water & Soil for Europe'. The evidence for the need to act is compelling, and so are the challenges and the opportunities. In most areas we are already on a good track, or it is still possible to deliver on our ambition if the proposals tabled by the European Commission are agreed and implemented quickly. This report will support decision-makers along the path towards cleaner air, water & soil and ensure that we deliver the benefits that this will bring.

I would like to particularly thank the European Environment Agency and the Commission's Joint Research Centre for the pioneering work underpinning this first zero pollution report. I am looking forward to working with them to prepare a second and an even more comprehensive report in 2024.

I wish you an interesting read and invite you to spread the word!

Virginijus Sinkevičius

Commissioner for Environment, Oceans and Fisheries

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Acknowledgements

We would like to thank numerous colleagues from the Joint Research Centre, the Directorate-General for Environment and the European Environmental Agency for their advice on analytical approaches, the interpretation of results and the revision of text passages. We are particularly grateful to the European Union Soil Observatory (EUSO) Technical Working Group on Soil Pollution and Anne Maréchal, Elise Van Eynde and Marc Van Liedekerke (European Commission, Joint Research Centre) for the revision of the soil chapter.

Note on the style of this document: The text was drafted in accordance with the Interinstitutional Style Guide rules (10.4.c) in place at the time of drafting, which stipulate that programmes, policies, agendas, strategies, action plans, frameworks, etc. should be written in lower case. (See *https://publications.europa.eu/code/en/en-4100400en.htm*)

Executive summary

Along with climate change and biodiversity loss, pollution is one of the top three global issues threatening the health of our planet, people and societies. With the deployment of the zero pollution action plan, the European Commission acknowledges the importance and urgency of the public health, environmental, moral and socioeconomic case for the European Union (EU) to lead the global fight against pollution.

The zero pollution outlook uses modelling and foresight approaches to provide a perspective on whether we are on track with regard to the objectives of the EU zero pollution ambitions and associated EU legislation. It quantifies the impacts of policies designed to reduce pollution, and evaluates the plausibility of reaching the zero pollution targets for 2030 with current policy measures.

In this first edition, we look at air, water, soil, nutrients, consumption and noise pollution. While we plan to further integrate these Earth system compartments in future editions of the zero pollution outlook, the current report addresses them in separate chapters.

The zero pollution outlook also includes a foresight component that describes alternative pathways and new trends that could reshape societies and economies in the future.

This first edition of the zero pollution outlook report covers a selection of objectives and targets for air, water and soil based on data and information availability. It is published together with an integrated Commission report on zero pollution monitoring and outlook and the first zero pollution monitoring report by the European Environment Agency [Box 1, page 14]. Produced under the remit of the zero pollution action plan, these reports provide an overview on where we currently stand and whether we are on track for the future in terms of zero pollution ambitions and objectives. They are designed to inform stakeholders and to support decision-makers with information based on best available scientific evidence.

The current report focuses on a selection of objectives and targets for air, water and soil, for which sufficient data and information is available. We will extend our analysis in future editions of the zero pollution outlook.

The main findings of the zero pollution outlook for air, water, soil, nutrients, the consumption footprint, noise and foresight are summarised in the following.

Air

Although emissions of pollutants to air have reduced over recent decades, primarily as a result of legislation, air quality remains a major concern in many parts of Europe. Air quality limits set by EU legislation for particulate matter, nitrogen dioxide and ozone continue to be exceeded, especially in many urban areas. Consequently, the number of premature deaths and diseases attributable to air pollution remains high.

These results illustrate the strong inter-linkages between clean air and biodiversity policies, and how they mutually contribute to each other's objectives. For example, the ammonia reduction measures proposed by Member States and the proposed regulation on nature restoration can deliver benefits for both clean air and biodiversity. These synergies should be considered by all actors when implementing policies in order to maximise societal benefits.

The key 2030 zero pollution targets for air are:

Target 1: to reduce by more than 55 % the health impacts (premature deaths) of air pollution,

Target 3: to reduce by 25 %, the EU ecosystems where air pollution threatens biodiversity.

The Commission's third clean air outlook report finds that it is possible to reach the health-related target, but only if appropriate clean air measures as well as the climate and energy policies of the fit for 55 package are implemented. In such a situation, the number of premature deaths due to air pollution would fall by 66 % by 2030, compared to 2005 figures.

This encouraging conclusion does not apply to the ecosystem target. The third clean air outlook shows that, even if all agreed measures and policy proposals are implemented, the area of EU ecosystems under threat from air pollution would only reduce by 20 % by 2030 compared to 2005. However, the 25 % target could be achieved with more stringent air pollution policies, and closer alignment of EU air quality standards with the updated World Health Organization (WHO) guidelines, as put forward by the Commission in its proposal for a revision of the ambient air quality directives.

Water

Aquatic ecosystems are often the final recipients of pollutants originating from as soil or air. The zero pollution action plan helps strengthen and streamline the governance of freshwater systems and the marine realm, and increase the added benefit of EU intervention in the fight against aquatic pollution.

The key 2030 zero pollution targets for water are:

Target 5: to reduce by 50 % plastic litter at sea and by 30 % microplastics released into the environment,

Target 4: to reduce by 50 % nutrient losses, the use and risk of chemical pesticides, the use of the more hazardous ones, and the sale of antimicrobials for farmed animals and in aquaculture.

The latter target indirectly impacts rivers, lakes and seas. Based on an integrated modelling framework, the JRC analysis yielded the following key findings.

Nutrients: Application of very ambitious measures can help reduce nitrogen (N) and phosphorous (P) inputs to marine ecosystems by 32 % and 17 %, respectively. The zero pollution target (50 % reduction) would be achieved in only 4 out of the 10 EU marine regions analysed for N, and in 2 out of 10 for P. In some marine regions, an unbalanced reduction of N and P could alter the natural N:P ratio, potentially favouring phytoplankton blooms. Nutrient reduction measures are found to have more impact in coastal marine regions than in open seas. Strategies therefore need to address N and P reductions together and consider regional characteristics.

Chemicals: For the Black Sea (the only marine basin for which sufficient data is available), reducing chemical pesticide use by 50 % by 2030 translates into a decrease in marine concentration of -56 % (shelf) to -12 % (open sea), depending on the pesticide persistence. Climate change could lead to variations in hydrological conditions, potentially counteracting the impacts of policy measures.

Plastics: In the Mediterranean Sea, only 24 % of all macrolitter originates from EU countries, but pollutes 40 % of non-EU beaches, highlighting the high interconnectivity of litter pollution in this marine region. A total ban on single-use-plastic items in the EU would only reduce total litter by 14 %. The zero pollution target of 50 % would only be achieved in about 8 % of the basin's surface and on about 44 % of all beaches. A total ban on plastic littering in the EU would reduce total litter by 25 % in 50 % of the basic surface and 54 % of beaches. Consequently, the EU cannot, by itself, achieve the zero pollution target in the Mediterranean Sea.

Soil

Due to stronger legally binding EU frameworks, the monitoring and outlook of air and water pollution has been more advanced to date than for soil. As a result, and given the inherent complexity of soils, there are substantial knowledge gaps, particularly regarding the levels of several contaminants in soil.

The vision for 2050 for soil pollution to be reduced to levels no longer considered harmful to human health and natural ecosystems, thereby creating a toxic-free environment, translates into objectives of preventing and reducing pollution by

- reducing diffuse soil pollution from industrial emissions and transport by improving air quality,
- reducing the use of polluted water on land and reducing emissions from soil to water,
- reducing emissions to water from soil and the use of polluted water on land,
- reducing waste streams to land that introduce pollutants to soils,
- engaging in a more sustainable use and management of soils.

Addressing soil pollution can be complicated, as some potentially harmful substances occur naturally in undisturbed soils, independent of human activities (e.g. salt from groundwater). Also, several potentially harmful substances, such as pesticides, are deliberately applied to the soil. Some organic waste streams enrich the soil with nutrients and organic matter (e.g. manure, sewage sludge). While soils can filter and transform pollutants, they can also accumulate them and become a potential source of pollution for other media.

The adoption of the integrated nutrient management action plan and the proposal for the safe use of processed manure above the threshold established for nitrate-vulnerable zones by the nitrates directive (91/676/EEC) should lead to a more efficient use of nutrients, and hence a reduction in the loss of nitrates and phosphates from soil to water and air.

The rate of excess nitrogen in agricultural lands remained around 50 Kg per hectare from 2010 to 2014, with negative effects on the rates of both nitrogen runoff and nitrogen leaching. These nitrogen pollution rates should decrease as the farm-to-fork strategy is implemented and fertiliser use is reduced by at least 20 % by 2030 (see chapter 2.4 - nutrients outlook).

Some scenarios indicate a potential 6-11 % increase in phosphorous losses due to soil erosion by 2050, given the projected increase in soil erosion in the EU. By the same reasoning, mercury displacement rates could increase to 49-53 tonnes annually if global emissions of mercury remain constant.

Concentrations of heavy metals in soils should not increase significantly once European actions to reduce the application of metals to soils are implemented.

The target of increasing organic farming in the EU to at least 25 % of agricultural areas should significantly increase the uptake of agroecological practices and lead to a reduction in the use of synthetic pesticides.

Pollution from the residues of plant protection products (pesticides) is expected to decline under the farm-to-fork (F2F) strategy.

The global pollution of terrestrial and aquatic environments by plastics is substantial and increasing. By 2019, 22 million tonnes (Mt) of plastics were introduced into the terrestrial environment, with a projection that this figure will double to 44 Mt by 2060. Based on this we can estimate an increase in the incorporation of microplastics into soils through sewage sludge in the order of about 62-84 thousand tonnes annually.

Nutrients

While nutrients, specifically nitrogen (N) and phosphorous (P), are fundamental elements for growing plants and sustaining life on Earth, they can become pollutants when present in excessive amounts in water, soil and the atmosphere. Agricultural intensification and the use of fossil fuels have strongly altered the natural biogeochemical cycles of these elements. The upcoming integrated nutrient management action plan will propose further policy measures to improve the efficiency of nutrient use and reduce losses to the environment, and will explore novel techniques for recovering and recycling nutrients.

Four of the six zero pollution targets for 2030 are directly or indirectly related to excess nutrients in the environment.

- **Target 1:** reduce by more than 55 %. the health impacts (premature deaths) of air pollution,
- **Target 3:** reduce by 25 % the EU ecosystems where air pollution threatens biodiversity,
- **Target 4:** reduce by 50 % nutrient losses, the use and risk of chemical pesticides, the use of the more hazardous ones, and the sale of antimicrobials for farmed animals and in aquaculture,
- **Target 6:** reduce significantly total waste generation and by 50 % residual municipal waste.

The outlook for nutrients assesses scenarios to reduce nutrient losses in different emissions pathways, such as by transforming N and P from organic waste into concentrated mineral fertilisers and reducing mineral N fertilisers in agricultural areas with N surpluses. A more balanced approach might lead to savings of N fertilisers and a reduction in overall N losses.

The potential effects of existing and proposed EU policy instruments on nutrient losses to air and water include:

1. reducing nutrient discharges from domestic wastewaters (revision of the urban wastewater treatment directive);

2. reducing nutrient emissions from agricultural sources (new common agricultural policy (CAP), the F2F strategy, the biodiversity strategy (BDS) and NextGenerationEU funds);

3. reducing nitrogen input from atmospheric deposition (fit for 55 package and in the national emission ceilings (NEC) directive).

All of the various scenarios for the future of the agrofood system of Europe in 2050 (business-as-usual, implementation of the F2F targets and more far-reaching agroecological scenarios) meet European food demand (under different diets), but are associated with differing levels of international trade and environmental impacts.

If all the measures modelled in the scenarios are implemented, the nutrient load in European seas could be reduced by about 30 % for N and 20 % for P.

Consumption footprint

The European Commission has developed an assessment framework to monitor the evolution of the environmental footprint of EU production and consumption, and to compare the footprint against the planetary boundaries. The consumption footprint is based on a set of 16 life-cycle-assessment-based indicators that provide a systemic and holistic assessment of transitions towards sustainability.

Over the past decade, environmental impacts of domestic consumption within the EU have decreased by 13 % as a result of EU territorial policies, but the total environmental impacts of EU consumption have increased by 4 % (mainly due to a growth in the intensity of food consumption, mobility and housing). This indicates that the EU is importing environmental impacts embedded in imported goods. Current impacts have transgressed several planetary boundaries associated with emissions to the environment (air, water and soil).

The environmental impacts of EU consumption are projected to keep increasing until 2030 in line with economic development. This will keep the EU consumption footprint beyond the planetary boundaries for several categories associated with environmental pollution. Although the projected evolution under the EU ambitions scenario is slightly better than under the business-as-usual scenario, it does not show a significant effect in reducing the impacts to the level needed to remain within the planetary boundaries.

While the third clean air outlook foresees that the health-related air pollution target will be met (see chapter 2.1 - air outlook), it looks at this target from a territorial perspective, focussing on direct emissions from within the EU. However, from a consumption and supply chain perspective, pollution impacts also include emissions associated with EU imports, that are generated outside the EU. From this perspective, the consumption footprint outlook indicates that further efforts are needed to ensure that EU production and consumption does not shift environmental burdens to third countries. Similarly, the impacts of pollution on ecosystems and biodiversity outside the EU due to EU consumption should also be considered and reduced.

Transport noise

Long-term exposure to environmental noise is a widespread problem across Europe. In 2017, about 18 million people in the EU suffered from long-term high annoyance due to transport noise from road, rail and aircraft sources. One of the headline targets of the zero pollution action plan is to reduce the number of people chronically disturbed by transport noise by 30 % by 2030 compared with 2017.

The results of this outlook assessment suggest that there are no prospects of achieving the noise target by 2030 with the planned noise mitigation measures. In fact, even our optimistic scenario suggests that a reduction of only about 19 % in the number of people chronically disturbed by transport noise could be achieved. This is because the projected growth in population and transport outweighs the benefits of implementing the measures.

The main obstacle to reaching the zero pollution target is the large number of people exposed to road traffic noise, with road traffic being by far the most prevalent source of noise. Although the scale of the impacts of rail noise is much less than that of road traffic noise, increased efforts need to be made to outweigh the negative health impacts resulting from projected growth in rail activity, new rail infrastructure and faster trains. In terms of aircraft noise, even if the number of people highly annoyed is reduced by as much as the scenarios project, a very high number of people will still be exposed to levels of aircraft noise that the World Health Organization considers to be harmful tohealth.

Foresight

Foresight helps understand the possible consequences of current trends, detect signals of change and determine their potential developments. The horizon scanning of emerging environmental issues related to the zero pollution ambition has identified five clusters of developments that point towards the emergence of new drivers and sources of pollution, alongside opportunities to reduce the pollution burden of some sectors:

1. Pervasive digital tools and lifestyles: As life and work become more digitalised, remote work and "virtual lifestyle services" increasingly reduce physical consumption of goods and services, potentially leading to reduced pollution;

2. Transformations in where and how we live and work: More flexible work patterns, a focus on health and welfare, and the impacts of climate change could lead to an exodus of office workers from urban centres to urban peripheries, small towns and rural areas;

3. New pollution monitoring and data methods: New sensors, new sources of data, and more complete and transparent monitoring will lead to increased availability and accuracy of information on pollution;

4. Living buildings and new materials: A new range of building materials, together with the use of sensors and advanced manufacturing, could lead to more regenerative buildings that could self-repair and even grow, provide a source of food, and absorb air and chemical pollution;

5. Multi-faceted food-system revolutions: Regenerative agricultural approaches and food system developments such as cellular agriculture and synthetic biology will have far-reaching implications for agriculture, possibly reducing the use of agricultural chemicals, runoff to water bodies and long-distance transport. However, such developments could require new inputs and more energy.

The world of 2050 may be very different from that of today. Cross-cutting foresight capacity for zero pollution could focus on

1. regular horizon scanning of emerging issues related to pollution;

2. combining quantitative projections and modelling with more qualitative foresight scenarios that integrate the air, water and soil pollution dimensions;

3. backcasting from the future to the present to imagine the milestones and indicators necessary to fulfil the zero pollution ambition and identify pathways towards a zero pollution future.

The following chapters of this zero pollution outlook provide more detailed analyses that further illustrate these findings. Generally, data and knowledge gaps lead to uncertainty with respect to the results of our modelling. Results and conclusions therefore provide an indication of whether we are on the right track but need to be interpreted in light of inherent uncertainty. We trust that the zero pollution outlook reporting, which will be repeated every two years, will benefit from combined efforts of Member States and stakeholders to ensure a progressive increase in the availability of robust and reliable datasets.

Overall, the zero pollution outlook shows that we need to make a bigger efforts in the areas covered. Key interlinkages between different policies (e.g. addressing clean air, soil, water, nutrient management and biodiversity) can mutually contribute to each other's objectives. Synergies and spillover effects should be considered by all actors when implementing policies in order to maximise benefits for the environment, health and society.

Table 1: *Zero pollution targets for 2030. This table summarises the zero pollution targets, highlights what can be achieved ('achievable target') and outlines which conditions have to be met to ensure target achievability ('Conditions/Recommendations'). Please note that this table does not cover all objectives and targets for air, water and soil but a selection based on data and information available.*

Zero pollution targets for 2030	Achievable target (based on available information and analysis used for this report)	Conditions/Recommendations (based on available information and analysis used for this report)
Target 1		
Reduce the health impacts (premature deaths) of **air pollution** by more than **55 %**	**66 %** reduction in premature deaths due to air pollution between 2005 and 2030.	Full and swift agreement and Implementation of the Commission proposals with clean air benefits, as well as the more ambitious climate and energy policies of the fit for 55 package.
Target 2		
Reduce the share of people chronically disturbed by **transport noise** by **30 %**	**19 %** reduction under an optimistic scenario.	The benefits of implementing the measures are outweighed by the projected growth in population and transport; while road traffic is the most prevalent source of noise, rail and air traffic are projected to increase.
Target 3		
Reduce the area of EU ecosystems where **air pollution threatens biodiversity** by **25 %**	**20 %** reduction by 2030 compared to 2005.	Full and swift agreement and implementation of the Commission proposals with clean air benefits, as well as the ambitious climate and energy policies of the fit for 55 package, and in particular the Commission proposals to revise the ambient air quality directives and the industrial emissions directive
Target 4		
Reduce **nutrient losses**, the use and risk of chemical pesticides, the use of the more hazardous ones, and the sale of **antimicrobials** for farmed animals and in aquaculture by **50 %**	Possible reduction of nutrient inputs into marine ecosystems: nitrogen **32 %**, phosphorous **17 %** **50 %** reduction in nutrient inputs could be achieved in four of the ten examined regions for nitrogen and in two of the ten for phosphorous. **56 %** reduction in pesticides concentration can be achieved in shelf seas, **12 %** in open seas, depending on the persistence of the pesticide. Reduction of (more hazardous) pesticide concentration in soil due to increased organic farming and other farm-to-fork objectives.	In addition to reducing nitrogen atmospheric emissions, and measures under the common agricultural policy to achieve the targets of the biodiversity and farm-to-fork strategy, further actions are needed to reach the target of nutrient losses by 2030 Strategies need to address nitrogen and phosphorous reductions together in order to avoid imbalance and worsening of eutrophication conditions in marine waters. Reduction measures have more impact in coastal marine regions than in open sea areas. Climate change may lead to variations in hydrological conditions and could thus potentially counteract the impacts of policy measures
Target 5		
Reduce **plastic litter** at sea by **50 %** and **microplastics** released into the environment by **30 %**	**14 %** reduction of plastic litter (in **8 %** of the basin surface of the Mediterranean Sea and **44 %** of all beaches) with a total ban on single-use-plastic items. **25 %** reduction of plastic litter (in **50 %** of the basin surface and **54 %** of all beaches) with a total ban on plastic littering in the EU. Microplastic concentration in soils is expected to further increase (double by 2060 compared to 2019) due to the incorporation of sewage sludge.	International collaboration and coordination is needed as only **24 %** of all macrolitter in the Mediterranean Sea originates from the EU. The EU cannot, by itself, achieve the zero pollution target in the Mediterranean Sea but could act as a role model for neighbouring regions.
Target 6		
Significantly reduce total **waste** generation and residual municipal waste by **50 %**	Will be addressed in the next edition of the outlook report	

Box 1.

The zero pollution reporting under the remit of the zero pollution action plan:
Pathways towards cleaner air, water and soil for Europe.

The reporting under the zero pollution action plan consists of three elements: the integrated Commission report on zero pollution monitoring and outlook, the zero pollution monitoring report and the zero pollution outlook report.

The **integrated Commission report on zero pollution monitoring and outlook** (COM(2022) 674) is an integral part of the 8th environment action programme monitoring framework. It compiles information derived from the zero pollution monitoring and outlook reports and sets the starting point for the 'Pathways towards Cleaner Air, Water & Soil for Europe'.

The **zero pollution monitoring report** (EEA 2022e) is compiled by the European Environment Agency (EEA) and integrates the most relevant past and current data across all pollution areas monitored at EU level. It assesses progress to date against the objectives and targets detailed in the zero pollution action plan. It does so through its ongoing monitoring and reporting on the state of the European environment and through its collaboration with the European Environment Information and Observation Network (Eionet). The EEA assessment is available online here: Zero pollution — European Environment Agency [https://www.eea.europa.eu/publications/zero-pollution].

The **zero pollution outlook report** is produced and coordinated by the Joint Research Centre of the European Commission (JRC). It presents modelling and foresight results, assessing the expected pollution-reduction benefits of key, including recently tabled, EU policy initiatives. This first zero pollution outlook report has been fed by JRC in-house analyses on water/marine, soil, nutrients, consumption & production, the European Commission's third clean air outlook report, as well as topical outlook assessments on noise (contributed by the EEA) and key findings from the EU environmental fore-sight system. It offers scientific advice to inform decision-makers regarding the actions needed to successfully implement the European Commission's zero pollution action plan. Importantly, the report only covers a selection of objectives and targets for air, water and soil but a selection, based on the availability of data and information needed for the analytical process.

1. Introduction

Earth Overshoot Day[1] marks the date on which humanity has used all the biological resources that Earth regenerates during the entire year. In 2022, Earth Overshoot Day fell on 28 July, the earliest since it was first recorded in 1971. We now need 1.75 planet Earths in order to maintain our current levels of consumption.

Pollution contributes greatly to the critical condition of our planet. Along with climate change and biodiversity loss, it is one of the top three global issues threatening the health of our planet. Pollution also poses a threat to humankind and our societies: it causes nine million premature deaths per year - one in six deaths worldwide. The fact that we need to act is confirmed by the latest EU surveys, in which citizens regularly rank public health among the top issues in terms of policy priorities. By reducing gross domestic product (GDP), pollution also damages our economy and social fabric.

With the deployment of the zero pollution action plan, the European Commission acknowledges the importance and urgency of the EU's case for leading the global fight against pollution, from public health, environmental, moral and socioeconomic perspectives.

Box 2. The zero pollution ambition, taken from EU action plan: "Towards zero pollution for air, water and soil"

The zero pollution vision for 2050: a healthy planet for all

Air, water and soil pollution is reduced to levels no longer considered harmful to health and natural ecosystems and that respect the boundaries our planet can cope with, thus creating a toxic-free environment.

The zero pollution targets for 2030

Under EU law, Green Deal ambitions and in synergy with other initiatives, by 2030 the EU should reduce:

1. by more than 55 % the health impacts (premature deaths) of air pollution;
2. by 30 % the share of people chronically disturbed by transport noise;
3. by 25 % the EU ecosystems where air pollution threatens biodiversity;
4. by 50 % nutrient losses, the use and risk of chemical pesticides, the use of the more hazardous ones, and the sale of antimicrobials for farmed animals and in aquaculture;
5. by 50 % plastic litter at sea and by 30 % microplastics released into the environment;
6. significantly total waste generation and by 50 % residual municipal waste.

Box 2. *The zero pollution ambition, taken from the EU action plan: "Towards zero pollution for air, water and soil"*

(1) *https://www.overshootday.org/*

Successfully addressing the related threats of pollution, biodiversity loss and climate change requires coherent policies that are based on the best available scientific advice. The zero pollution outlook offers a starting point and paves the road towards the zero pollution ambitions. It ultimately aims to quantify the effectiveness and impacts of existing or planned policies designed to reduce pollution, and to evaluate the plausibility of reaching the zero pollution targets for 2030 with the tested set of policy options.

Until now, from an analytical perspective, air, water and soil have tended to be looked at separately, even though pollution released into the air can be transferred to soil and end up through rivers in the ocean. The inevitable 'pollution link' between these three realms prompts us to pursue their integration into the modelling and analytical frameworks underpinning our zero pollution outlook. This we have achieved to an extent for freshwater and marine systems, but less so for air and soil. While it is our ambition for future editions of the zero pollution outlook to further expand the integration of different Earth system components, this outlook report addresses air, soil and water in separate chapters.

The zero pollution outlook also includes chapters on integrated nutrient management, the consumption footprint, noise and foresight for the zero pollution ambition.

This first edition of the zero pollution outlook is published together with the zero pollution monitoring report and a communication by the European Commission (see Box 1). Taken together, these documents - produced under the remit of the zero pollution action plan - provide an overview on where we currently stand and whether we are on track for the future in terms of our zero pollution ambitions and objectives.

Through this report, we aim to inform stakeholders and to support decision-makers with information based on the best available scientific evidence. Since pollution is a complex and evolving concern, and as we are confident that we will continue to fill data gaps and enhance our knowledge, both the zero pollution outlook and the monitoring reports will be published every two years.

2. Zero pollution outlook – main findings

In the following pages, we summarise the main findings stemming from analytical work covering air, water and soil. Further chapters address nutrient management, the consumption footprint, transport noise and foresight for the zero pollution ambition. The chapters are based on several projects and initiatives, including modelling or foresight studies which are coordinated or carried out by the European Commission and (for noise) the European Environment Agency.

Air outlook

2.1. Air outlook

Air pollution[2] causes over 6.5 million premature deaths each year globally, and this number is increasing (The Lancet, 2022). In the European Union, it is the single largest environmental health risk, causing cardiovascular and respiratory diseases that lead to the loss of healthy years of life and, in the most serious cases, premature deaths (about 240 000 reported in the European Union (EU) for 2021) (European Environment Agency (EEA), 2022d).

Ecosystems are affected by air pollution, primarily by the deposition of sulphur- and nitrogen-containing compounds and tropospheric ozone (O_3) concentrations. Tropospheric ozone causes damage to plant cell membranes, which consequently reduces agricultural crop yields and affects biodiversity. Deposition of excess nitrogen compounds can cause eutrophication in both terrestrial and aquatic ecosystems.

Although emissions of air pollutants have been reduced over recent decades (primarily as a result of legislation), air quality remains a major concern in many parts of Europe. Air quality limits set by EU legislation for particulate matter, nitrogen dioxide and ozone continue to be exceeded, especially in many urban areas. According to the EEA (2022d), the EU urban population exposed to concentrations above the 2021 World Health Organization (WHO) annual guideline values is about 70 % for coarse particulate matter (PM_{10}), about 70 % for nitrogen dioxide (NO_2), and more than 90 % for ozone (O_3) and fine particulate matter ($PM_{2.5}$). Consequently, the number of premature deaths and other diseases attributable to air pollution remains high. The same holds true for ecosystems, with about 40 % of the agricultural area, 87 % of the forest area and 74 % of the ecosystem area exposed to levels above the critical levels established by the United Nations Economic Commission for Europe (UNECE) Air Convention (UNECE, 1979).

“Air quality limits are exceeded in the EU, particularly in urban areas.”

(2) Note that the ‘Save gas for a safe winter’ Communication (COM(2022) 360 final) is not included in the analysis developed for the third clean air outlook report, as the time horizon of the report goes beyond the short-term actions presented in the communication.

The EU has a robust regulatory framework in place designed to address ambient air pollution based on three interconnected pillars.

1. Improving air quality. The ambient air quality directives (2008/50/EC, 2004/107/EC) set EU air quality standards, guide the assessment of air quality (through a high-quality monitoring network), call for Member States to prepare air quality plans to ensure compliance when standards have been exceeded, and require the dissemination of information to the public. On 26 October 2022, the Commission proposed[3] that the EU's air quality standards be aligned more closely with the 2021 WHO recommendations, and that provisions for monitoring, modelling and air quality plans be strengthened to help local authorities achieve cleaner air, while improving the overall enforceability of the regulatory framework.

2. Reducing national emissions of air pollutants. The national emissions ceilings (NEC) directive (2016/2284) sets reduction commitments for five main air pollutants that have a significant negative impact on human health and the environment (SO_2, NOx, non-methane organic volatile compounds, NH_3 and $PM_{2.5}$). The directive also requires national air pollution control programmes to be drawn up, adopted and implemented. In 2022, the Commission checked the fulfilment of the 2020 national emission-reduction commitments based on the reported national emissions for 2020, and will follow up as needed.

3. Reducing air pollution from key sectors. Several directives regulate the emissions of air pollutants from various sources: agriculture (e.g. Regulations (EU) 2021/2116 and (EU) 2021/2115 on the common agricultural policy), transport (e.g. Directive 2009/33/EC on clean road transport vehicles, Regulation (EU) 2019/631 on CO_2 emissions for new passenger cars, Directive 2014/94/EU on the deployment of alternative fuels infrastructure), energy (e.g. Directive 2009/125/EC on eco-design, Directive 2012/27/EU on energy efficiency, Directive (EU) 2015/2193 on medium combustion plants), industry (Directive 2010/75/EU on industrial emissions, Directive 2004/42/EC on volatile organic compounds emissions, etc.), waste, and in relation to climate actions. The Commission has proposed the introduction of stricter requirements in several of these policy fields so that air pollution is better tackled at the source. This includes several European Green Deal measures and strategies such as sustainable and smart mobility, the renovation wave initiative, and the farm-to-fork strategy.

(3) COM(2022) 542 final.

In the following sections, we review the objectives and actions proposed by the zero pollution action plan (ZPAP) to reduce the impacts of air pollution on human health and ecosystems by 2030–2050.

2.1.1. The zero pollution ambitions

As part of the European Green Deal, the zero pollution vision for 2050 is to create a toxic-free environment by reducing air, water and soil pollution to levels that are not considered to be harmful to health and natural ecosystems, and that respect the boundaries within which our planet can cope.

The key 2030 zero pollution (ZP) targets for speeding up air pollution reduction at the source include the following.

- **Target 1:** Reduce the health impacts of air pollution (estimated by the number of premature deaths caused by fine particulate matter) by more than 55 % by 2030 compared to 2005.
- **Target 3:** Reduce the area of EU ecosystems where air pollution threatens biodiversity (estimated by the ecosystem areas that contain above 'critical loads' of nitrogen deposition) by 25 % by 2030 compared to 2005.

2.1.2. Putting the zero pollution ambitions to the test

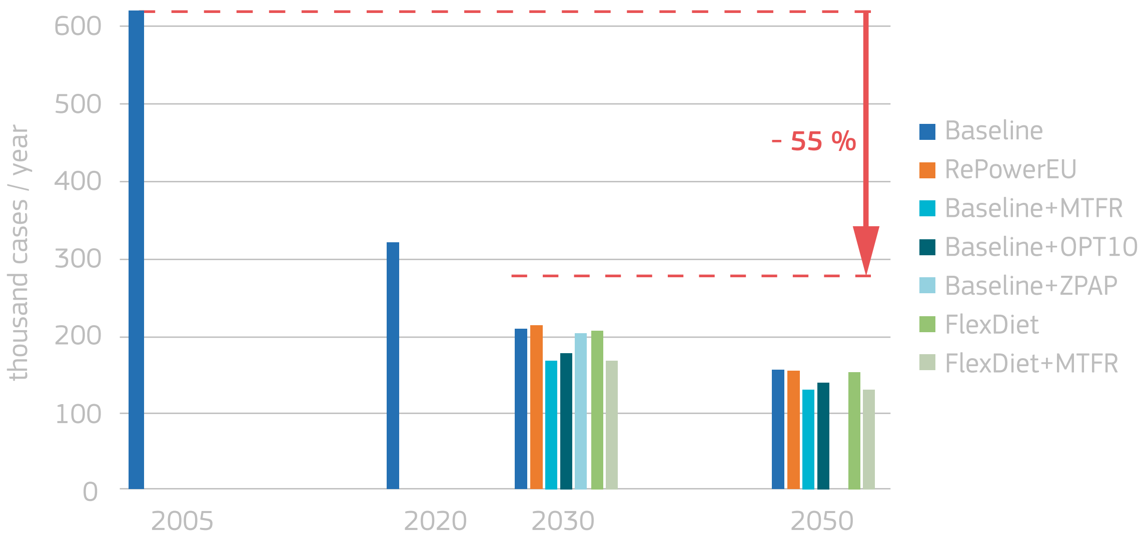
The two ZP targets for 2030 linked to the reduction of air pollution were defined based on the findings of the European Commission's second clean air outlook report. They are designed to be achievable if all related policies – at EU and Member State levels – are fully implemented. In particular, regarding the health-related target, the reduction in the number of premature deaths due to air pollution was projected to be achievable by 2030 if all Member States fully implement all measures announced in their first national air pollution control programmes (Article 6 of Directive (EU) 2016/2284) and other relevant EU legislation (in particular, those relating to energy and climate policies). In addition to the full implementation of these policies and measures, achieving the ecosystem target requires complementary measures, notably related to the delivery of the farm-to-fork (F2F) strategy and the biodiversity strategy (BDS).

The European Commission's third clean air outlook report (European Commission, 2022b), which is based on a study of the International Institute for Applied Systems Analysis (IIASA), updated several aspects of this analysis. Particularly relevant for the ZP targets is the inclusion in the baseline scenario of the Commission's fit for 55 proposals and of the agriculture-related elements of the proposal to revise the industrial emissions directive (IED). The modelling results show that it is possible to reduce the number of premature deaths by more than 55 % by 2030, provided that the envisioned clean air measures, along with the more ambitious climate and energy policies of the fit for 55 package, are implemented. In such a situation, the number of premature deaths due to air pollution would actually decrease by 66 % between 2005 and 2030, putting the EU on a suitable trajectory towards its zero pollution ambition for 2050 with respect to the health impacts of air pollution[4]. These results remain mostly stable when factoring in the latest projections for the energy mix incorporating, on top of the measures already included in the baseline, the consequences of phasing out fossil fuels from Russia and the RePowerEU measures (with a slight increase in premature deaths by 2030 due to increased use of coal).[5]

(4) Please note that, in addition to the third clean air outlook used in this report, the report from the Commission on zero pollution monitoring and outlook (COM(2022) 674) also takes into account the recent revision of the ambient air quality directives, concluding that “it is likely that reductions by about 71 % and 78 %, compared to 2005 levels, can be achieved in 2030 and 2050 respectively.”.

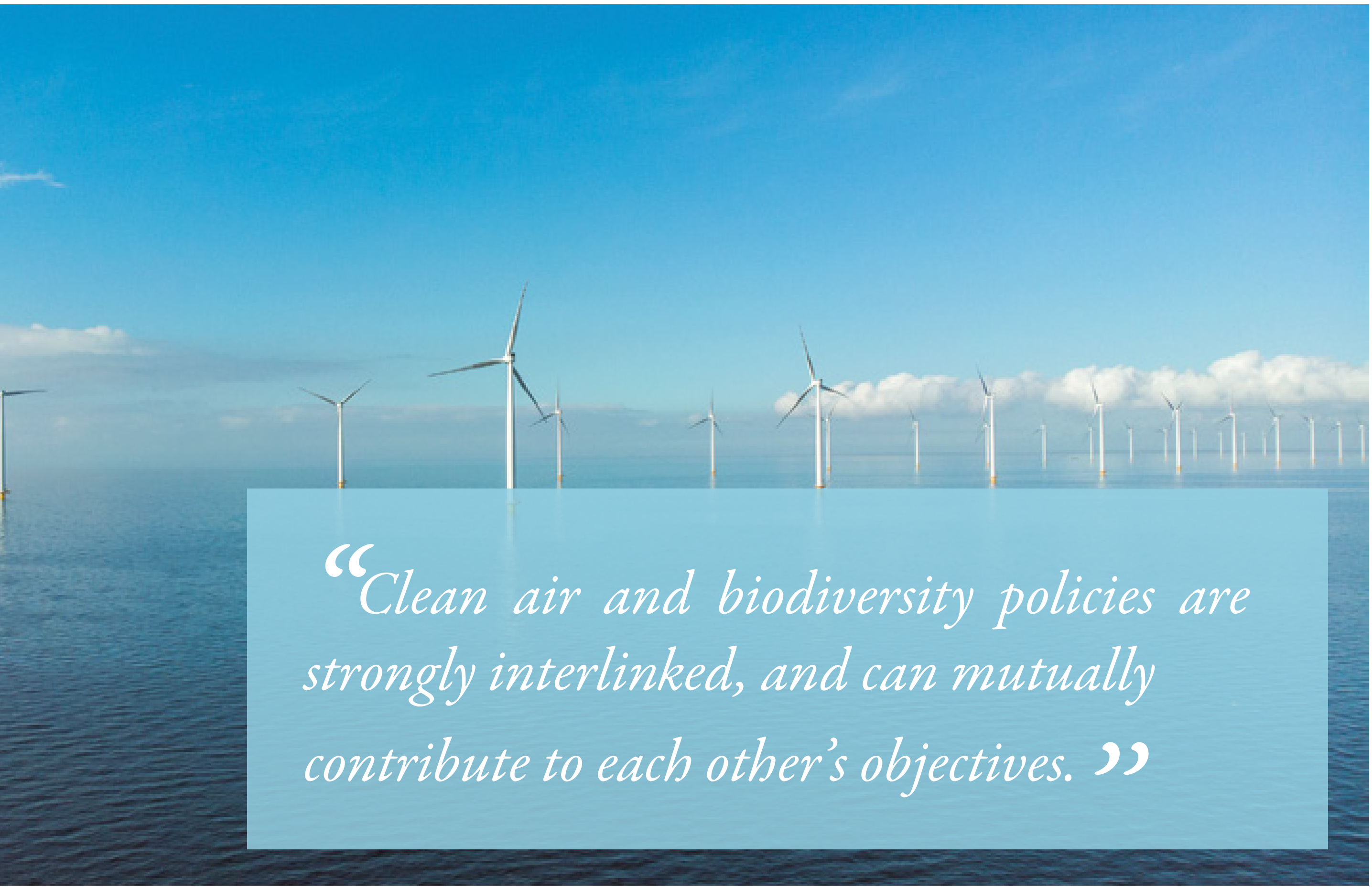
(5) COM(2022) 230 final; note that the ‘Save gas for a safe winter’ Communication (COM(2022) 360 final) is not included in the analysis developed for the third clean air outlook report, as the time horizon of the report goes much further than the short-term actions presented in the communication.

__Figure 1.__ Number of premature deaths attributable to exposure to total $PM_{2.5}$ in the EU-27 under various scenarios. The marked 55 % reduction in premature deaths by 2030 reflects the related zero pollution target. The MTFR (Maximum Technically Feasible Reduction) scenario is developed to identify the scope for further mitigation starting from the baseline. It explores the mitigation potential available via implementation of proven technical solutions to reduce emissions beyond existing legislative requirements. Application of measures is limited by 'applicability' constraints, which consider the age structure of installations, lifetime of technologies, technical feasibility of installing the respective measures, geophysical constraints, etc. In the OPT10 scenario, the optimisation is performed to bring the grid-based annual mean $PM_{2.5}$ concentration below 10µg/m³ – this scenario foresees a closer alignment of EU air quality standards with the 2021 WHO air quality guidelines (WHO, 2021).*



Source: European Commission's third clean air outlook report.

* For a full description of the scenarios, see the IIASA third clean air outlook supporting study.

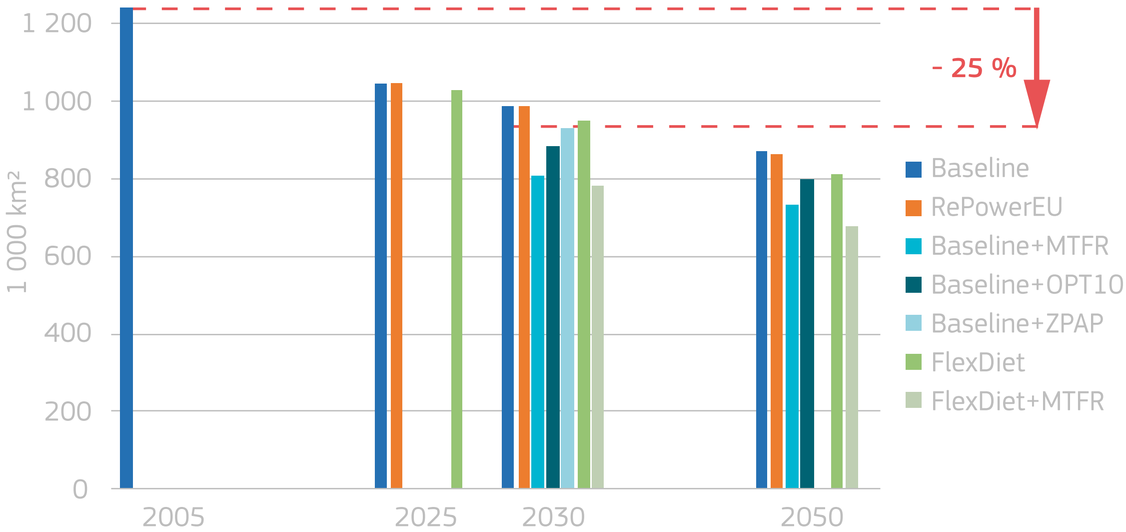


"Clean air and biodiversity policies are strongly interlinked, and can mutually contribute to each other's objectives."

The outlook is rather bleaker for the ecosystem target. The modelling undertaken for the third clean air outlook report shows that the implementation of all agreed measures, the fit for 55 and the agricultural part of the IED proposals (i.e. the same baseline as described for the health target above) would only reduce the area of EU ecosystems under threat from air pollution by 20 % by 2030 compared to 2005, falling short of the 25 % target. However, with more stringent air policies[6] , such as through aligning EU air quality standards more closely with the updated WHO guidelines, this target could be achieved (e.g. the EU area at risk would decrease by 28 % in a scenario where the annual mean $PM_{2.5}$ limit value is set at 10 μg/m³), as per the European Commission proposal COM(2022) 542 final.

These results illustrate the key interlinkages between clean air and biodiversity policies, which mutually contribute to each other's objectives. These synergies should be considered by all actors when implementing both policies in order to maximise societal benefits. In particular, the uptake of the ammonia reduction measures proposed by Member States in their common agricultural policy (CAP) strategic plans will be crucial, as those measures can deliver benefits for clean air but would also have positive spillover effects for biodiversity.

__Figure 2__. Ecosystem area in the EU-27 where the critical loads for eutrophication are exceeded, under various scenarios. The marked 25 % reduction by 2030 reflects the related zero pollution target.*



* For a full description of the scenarios, see the IIASA third clean air outlook supporting study.

Source: European Commission's third clean air outlook report.

(6) Or assuming all possible technological measures (disregarding their costs) would be implemented (maximum technically feasible reduction (MTFR) scenario), in particular reducing ammonia emissions from the agricultural sector.

The outlook for the zero pollution ambitions

The analysis undertaken for the third clean air outlook report has shown that there is a good chance of reaching the air-related ZP targets for 2030, but only if policies regarding clean air, climate and biodiversity are also implemented. There is, therefore, a strong incentive for all involved actors to join efforts as soon as possible since it always takes time for policies to deliver actual results on the ground. The agricultural sector is key to reaching these targets, in particular with regard to reducing the air pollution impacts on ecosystems. Emissions of ammonia (of which 94 % come from the agricultural sector) have to decrease drastically in many Member States if they are to meet their NEC directive commitments and to deliver on wider objectives such as zero pollution and biodiversity protection.

“If all clean air and climate measures were implemented, the number of premature deaths due to air pollution would fall by 66 % by 2030, i.e. the respective zero pollution target would be achieved.”

Water & marine outlook

2.2. Water and marine outlook

Aquatic ecosystems are often the final recipients of pollutants originating from air or soil. At the EU level, a number of legislative acts aim to fight against the pollution of aquatic systems. These include the water framework directive (WFD), the marine strategy framework directive (MSFD), the nitrates directive (ND), the plastics directive and the urban waste water treatment directive (UWWTD). The zero pollution (ZP) ambition is highly relevant in this complex legislative context as, to some extent, the coordination between the different legislative acts needs to be improved. The zero pollution action plan (ZPAP) should help strengthen and streamline the connections between the water and marine directives and thereby increase the added benefit of EU intervention in the fight against aquatic pollution.

Obviously, policy analyses should ideally be carried out in an integrated and holistic manner, considering the sources of pollution of aquatic systems, their distribution and dispersion in freshwater and marine ecosystems, and their impact on the ecological status of the receiving basins. This was done for the ZP outlook by making use of an integrated modelling framework developed at the Joint Research Centre (JRC): the JRC-Digital Twin for water/marine environments (JRC-DT, Macias et al., 2022). This analysis was useful both for quantifying the impacts of policy options that aim to reduce the pollution of aquatic ecosystems, and for evaluating the plausibility of reaching the ZP targets for 2030 with the tested set of policy options.

2.2.1 The zero pollution ambitions

Of the six top ambitions of the ZPAP, two are particularly relevant for the water/marine environments. First, the ZPAP aims at 'improving water quality by reducing waste' and, in particular, puts emphasis on the reduction of plastic litter at sea by 50 % by 2030. The second relevant ambition refers to 'improving soil quality by reducing nutrient losses and chemical pesticides' use by 50 %', which impacts not only soil quality but also the receiving hydrosphere (rivers, lakes and seas).

Given these priorities of the ZP ambition, the water/marine outlook has focused on three particular pollution pressures in aquatic environments: inorganic nutrients, chemical pollutants and plastics. The JRC-DT, which incorporates a sophisticated set of land use, hydrological, hydrodynamic and biogeochemical models, has been used to explore how current and future policy implementation could help deliver the particular ambitions of the ZPAP for these environmental pressures by 2030, including the background impacts of climate change. Energy pollution (e.g. in the form of underwater noise) was excluded from the analyses as the JRC models are not yet able to account for this particular pressure on the marine ecosystem.

2.2.2.
Putting the zero pollution ambitions to the test

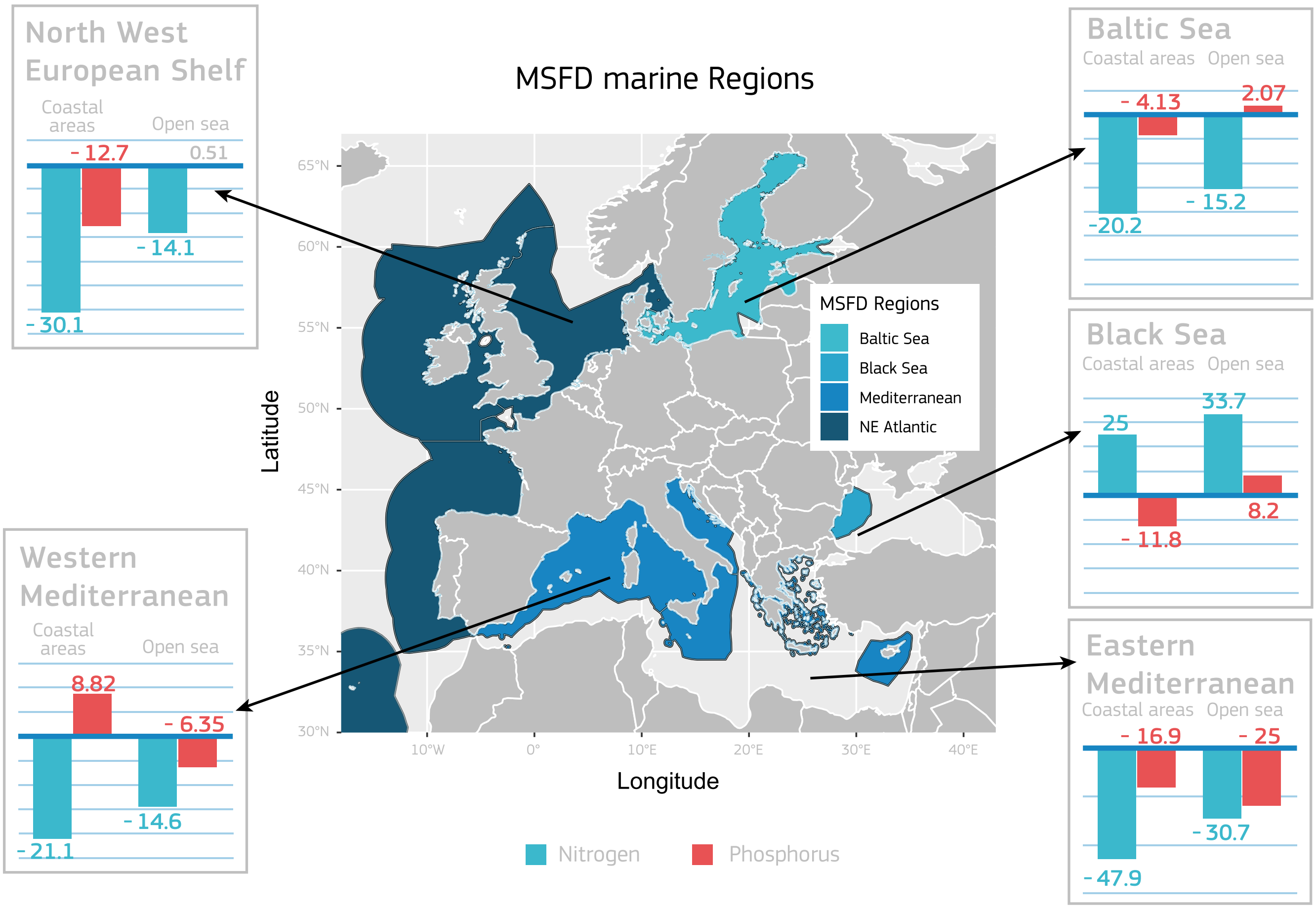
In the following we look at inorganic nutrients, chemical pollutants and plastics in specific sea basins around continental Europe. The choice of pressures and regions was largely driven by the availability of suitable models within the JRC-DT and the existence of adequate data to force and validate those models.

Nutrients

For this particular pressure, the status (or **reference,** REF) of freshwater and marine EU ecosystems for 2015 to 2018 was simulated using the JRC-DT, calibrated and validated against the WFD and MSFD reporting data from the European Environment Agencys' Water Information System for Europe (WISE) database and the Directorate-General for Maritime Affairs and Fisheries' European Marine Observation and Data Network (EMODnet) dataset. The JRC-DT was also used to create a scenario for 2030 in which a set of very ambitious measures to fight nutrient pollution are implemented; this scenario is named the **high ambitious scenario** (HAS). Such HAS measures include agricultural practices, urban wastewater treatment and atmospheric emissions prescribed by different legislative proposals, such as the fit for 55, farm-to-fork and biodiversity strategies and the recent review of the UWWTD (Grizzetti et al., 2022 and Macias et al., 2022), while climatic conditions were derived from the Intergovernmental Panel on Climate Change (IPCC) emissions scenario RCP4.5 (representative concentration pathway 4.5).

The HAS represents the maximum reduction in nutrient pollution currently achievable. It shows that, if the entire set of measures is implemented, it is possible to reduce nitrogen and phosphorous inputs into marine ecosystems by 32 % and 17 %, respectively. Under this scenario, the ZP target of 50 % reduction is almost achieved in 4 out of 10 marine regions for nitrogen, and in 2 out of 10 for phosphorous. As a result of the stronger

Figure 3. Projected change in nutrient load for 2030 in the marine strategy framework directive regions. Depicted is the percentage change in nitrogen and phosphorous concentration for open and coastal waters under the high ambitious scenario (HAS)



Source: JRC

percentage reduction in nitrogen, the N:P ratio (a measure of the relative limitation by inorganic nutrients) of the loads delivered into EU seas decreases by about 18 %, with potential consequences for the receiving marine ecosystems (see Figure 3).

Reducing nutrient loads delivered into EU seas leads to a reduction in the dissolved inorganic nutrients (a eutrophication indicator) in the receiving waters. For nitrogen, the 32 % reduction in loads translates into a 27 % reduction in its concentration in coastal waters and 9 % reduction in open-sea regions. For phosphorous, on the other hand, the 17 % lower loads lead to a reduction of only 9 % in

> *"All kinds of pollution often end up and accumulate in rivers, streams, lakes, oceans."*

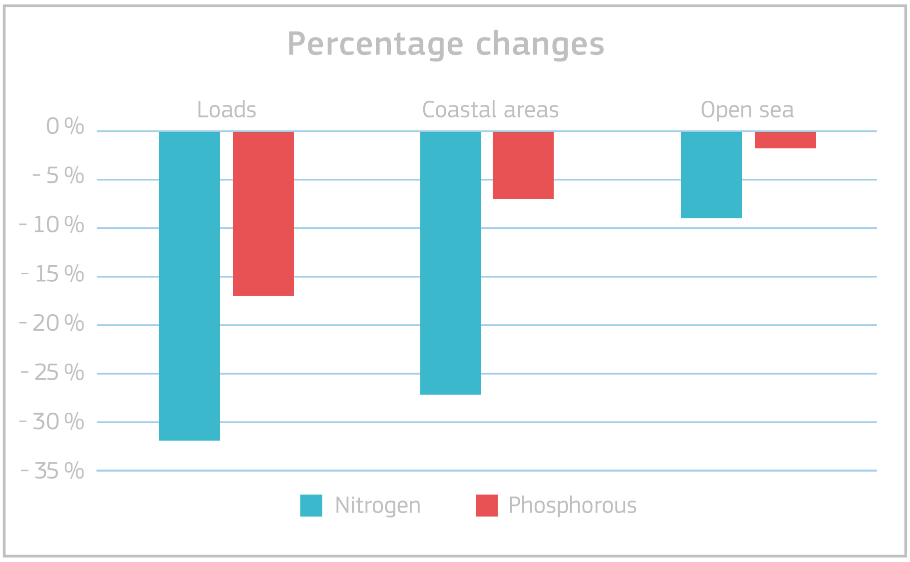


*Figure 4. Relative changes ((HAS-REF)*100/REF) in nutrient pollution in EU aquatic ecosystems for the loads (i.e. the amount of nutrients entering the sea) in coastal areas (with shallow depth) and in the open sea under the HAS.*

Source: JRC

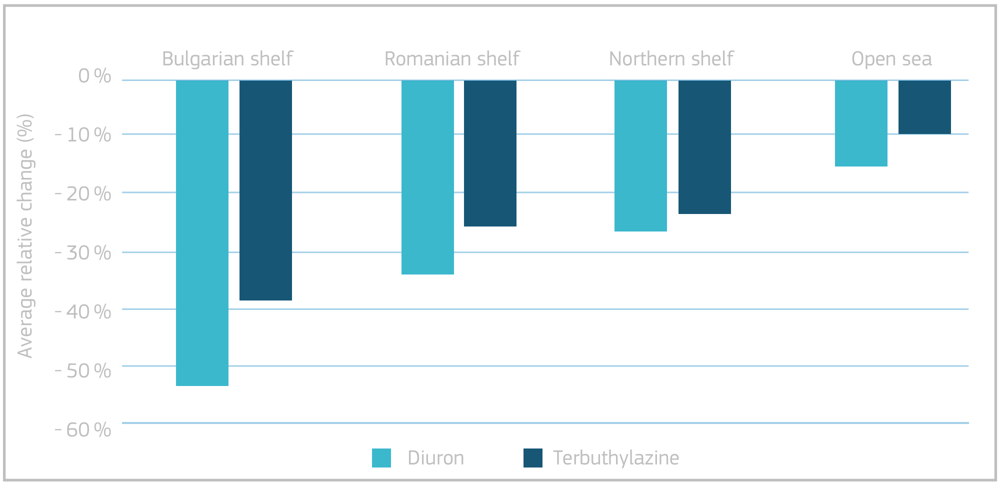
coastal waters and 4 % in open-sea regions. Due to the stronger nitrogen reduction, the N:P ratio in EU marine regions decreases sharply (- 30 %), indicating that the HAS would result in much more bioavailable phosphorous in marine ecosystems. Such a situation could favour the blooming of phytoplankton species that are not limited by inorganic nitrogen availability (e.g. those that form red tides), and thus worsen the eutrophication condition of EU marine waters. These results show that a holistic interpretation of the nutrient reduction measures is needed in future initiatives: reduction strategies should address both nitrogen and phosphorous together, and should also consider the particular characteristics of the receiving aquatic ecosystems.

Figure 4 shows that the nutrient reduction measures considered in the HAS have a greater impact on the ecological status of coastal marine regions than that of open-sea areas, where oceanographic dynamics are more relevant. Indeed, a separate analysis of the climate change impacts (change in HAS from 2018 to 2030) indicates that open-sea regions are more sensitive to changes in atmospheric forcing than to the pollution-reduction measures explored in the scenario. It is worth mentioning that the scenario assumes that measures are fully and immediately implemented, and that there is no legacy or inertia in the natural system.

Chemicals

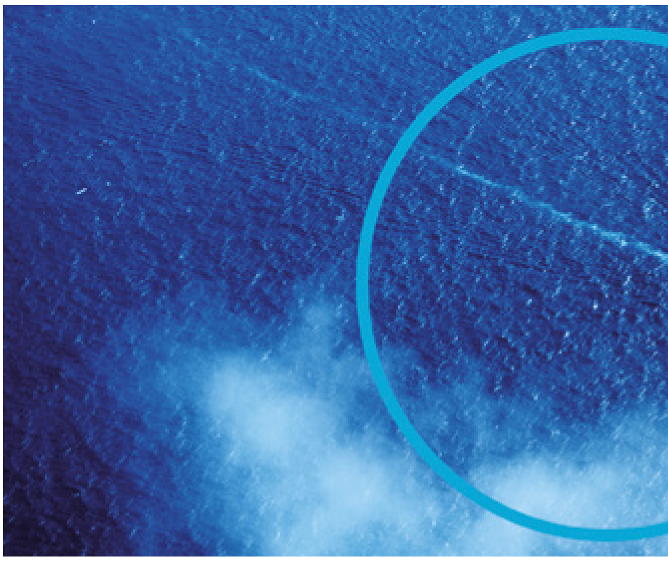
The impact on marine status of reducing the use of chemical pesticides by 50 % by 2030 was explored in the Black Sea, as this is the only basin currently covered by the JRC-DT for this particular pressure. A progressive reduction in the concentration of freshwater pesticides to 50 % by 2030 was tested together with the atmospheric conditions provided by climate models under the IPCC RCP4.5 emissions scenario (as for the nutrients analysis). A 50 % reduction in chemicals in riverine loads translates into a decrease in marine concentration that ranges from -56 % in the Bulgarian shelf region to only -12 % in the open-sea area. The size of the reduction is dependent on the persistence of the considered pesticide, with highly persistent ones (such as Terbuthylazine) decreasing less. In contrast, more short-lived substances (such as Diuron) disappear faster from the water body.

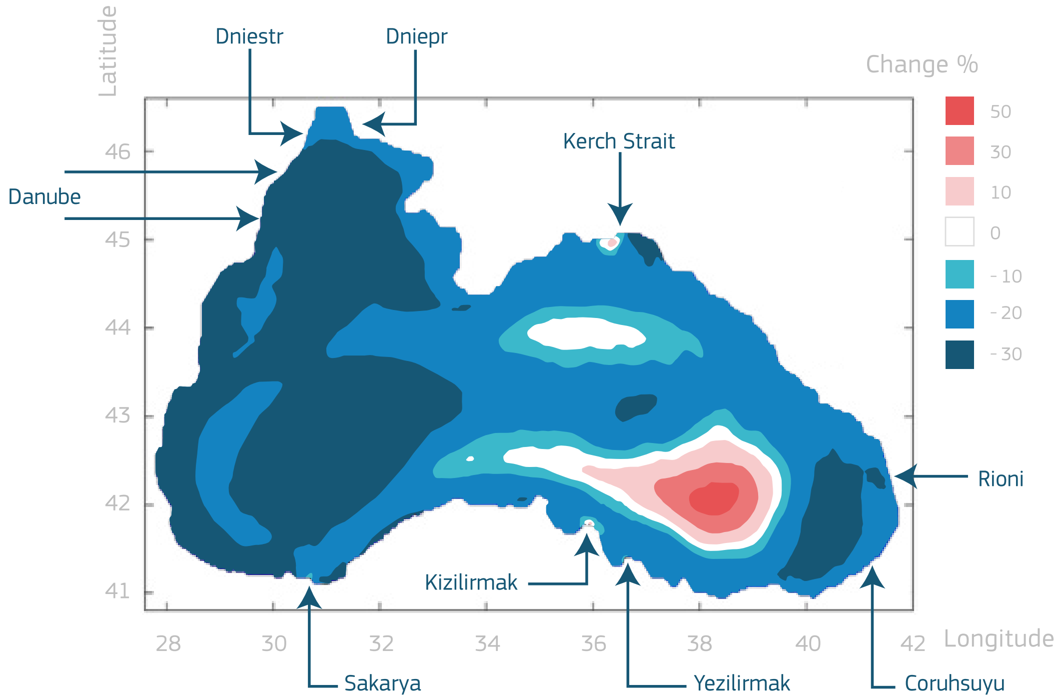
*__Figure 5.__ Percentage reduction ((HAS-REF)*100/REF) of high- and low-persistence chemicals in different regions of the Black Sea under the HAS.*



Source: JRC

JRC-DT results also indicate that, for some regions within the open Black Sea, the concentrations of the considered chemical substances could increase in the HAS simulation even if the total load delivered to the sea decreases. This is due to the changing hydrodynamic conditions (ocean currents, vertical stratification) associated with climate change that impact the distribution and accumulation patterns of the dissolved substances.





Source: JRC

Figure 6. *Map of the relative change in the concentration of a persistent substance in the Black Sea under the HAS compared to the reference scenario ((HAS-REF)*100/REF).*

This particular set of simulations indicate that climate-change-induced modifications of the hydrological conditions of EU marine basins could counteract the impacts of policy measures (i.e. localised increase in the concentrations in spite of the general reduction in the loads). It is also quite clear that the impacts of the reduction measures could take some time to take effect in the receiving marine regions due to the natural inertia of the ecosystems. Both aspects should be considered when evaluating the impacts of policy measures that aim to reduce chemical pollution in natural aquatic ecosystems.

“The EU cannot, by itself, achieve the zero pollution target in the Mediterranean Sea; cooperation between all Mediterranean neighbouring states and regions is needed.”

Plastics

The JRC-DT was applied to describe the distribution, accumulation and beaching pattern of plastic macrolitter in the Mediterranean Sea during the years 2016, 2017 and 2018 (baseline). The Mediterranean Sea basin was selected as a test case for this first outlook report as transport models are less developed for the other EU seas. The baseline simulation indicates that 24 % of all macrolitter in the Mediterranean Sea is produced within the EU, while 76 % is generated within non-EU countries. EU litter pollutes 40 % of non-EU beaches (although it represents only 1 % of all litter in those beaches) while non-EU litter pollutes 37 % of EU beaches (representing 10 % of all beached litter) in the basin. This is a clear indication of the high interconnectivity of litter pollution in this marine region.

The first management scenario tested in this case is a total ban on single-use-plastic (SUP) items in the EU. SUP items represent 60 % of all beached litter in the EU (Hanke et al., 2021), so a total ban on those plastic items reduces the total litter (both floating and beached) in the Mediterranean by 14 %. This is far from the ZP target of 50 % reduction, but the spatially explicit nature of the simulations provided by the JRC-DT shows that this target could be achieved for 8 % of the surface of the basin (for floating litter) and for 44 % of all beaches (mostly located within EU borders). Under this scenario, the amount of EU litter polluting non-EU beaches is reduced (in absolute numbers) but the spatial extent (number of beaches) affected by this cross-boundary littering remained unchanged. A more extreme (albeit unrealistic) scenario was also considered, by simulating a complete ban on plastic littering by the EU. This scenario would require a full ban on the use of plastic items in the EU, or the implementation of a perfect waste and recycling management system that prevents plastic items from reaching the environment. In this case the total amount of litter in the Mediterranean Sea would be reduced by approximately 25 %, and the ZP target would be achieved for 50 % of the sea surface (for floating litter) and for 54 % of all beaches.

	SUP ban	Zero plastic from EU
Total litter reduction	- 14 %	- 25 %
ZP target reached in the open sea	8 %	50 %
ZP target reached on beaches	40 %	54 %

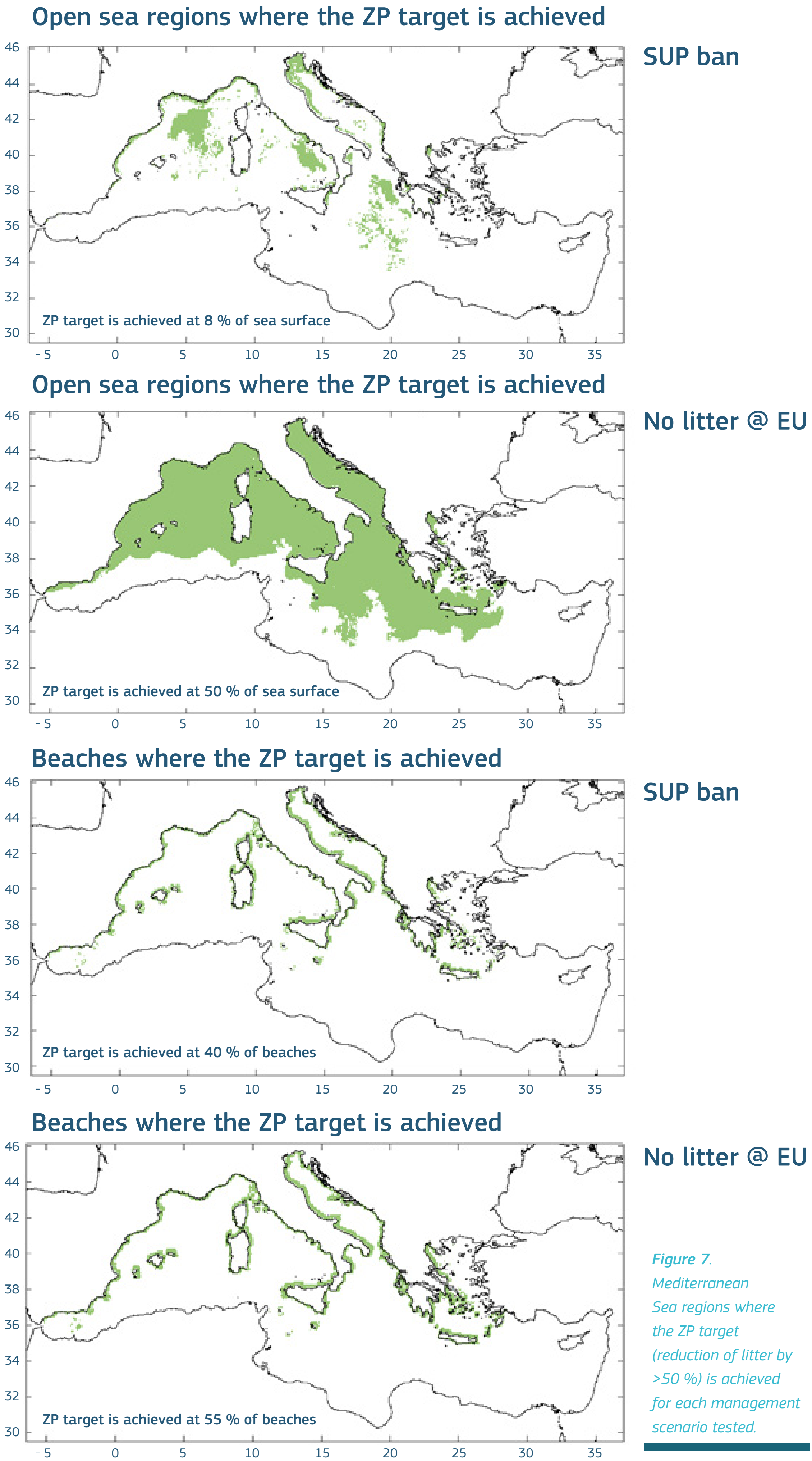


Figure 7. Mediterranean Sea regions where the ZP target (reduction of litter by >50 %) is achieved for each management scenario tested.

Source: JRC.

A major conclusion of the scenarios tested for plastic pollution is that the EU cannot, by itself, achieve the ZP target for this pressure in the Mediterranean Sea. Due to the high connectivity in this basin and the relatively larger amount of plastic pollution generated by non-EU countries, international cooperation is fundamental to achieving reduction objectives. This chimes perfectly with the 'fight pollution at source' concept, and with the international dimension and EU leadership sought by the European Green Deal.

The outlook for the zero pollution ambitions

With the currently maximum achievable reductions in nutrient leakages it is possible to reduce nitrogen inputs to marine ecosystems by 32 % with respect to current values, and by 17 % in the case of phosphorous. Our analysis of nutrient pollution indicates that it is of paramount importance not only to strive for the total reduction of nutrient leakages, but also to consider their relative ratio (N:P) in the receiving waters. Marine ecosystems have a natural N:P ratio that allows a diversity of phytoplankton types to coexist and maintain healthy biodiversity levels. Alterations to this ratio (for example by interventions at the source) will tilt the delicate natural balance and could allow opportunistic, highly specialised species to thrive and dominate the ecosystem. The appropriate reduction targets for both macronutrients (N and P) might be different for each EU marine basin as they have different biogeochemical structures. Therefore, further regionally focused analyses are needed to determine the most appropriate nutrient reduction targets for each marine region.

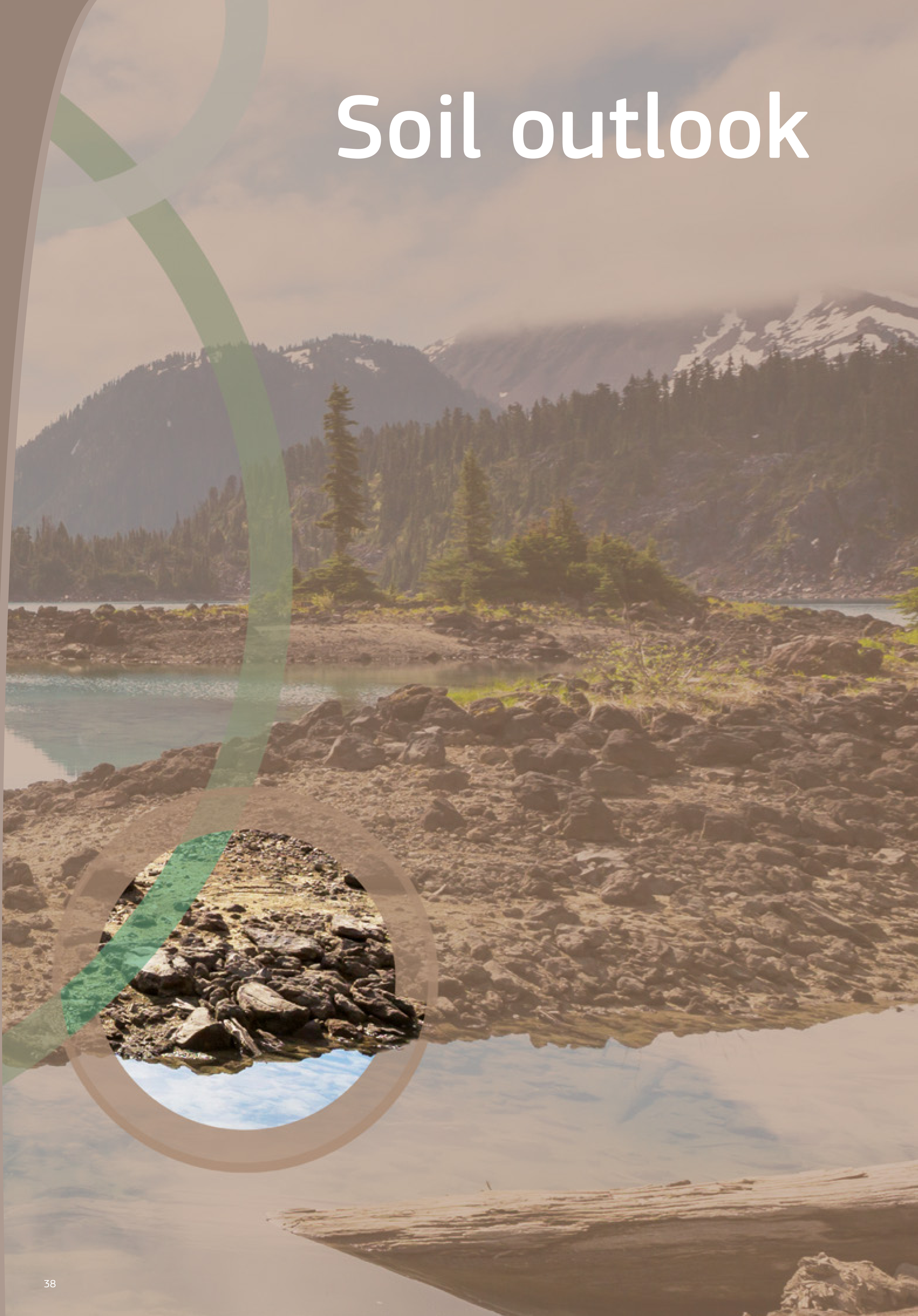
The simulations of chemical contaminants show that many substances, even very persistent ones, would almost totally disappear from coastal/riverine regions under the HAS. However, a crucial element emerging from the simulations of chemical pollutants is the need to account for the natural inertia of the water/marine ecosystems. This is also the case for nutrients, as chemical substances can accumulate in different environmental compartments (such as soil, sediment and even biota). There is therefore a delay (or inertia) between the moment a measure is applied (e.g. a certain percentage reduction of the pressure) and when measurable improvements can be registered in the targeted environment. Climate change impacts should also be considered. For certain pressures and regions, climate-induced changes can counteract the effects of the measures (as in the case of the chemicals tested in the centre of the Black Sea), while in other cases it could have a synergistic effect. To better assess the consistency of these conclusions, more chemical compounds should be included in the JRC-DT (also applying them to different basins), and alternative climate models and scenarios should be considered to obtain an estimate of the uncertainty in the model simulations.

There is also uncertainty regarding the loads of plastics entering the seas and oceans, as we must rely on statistical models calibrated with scarce data. To improve the simulations of plastic dispersion and accumulation at sea and assess with higher certainty the impact of measures, we need better knowledge about the loads and the presence of litter (both floating and beached). There are already substantial efforts in place to fill this knowledge gap, but further harmonisation and coordination is still needed in terms of monitoring.

Despite these limitations, two messages emerge from the analyses carried out on plastic pollution. First, planned measures result in significant reductions in the amount of plastic reaching the Mediterranean Sea. Second, the EU cannot, by itself, fight this very pervasive type of pollution and achieve the ambitious targets of the ZP. International collaboration and coordination are key to success; the EU should lead by example and become a source of inspiration for our neighbouring regions.

“Application of very ambitious measures can help reduce nitrogen and phosphorous inputs to marine ecosystems by 32 % and 17 %, respectively.”

Soil outlook



2.3. Soil outlook

Due to stronger legally binding frameworks at the EU level, the monitoring and outlook of air and water pollution is more advanced than for soil. In some Member States, there is a lack of investment in the development of a detailed knowledge base through monitoring and modelling. This is why public awareness and our understanding of risks emerging from soil pollution tend to be weak. However, with the EU Soil Strategy for 2030, efforts are underway to close this gap.

Addressing soil pollution needs to be approached differently than air and water pollution as several potentially harmful substances occur naturally in undisturbed soils, often at high levels without human interference (e.g. due to geological conditions, salt from groundwater). Also, several potentially harmful substances are deliberately applied to the soil, either to combat pests (e.g. pesticides) or as part of waste-management practices (e.g. landfills). Some organic waste streams enrich the soil with nutrients and organic matter (e.g. manure, sewage sludge). While soils (and the biological communities they sustain) can filter and transform pollutants, they can also accumulate them and become a potential source of pollution for other media. Finally, the increase in agricultural activities that has taken place during the last 60 years in Europe resulted in intense use of plant protection products and inorganic fertilisers.

There is a strong need for an integrated approach to assess terrestrial and aquatic-based pollution and the cross-media transfer of pollution (e.g. through water, air or sediments). Interactions between soil and other media (such as groundwater, surface waters and air), and their impacts on ecosystems and human health, should be better understood, described and quantified, especially as emerging pollutants are identified. Such an integrated approach should more effectively assess current and future trends.

Ultimately, implementing adequate management of contaminated sites and halting sources of diffuse pollution is a challenging and ongoing task that must be undertaken if we are to reach the targets of healthy soils by 2050, as proposed by the new EU soil strategy for 2030 (COM(2021) 699 final).

> *"Several potentially harmful substances occur naturally in soils."*

2.3.1.
The zero pollution ambitions

Taking action through legal provisions and establishing EU-level monitoring of soil pollution are recognised as priorities by the zero pollution action plan (ZPAP). The vision for 2050 is for soil pollution to be reduced to levels no longer considered harmful to human health and natural ecosystems, thereby creating a toxic-free environment. This supports the vision of the EU soil strategy for 2030 to have healthy soils across the EU by 2050. Specifically, although definitions are being aligned as part of that work, this translates into objectives to prevent and reduce pollution.

The objectives to prevent and reduce pollution include:

- improving air quality, thus reducing diffuse soil pollution from industrial emissions and transport,
- reducing emissions to water from soil and the use of polluted water on land,
- reducing waste streams to land (e.g. excess nutrients, microplastics in sewage sludge),
- more sustainable use and management of soils (e.g. reduce the use of hazardous pesticides, restrict the use of plastics and inorganic fertilisers).

The EU soil strategy and zero pollution (ZP) ambitions on soil pollution envisage

- increased efforts to identify and remediate contaminated sites, together with the prevention of new soil pollution,
- the establishment of a priority watch list for soil contaminants similar to that already established under the water framework directive and environmental quality standard directive,
- improved monitoring of diffuse pollution supported by the future land use / cover area frame survey (LUCAS) soil pollution module,
- implementation of a soil passport scheme, and
- increased awareness of funding schemes to tackle soil pollution.

These ambitions will be supported by efforts to revise the urban waste water treatment directive and evaluate the sewage sludge directive, in synergy with the revision of the industrial emissions directive. The living labs of the Horizon Europe mission ‘A soil deal for Europe’, the EU’s destination Earth programme, and the zero pollution stakeholder platform, along with the work of the European Environment Agency (EEA) and the Joint Research Centre’s EU Soil Observatory, will advance the knowledge base required to achieve a toxic-free environment. Soil pollution has high relevance to actions targeting health inequalities (e.g. links between soil pollution and cancer, pharmaceuticals in soil) and sustainable urban areas, and those on investments and compliance.

Efforts will also be made to minimise the EU’s external pollution footprint. Global commitments for the management of contaminated sites, such as the United Nations Environment Assembly (UNEA)-3 resolutions 3/4 on environment and health and 3/6 on managing soil pollution, the United Nations sustainable development goals (SDGs 3.9 and 15.3), the Minamata Convention (Article 12), the Stockholm Convention (Article 6), and the Ostrava declaration of the Sixth Ministerial Conference on Environment and Health, should also be respected. Together with the Global Soil Partnership, the EU will also look to minimise risks arising from legacy pollution in soil.

2.3.2.
Putting the zero pollution ambitions to the test

Currently, the ZPAP monitoring report provides some harmonised insights into soil pollution across the EU, often reflecting a cumulative memory of soil where persistent substances could pose a risk to human health and ecosystems. Additionally, excessive use of nutrients such as nitrogen (which provokes acidification), phosphorous surplus (saturation) and mineralisation of organic matter are known to mobilise and release pollutants.

According to the current state of the art and following up on the EU soil strategy, several points regarding soil pollution could be raised.

- The overall risks posed by soil pollution to human health and environmental well-being are understood. However, there is still room for improvement through a better quantification of these risks by considering emerging pollutants and harmonised monitoring.

- There are still several knowledge gaps regarding soil pollution due to lack of investment in monitoring, research, systematic inventory and reporting obligations. Addressing these gaps would allow for the definition of a robust baseline for soil pollution.

- A common EU framework and definitions are required to make an inventory of both contaminated sites and diffuse sources of pollution. This could be addressed through a harmonised approach to improving the quantification of soil pollution risks and impacts.

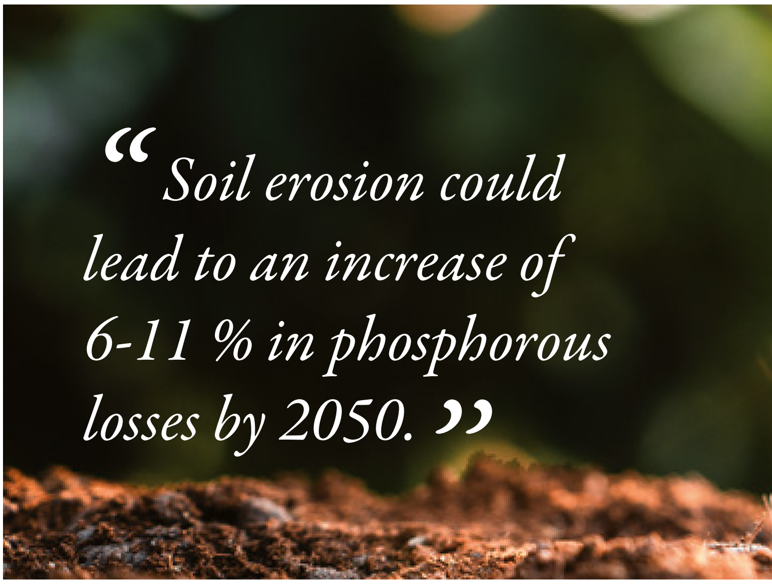
- The soil compartment, with its high inherent variability, is insufficiently addressed in risk assessment procedures for market authorisation of chemicals, and the interaction between cocktails of substances and the soil microbiome are often not considered. The improvement of the fertilising products regulation ((EU) 2019/1009) could lead to better safety controls of fertilisers.

- The new soil health law could address various soil pollution issues, by providing a holistic EU-wide legislative approach to protect and sustainably manage soils. Additional policy targets under the European Green Deal are also expected to have a positive impact on soil pollution (e.g. reduction of hazardous pesticides, increased remediation, increased use of biodegradable, bio-based and compostable plastics, and manure management). However, there are some uncertainties associated with shifts in practices and improved inventories of contaminated sites.

- The farm-to-fork (F2F) strategy could reduce the use of fertilisers by at least 20 % by 2030, thereby helping to meet the ambition of reducing nutrient losses by at least 50 % while ensuring that there is no deterioration in soil fertility and food security. This would result in positive impacts on emissions from soil to water and air.

- The F2F strategy could reduce the use and risk of pesticides by 50 % by 2030 (regulation of sustainable use of pesticides), resulting in positive impacts on emissions from soil to water and air.

According to available EU data, an estimated 2.5 million local soil sites were potentially contaminated in 2011 in EEA member and cooperating countries (EEA, 2014). This figure rose to around 2.8 million sites by 2016 (JRC, 2018). The needs for risk assessment are growing, since more than 76 000 new potentially polluted sites were registered between 2011–2016, and by 2016 only 65 500 sites had been fully investigated and remediated (JRC, 2018).



While soil pollution is partially addressed in several sectorial policies (e.g. policies addressing sewage sludge, fertilisers, water quality, chemicals), quantitative assessments have not been made for many substances due to a lack of systematic monitoring.

On average, 145 kg of nitrogen (kg N) per hectare were added to European soils in 2010. The average crop N offtake is 92 kg N per hectare, which implies a nitrogen excess of 53 kg N per hectare. The gross nitrogen balance decreased from 72 to 46 kg N per hectare between 2000 and 2009, but no significant reductions have been registered since 2010.

On average, 16 ±2 kg of phosphorous (inorganic, manure, atmospheric deposition, chemical weathering) per hectare are added each year to EU agricultural soils (average 2011-2019). The application of inorganic fertilisers shows a slightly decreasing trend compared to manure application.

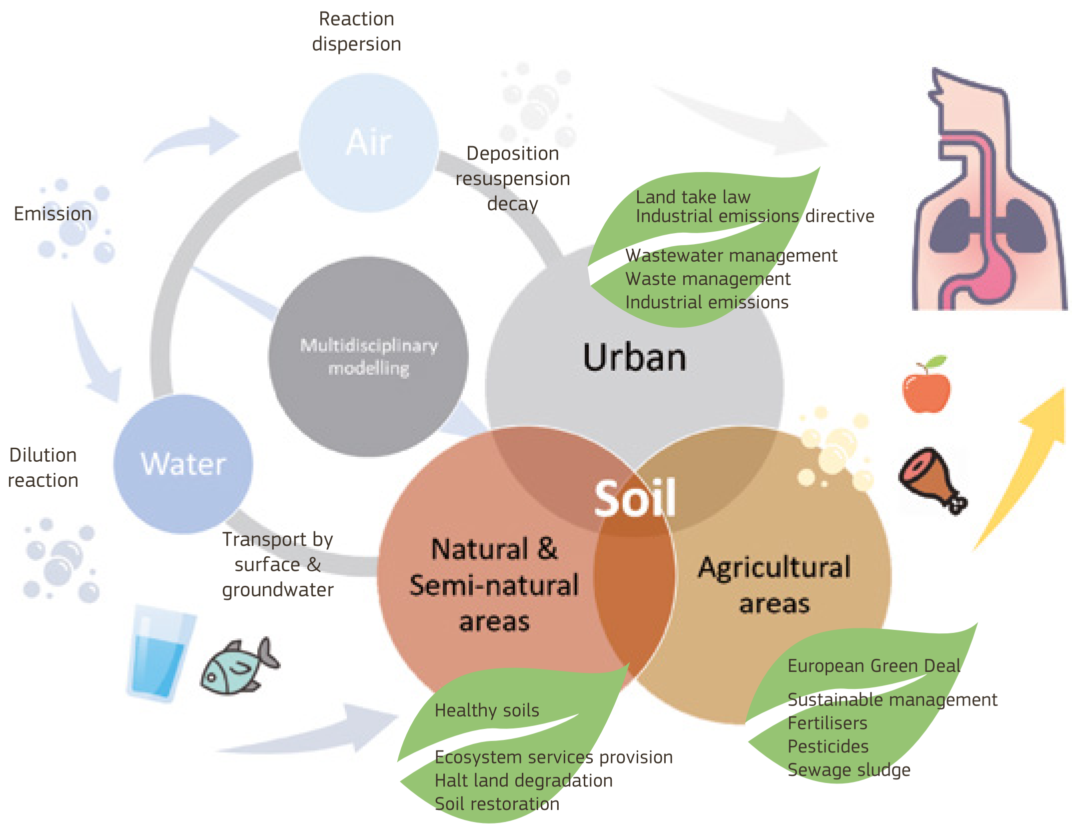
Between 31 000 and 42 000 tonnes of microplastics are applied to European soils annually through sewage sludge and the use of plastic mulches and greenhouses in agriculture.

The LUCAS 2009 topsoil survey found that most regions in the EU (67 % of soil samples from agricultural land) showed concentrations of heavy metals that were above threshold values. Around 6 % (corresponding to 137 000 km²) of agricultural land needs local assessment and eventual remediation action, as adverse effects of metal levels on human health are not well known. Additionally, 43 tonnes of mercury are displaced from topsoils by water erosion every year, of which around 6 tonnes reach water bodies.

More than 500 active substances are approved to be used as plant protection products (including pesticides) in the EU, with annual sales of 374 000 tonnes. Analysis of agricultural soil samples collected through the LUCAS survey showed that over 75 % contained residues of at least one pesticide. Almost 60 % of samples contain residues of at least two different pesticides, while over 10 % presented residues of more than 10 pesticides. The long-term consequences of the presence of these mixtures for human health and the environment are largely unknown.

Airborne pollution of soil should also be reduced following the ongoing revision of the industrial emissions directive and national emissions ceilings directive ((EU) 2010/75/EU) and a possible evolution of the NEC directive ((EU) 2016/2284) by introducing ambitious reduction commitments to be achieved by 2030. These initiatives should lead to a reduction in soil pollution by nutrients, metals and persistent organic compounds.

Figure 8. Soil and its interactions with the environment, from a multidisciplinary perspective.



Source: JRC.

> *"By 2019, 22 million tonnes (Mt) of plastics were introduced into the terrestrial environment, with a projection estimating that this figure will double to 44 Mt by 2060."*

The outlook for the zero pollution ambitions

This is the first attempt to produce a qualitative soil pollution outlook for the EU driven by the European Commission's ZPAP and by the increased availability of data on soil health. Until now, as demonstrated by the recent Lancet Commission report on pollution, which mentions soil only once (Lancet Planetary Health, 2022), there was little focus on soil pollution. Additionally, actions under the European Green Deal will help to address important commitments, such as the reporting of SDG 3.9[7] by Member States and the EU.

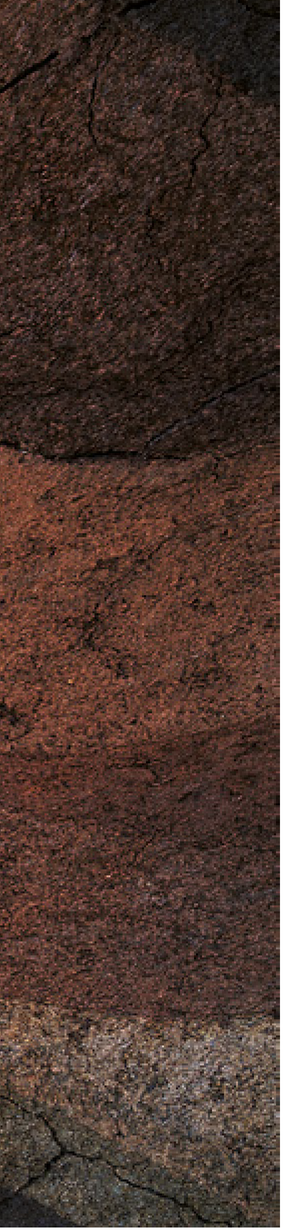
Soil pollution is the result of global human activities, in particular industrial processes, agriculture and waste management. Inevitably, future trends in soil pollution are closely linked to these drivers.

Soil pollution should reduce once the actions taken under the European Green Deal are fully implemented. Preparations for the new soil health law (Commission proposal, under development) will look further into creating a more holistic legal framework.

The number of known potentially contaminated sites are likely to increase due to improved assessments and monitoring, which will lead to increased registrations in national inventories. Based on current trends, there is an expectation that more than 15 000 potentially contaminated sites will be identified each year (JRC, 2018).

Although progress has been made in some Member States, the high number of contaminated sites to be investigated,

(7) By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.



together with the current rate of remediation, means that it will take several decades to complete the risk assessment procedure and remediate all contaminated sites, even before considering new additions of pollution to soil, e.g. caused by accidents or revealed through improved monitoring schemes.

The future soil health law will look into the issue of excavated soils by limiting their disposal in landfill sites, and where necessary through off-site remediation techniques.

The adoption of the integrated nutrient management action plan and the technical proposal for the safe use of processed manure above the threshold established for nitrate vulnerable zones by the nitrates directive (91/676/EEC) should lead to a more efficient use of nutrients, and hence a reduction in the loss of nutrients from soil to water and air (F2F strategy, circular economy action plan). Based on trends in water quality modelling, we would expect these initiatives to lead to a reduction in nitrates and losses of phosphates from soils to water.

Some nutrient loss scenarios show a potential 6–11 % increase in loss of phosphorous due to soil erosion, based on projections of soil erosion in the EU by 2050. Mercury displacement rates could increase to 49–53 Mg annually if emissions of mercury remain constant.

In accordance with the trends already observed for the gross nutrient balance on agricultural lands, excess nitrogen rates remained around 50 kg per hectare from 2010 to 2014, which negatively affected both nitrogen runoff and nitrogen leaching rates. These nitrogen pollution rates should decrease as the F2F strategy – which aims to reduce the use of fertilisers by at least 20 % by 2030 (see Section 2.4. on nutrients) – is implemented.

According to the soil strategy, heavy metals in soils in the European Union should be more comprehensively monitored. Concentrations of heavy metals in soils should not increase significantly once European actions (e.g. F2F strategy, sewage sludge directive are taken to reduce the application of metals to soils.

The biodiversity strategy's target of increasing organic farming in the EU to include at least 25 % of agricultural areas should result in a reduction in the use of synthetic pesticides due to a significant increase in the uptake of agroecological practices. However, since the use of copper-based plant protection products is permitted under the organic farming scheme, this area expansion could see copper-based plant protection products being applied for the first time to some soils. While Regulation (EU) 2018/1981 limits the application of copper to 28 kg per hectare over a period of seven years, the impacts of an increase in organic farming, and the use of copper-based fungicides, should be further investigated in the long term.

Pollution from the residues of plant protection products is expected to decline if the F2F strategy's objectives of reducing by 50 % the use and risk of chemical pesticides by 2030 are reached. This will be reinforced by implementing integrated pest management practices, where alternative methods of pest control are considered before chemical pesticides are used. There are uncertainties regarding the increased use of low-risk active ingredients to compensate for these reductions.

The global pollution of terrestrial and aquatic environments by plastics is substantial and increasing. By 2019, 22 million tonnes (Mt) of plastics were introduced into the terrestrial environment, with a projection estimating that this figure will double to 44 Mt by 2060. Based on this we can estimate an annual increase in the incorporation of microplastics into soils through sewage sludge of 62–84 thousand tonnes.

Many of the outlook statements of this report have high uncertainties due to significant knowledge gaps. These must be addressed to fully describe soil pollution, its links with human health and effects on ecosystems, and to develop robust outlook statements.

Nutrients outlook

2.4.
Nutrients outlook

Nutrients, specifically nitrogen (N) and phosphorous (P), are fundamental elements for growing plants and sustaining life on Earth. However, these can become pollutants when they are present in excessive amounts in water, soil and in the atmosphere (e.g. in the form of ammonia or oxides of nitrogen). Human activities have altered the natural biogeochemical cycles of these elements through the intensification of agricultural production and the combustion of fossil fuels (Sutton et al., 2011).

Every year, the use of synthetic fertilisers in agriculture introduces new reactive nitrogen into the environment through the Haber–Bosch process[8], and mobilises P through mining from (limited) natural rock phosphate deposits. The part of nutrients that is not taken up by plants (nutrient surplus) is lost to the environment in different forms, such as nitrates (NO_3) to groundwater and surface water, ammonia (NH_3) and nitrous oxide (N_2O) emissions to the atmosphere, and the accumulation of P in soils, which later can end up in water bodies due to soil erosion.

In aquatic ecosystems, such as lakes or coastal waters, excess nutrients can produce eutrophication, whereby a disproportionate growth of aquatic plants results in the depletion of oxygen and disruption of the ecosystem, along with the possible production of harmful algal blooms. Furthermore, a high concentration of nitrates (NO_3 > 50 mg/L) is harmful to humans and therefore impairs drinking water resources. Ammonia (NH_3) and nitrous oxide (N_2O) emitted into the atmosphere are, respectively, an air pollutant and a strong greenhouse gas that contribute to climate change. In addition, the combustion of fossil fuels releases nitrogen oxides (NOx) into the atmosphere, which reduce air quality and contribute to the acidification of terrestrial ecosystems by atmospheric deposition on land. The intensity of the livestock sector, which is high in some parts of Europe, can further disrupt the N and P cycles, and wastewaters from large agglomerations or industries, if not treated, can represent a source of nutrient pollution for the receiving water bodies.

The N and P cycles are complex, involving exchanges between air, water, soil and biota, and many human activities contribute to their disruption. Also, the impacts can range from the local (point sources), to the regional (diffuse losses from agriculture) and global scales (atmospheric deposition, food and feed trade).

(8) The chemical process which synthesises reactive nitrogen as ammonia from the reaction of N_2 (nitrogen gas) (from the atmosphere) and H_2 (hydrogen gas) (Sutton et al., 2011). The Haber–Bosch process is used to produce synthetic fertilisers for agriculture.

Several pieces of legislation are in place in the EU to control and reduce nutrient pollution. Nutrient emissions to air from different sectors (NOx and NH_3) are limited by the national emissions ceiling (NEC) directive (2016/2284/EU). Pollutant emissions to air, water and land from industrial installations (including NH_3, NOx, N_2O, total N, total P) are regulated by the industrial emissions directive (2010/75/EU). Nutrient losses to water from wastewater discharges are covered by the urban waste water treatment directive (UWWTD) (91/271/EEC), while diffuse nitrate pollution from agricultural sources is addressed by the nitrates directive (91/676/EEC). Freshwater and marine resources are also protected by the water framework directive (2000/60/EC) and the marine strategy framework directive (2008/56/EC), which establish the frameworks for achieving a good environmental condition of aquatic ecosystems. Furthermore, the new common agricultural policy (CAP) (Regulation (EU) 2021/2116) includes environmental and climate objectives that should help to reduce nutrient pollution. In particular, the CAP should contribute to climate change mitigation and adaptation, to efficient management of natural resources such as water, soil and air, and to the protection of biodiversity, habitats and landscapes. Finally, the reduction of waste and the recycling of nutrients from sewage sludge are regulated under the waste framework directive (2008/98/EC) and sewage sludge directive (86/278/EEC).

The biogeochemical flows of nitrogen (N) and phosphorous (P) are among the key Earth system processes for which planetary boundaries have been exceeded (Steffen et al., 2015). In Europe, N and P losses have been found to exceed the estimated regional boundaries, by a factor of three for N and a factor of two for P (EEA, 2020b). Considering the degree to which N and P flows now exceed the safe operating space to stay within planetary boundaries, and given the complexity of the sectors and impacts involved, there is an urgent need to adopt a holistic approach to the way in which nutrients are managed. The sustainable and integrated management of nutrients is one of the ambitions of the European Green Deal and the zero pollution (ZP) vision, building on and improving existing EU legislation.

2.4.1. The zero pollution ambitions

The ZP vision for 2050 is a healthy planet for all, where the pollution of air, water and soil is reduced to levels no longer considered harmful to health and natural ecosystems and that respect the boundaries our planet can cope with'. To help achieve this goal, the EU aims to reduce N and P flows to levels that are within the safe planetary boundaries by 2050. Levels of N and P concentrations in air, water and soils should also be reduced to below critical thresholds for human and ecosystem health.

Four of the six zero pollution targets for 2030 are directly or indirectly related to the excess of nutrients in the environment.

- **Target 1:** reduce by more than 55 % the health impacts (premature deaths) of air pollution,
- **Target 3:** reduce by 25 % the EU ecosystems where air pollution threatens biodiversity,
- **Target 4 – r**educe by 50 % nutrient losses, the use and risk of chemical pesticides, the use of the more hazardous ones, and the sale of antimicrobials for farmed animals and in aquaculture,
- **Target 6:** reduce significantly total waste generation and by 50 % residual municipal waste.

In the biodiversity strategy (BDS), the farm-to-fork (F2F) strategy and the zero pollution action plan (ZPAP), the European Union set the goal of reducing nutrient losses to the environment (air, water, soil) by 50 % by 2030 (Target 4), while preserving soil fertility by reducing the use of fertilisers by 20 %. This will be achieved by implementing and enforcing the relevant environmental and climate legislation in full, identifying with Member States the nutrient load reductions needed to achieve these goals, applying balanced fertilisation and sustainable nutrient management, and better managing N and P throughout their lifecycles. To this end, the Commission is working with Member States to develop an integrated nutrient management action plan (INMAP) in 2022. The ZPAP announced that the INMAP will address 'holistically a long-standing environmental challenge, maximising synergies between policies and making best use of the green architecture of the new common agricultural policy, especially via conditionality and eco-schemes'.

"If all measures are implemented, the nutrient load in European seas could be reduced by about 30 % for nitrogen and 20 % for phosphorous, which are still below the zero pollution target of a 50 % reduction in losses."

Target 4 of the ZPAP will also entail positive benefits for targets 1, 3 and 6. The reduction of reactive nitrogen emissions in the atmosphere will improve air quality and have consequent health impacts (Target 1) and will mitigate threats to biodiverse ecosystems (Target 3). The reduction of waste in the food sector, under Target 6, will also involve curbing nutrient waste and help reduce environmental pollution.

2.4.2. Putting the zero pollution ambitions to the test

In 2011, the first European Nitrogen Assessment (Sutton et al., 2011) showed the level of alteration of the nitrogen cycle in Europe and the detrimental impacts on air and water quality, biodiversity and climate. A forthcoming study of the JRC and international experts estimates the current N and P fluxes in the EU and analyses the effects of possible measures to reduce nutrient pollution, using different data sources and modelling assessments (Grizzetti et al., forthcoming).

Our analysis (Figure 9) indicates that, in the EU, 12 teragrams (Tg) of N and 1 Tg of P are introduced per year in agriculture by synthetic fertilisers as well as biological N fixation by microorganisms. N and P applied to soils as manure are estimated at 6 Tg N/y and 2 Tg P/y which shows the relevance of the livestock sector in the nutrient cycles. Many nutrients are used by plants to grow, the rest is a surplus that can be lost to the environment. Overall, N emissions to air (reactive nitrogen forms, including from energy and transport) are 8 Tg N/y and losses to freshwater are 5 Tg N/y. Atmospheric deposition of N on land is 4 Tg N/y. Losses of P to waters by soil erosion and wastewater discharges are about 0.3 Tg P/y.

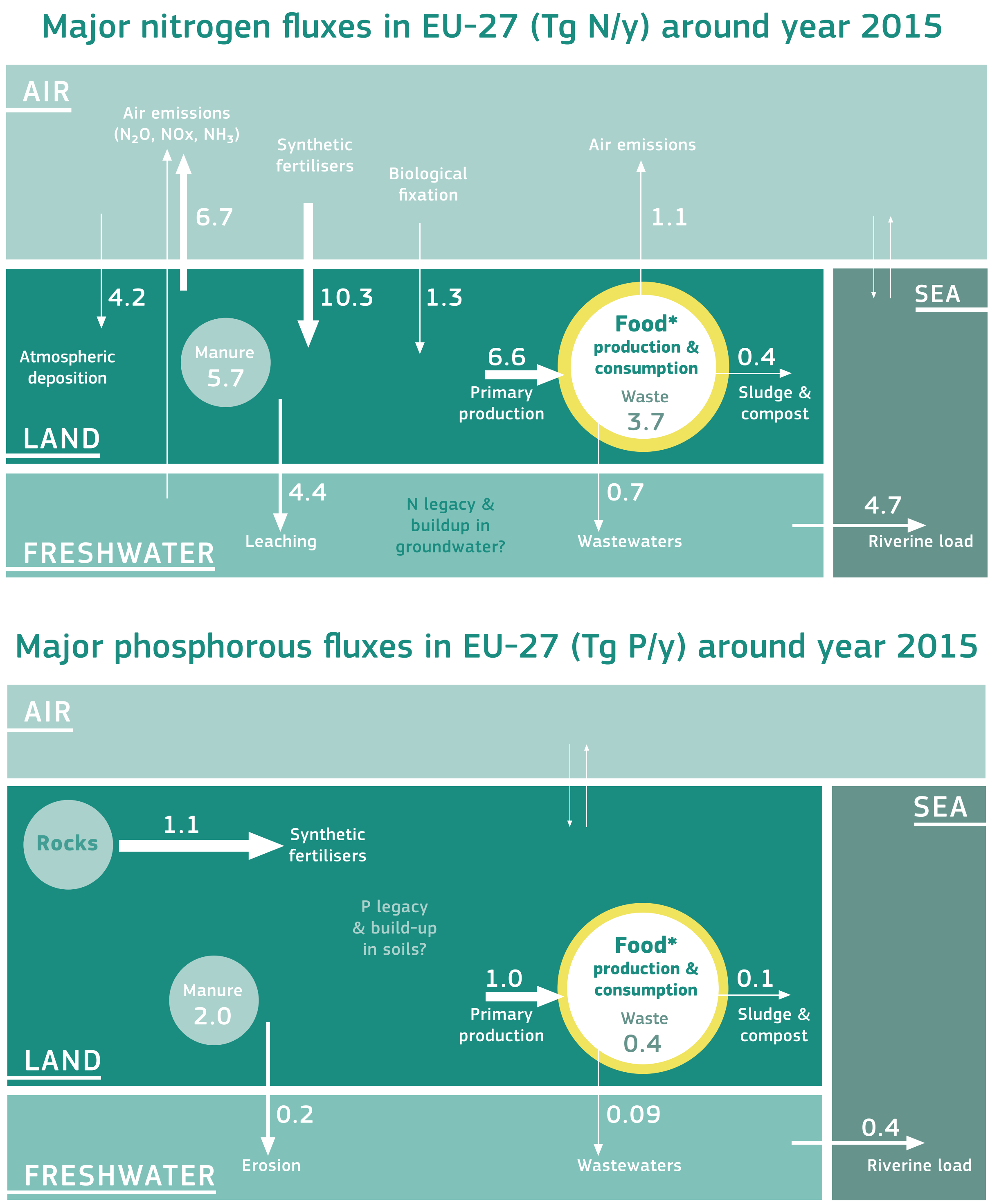
A large part of nutrients lost to surface- and groundwaters reaches the sea. About 50 % of N and 40 % of P from agricultural production that enters the food processing sector ends up in waste, with food waste representing around 10 % of total nutrient losses. There are major knowledge gaps in the quantification of N and P cycles regarding the legacy and build-up of N in groundwater and of P in soil. International trade in food and animal feeds moves nutrients across the globe and therefore affects the overall nutrient flows in different regions across the world.

As is evident from Figure 9, nutrient fluxes take several forms in the different steps of the nutrient cycle. Measures to reduce nutrient losses to the environment can be applied at various points in the cycle and within different sectors in order to target the various emission pathways. Such measures could include interventions ranging from technical measures for recovering and recycling nutrients from waste and for improving nutrient use efficiency in agriculture, to policy measures at the EU level to limit nutrient pollution. Achieving the target may also require broader societal changes, such as changes in the human diet and the agricultural system (food production–consumption system).

Our study (Grizzetti et al., forthcoming) investigates specific scenarios for a number of such pathways.

“Nutrients are fundamental to growth, but excessive amounts lead to pollution.”

Figure 9. Major nitrogen fluxes (teragram (Tg) N/year (y) (top) and phosphorous fluxes (Tg P/y) (bottom) in the EU-27 across air, land and water compartments. EU-27 as in January 2021, values refer to 2015 or closest year, only major fluxes (influenced by anthropogenic activities) are depicted.



*Net import of food 0.09 Tg N/y and 0.01 Tg P/y.

Source: Grizzetti et al. (forthcoming).

One strand of analysis concerns techniques to capture and transform N and P from organic waste into concentrated mineral fertilisers. Such techniques can enable trade and thus a transfer of nutrients from nutrient-excess to nutrient-lacking regions in the EU. Another approach looks at rebalancing mineral N fertilisation through a reduction in mineral N fertilisers in agricultural areas with N surplus, while allowing for an increase in mineral N fertilisers in areas with low use of fertilisers. A more balanced approach might lead to savings of N fertilisers and a reduction in N losses overall.

The potential effects of existing and proposed EU policy instruments on nutrient losses to air and water are also analysed. Relevant elements include to:

1. reduce nutrient discharges from domestic wastewaters according to the revision of the UWWTD;
2. reduce nutrient emissions from agricultural sources, in line with the new CAP, F2F and BDS targets and NextGenerationEU funds;
3. reduce nitrogen input from atmospheric deposition as planned for in the Commission's fit for 55 package and in the NEC directive.

Improved treatment of domestic wastewaters could decrease the amount of nutrients exported to European seas. Measures under the new CAP and those taken to achieve the BDS and F2F strategy targets could lead to a decrease in N and P loads as well. A reduction in atmospheric N emissions could lower atmospheric N deposition on land and decrease the amount of N exported to the sea.

Finally, various scenarios for the future of the agro-food system of Europe in 2050 are explored, considering business as usual, implementation of the F2F targets and more far-reaching agroecological scenarios. All scenarios meet European food demand (under different diets), but are associated with different levels of international trade and with differing environmental impacts. An important aspect would be the role of a possible change in diet, as decreasing the intensity of agriculture (especially livestock) is by far the most effective lever for reducing emissions of reactive N to the atmosphere and the hydrosphere.

The outlook for the zero pollution ambitions

The results of the study carried out for this outlook will be preliminary and not exhaustive. What remains clear is that a combination of policy measures in different sectors, combined with broader societal changes addressing different fluxes in the nutrient cycles, will be necessary to achieve the ZP ambitions. Impacts on all environmental compartments and feedback loops should be considered. Novel techniques for recovering and recycling nutrients from waste streams, together with reinforced targets to reduce waste along the food production and consumption chain, should further help reduce nutrient losses to the environment (Grizzetti et al., forthcoming).

Overall, while progress can be made under current policies, indications are that the EU will

"Stronger targets for reducing food waste should further help reduce nutrient losses to the environment."

not be able to reach the target of reducing all nutrient losses to the environment by 50 % by 2030 unless significant additional measures are put in place. Current measures for cutting air emissions under the fit for 55 package and NEC directive will substantially reduce NOx (- 40 %) and NH_3 (- 10 %), with a consequent reduction in N atmospheric deposition.

With the measures modelled in the scenarios of this study, including improvements in domestic wastewater treatment, reduction of N atmospheric emissions and measures under the CAP 2023–2027 and to achieve BDS and F2F strategy targets, the nutrient load in European seas could be reduced by about 30 % for N and 20 % for P. While these projected reductions are substantial, they are still below the BDS target of a 50 % reduction in losses. Also, measures will have to be taken in different sectors to achieve meaningful reductions of nutrient losses to the environment. These measures need to be conceived as part of an integrated approach to increase coherence and avoid possible 'pollution swapping' from one part of the environment to another, or from one region to another. This also underlines the advantage of reducing nutrient pollution at the source to avoid the cascade of negative impacts along the various parts of the nutrient cycle. Finally, the integrated approach can help improve the understanding of the legacy of nutrients in the environment, and underlines the importance of further improving our knowledge, including in the accounting of nutrient losses, to monitor progress towards the ZP targets.

The final study will be published together with the Commission's forthcoming integrated nutrient management action plan.

Consumption footprint outlook

2.5. Consumption footprint outlook

The European Commission developed an assessment framework to monitor the evolution of the overall environmental footprint of EU production and consumption, and to compare the footprint against the planetary boundaries. The consumption footprint responds to key challenges posed by the need for a systemic and holistic assessment of the transition towards sustainability, in support of the ambitions of the European Green Deal. It comprises a set of 16 life cycle assessment (LCA)-based indicators (also available as a single score) whose purpose is to quantify the environmental impacts of consumption at EU and Member State level (Sala and Mengual, 2022).

The consumption footprint is based on a combination of:

1. emissions to air, soil and water and the resources used along the life cycle of around 160 representative products, belonging to five areas of consumption (food, mobility, housing, household goods and appliances);
2. the consumption intensities of those products;
3. the environmental footprint (EF) impact modelling (JRC, 2021), which translates emissions and resource consumption into potential environmental impacts.

This indicator can be combined with the domestic footprint indicator (Sala and Mengual, 2022), which assesses the environmental impacts of domestic production and consumption activities within the territory of the EU based on statistics of resource extraction and emissions to the environment, and employing the EF method. Both indicators

“The environmental impacts of EU consumption are projected to increase until 2030.”

make up an LCA-based framework developed by the JRC that can support European Green Deal ambitions, including the zero pollution action plan (ZPAP), as follows (Figure 10):

- By monitoring trends over time, including the assessment of environmental decoupling and the sustainable development goals (especially SDG 12), through an integrated environmental impacts platform,
- By identifying hotspots at different levels (area of consumption, products, life cycle stage and substance), for a range of impact categories, including the biodiversity footprint and through the lens of the planetary boundaries,
- By testing scenarios regarding policy options, eco-innovations and changes in consumption patterns.

Figure 10. Policy support provided by the LCA-based framework, which combines the consumption footprint and the domestic footprint indicators.

Source: Sala, S. and Mengual, 2022

Monitoring the impacts of consumption trends. For the past decade, the environmental impacts of EU consumption have increased by 4 %. This is the result of a growth in the consumption intensity of food and mobility, which is only partially explained by population growth (+ 2 %). On the other hand, the environmental impact of activities taking place within the EU (the EU domestic footprint) decreased by 13 % (Figure 11) (Sala and Mengual, 2022; JRC, 2022a). This indicates that the EU is importing environmental impacts embedded in imported goods, while reducing environmental impacts through the positive effect of territorial EU policies. Compared to economic growth, the domestic footprint shows an absolute decoupling with an opposite trend to that of gross domestic product (+ 24 %), while this decoupling is only relative for the consumption footprint.

The current impacts of consumption have transgressed several of the planetary boundaries associated with emissions to the environment (air, water and soil) (Figure 12) (Sala and Mengual, 2022; JRC, 2022a). This absolute sustainability perspective is based on quantitative ecological thresholds and the possible repercussions of exceeding the thresholds. As the global planetary boundaries are allocated per capita, the current share allocated to the EU could shrink by 2030 due to global population trends.

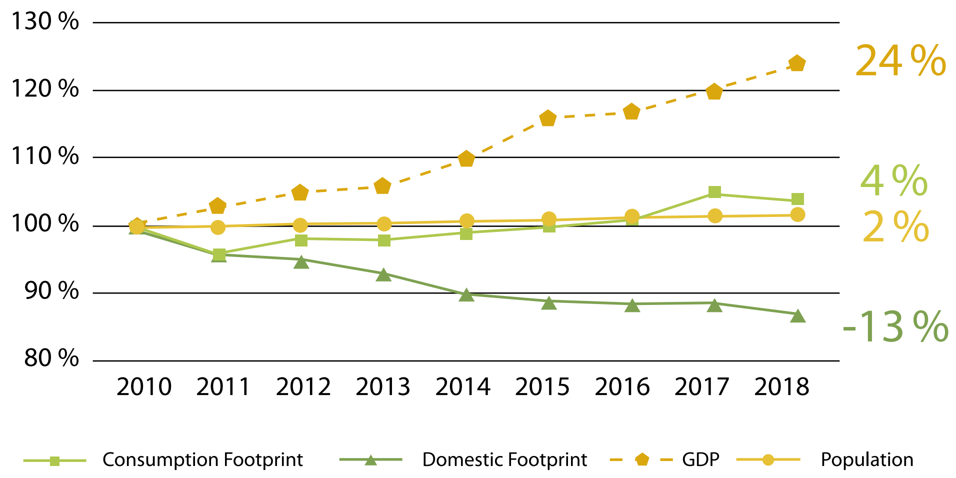
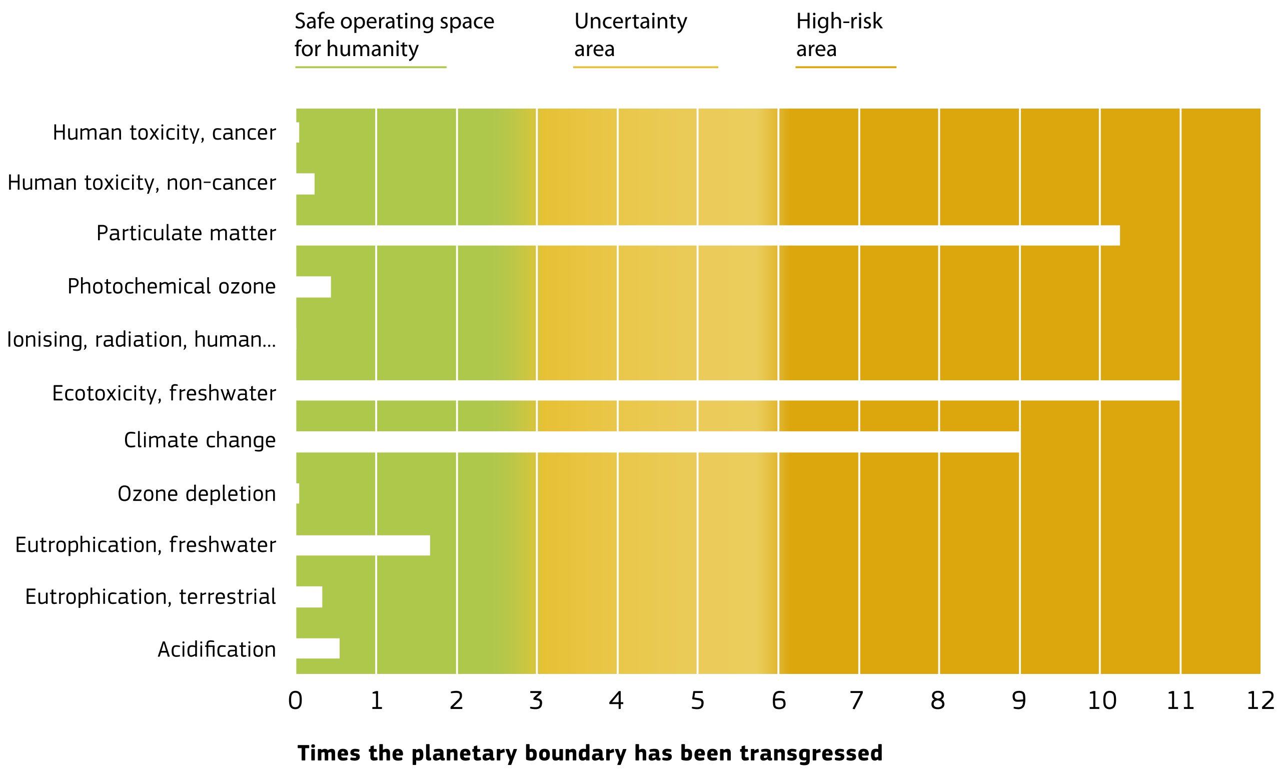


Figure 11. Evolution of the domestic and consumption footprints compared to gross domestic product (GDP) and population (2010–2018).

Source: Sala and Mengual, 2022.



Source: Sala and Mengual, 2022.

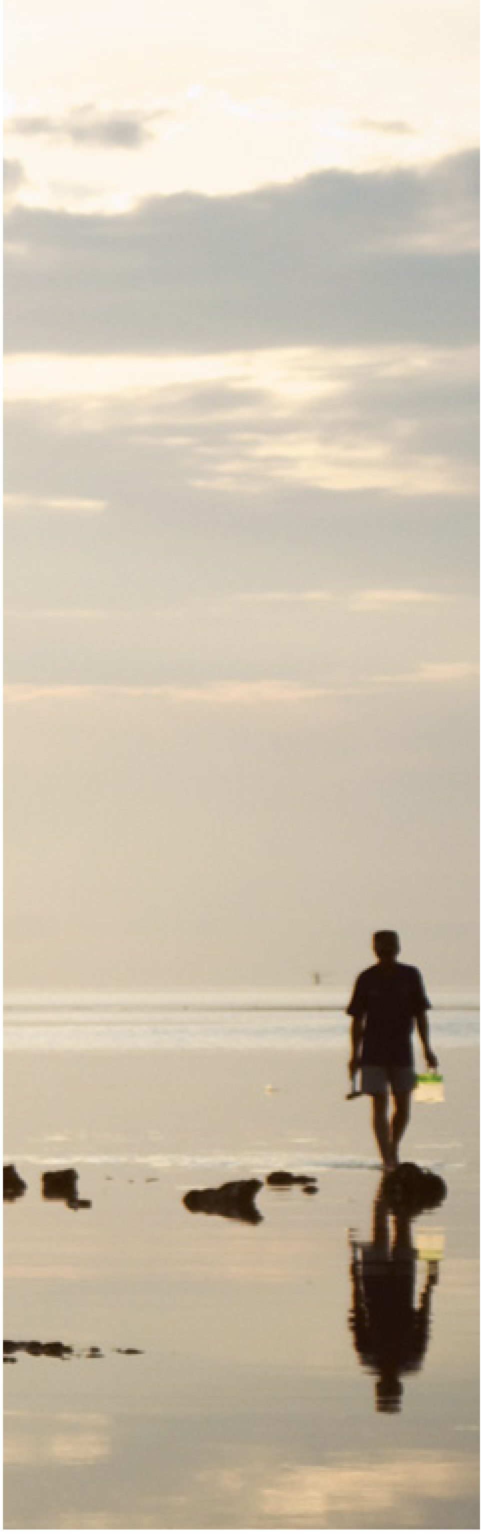
Figure 12. Assessment of the EU consumption footprint (2018) against the planetary boundaries (resource use EF impact categories and the single score were excluded).

The different levels of granularity of the consumption footprint – i.e. areas of consumption, product groups and representative products focusing on the main impacted compartment (air, soil, water) – help identify hotspots of environmental impacts. The current impacts of EU consumption on environmental pollution are dominated by the food, mobility and housing areas (Figure 13). Food dominates the categories associated with primary production, due to, for example, the associated emissions of nutrients (eutrophication), the use of chemicals (freshwater ecotoxicity), and refrigeration along the supply chain (ozone depletion). Housing is the major contributor to ionising radiation (due to energy consumption) and freshwater eutrophication (due to wastewater treatment). To several impacts, including climate change, there is a more balanced contribution of food, mobility and housing. The environmental impacts of pollution beyond climate change should be assessed in order to address a broad range of environmental issues and identify potential trade-offs.

2.5.1. The zero pollution ambitions

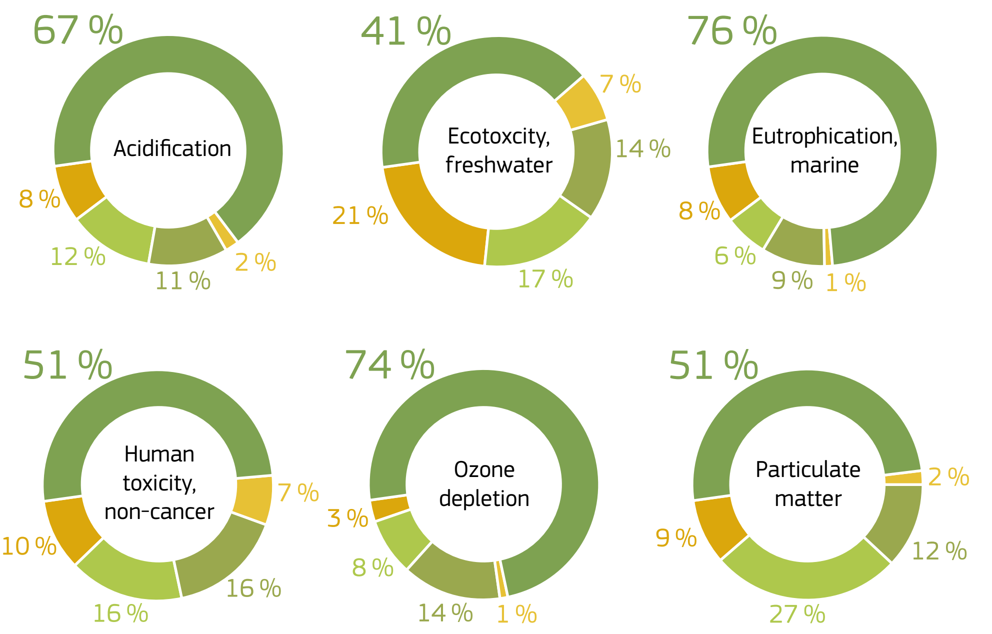
The consumption footprint (environmental impacts of consumption) can evaluate three 2030 ZPAP targets in an integrated manner from an impact perspective.

- **Target 1:** Improving air quality to reduce the number of premature deaths caused by air pollution by 55 %: associated with the environmental impacts of particulate matter, human toxicity (both cancer and non-cancer), ozone depletion and photochemical ozone formation.
- **Target 3:** Reducing the area of EU ecosystems where air pollution threatens biodiversity by 25 %: associated with the impacts of terrestrial acidification.
- **Target 4:** Improving soil quality by reducing nutrient losses and the use of chemical pesticides by 50 %: associated with the environmental impacts of eutrophication in marine, terrestrial and freshwater resources.

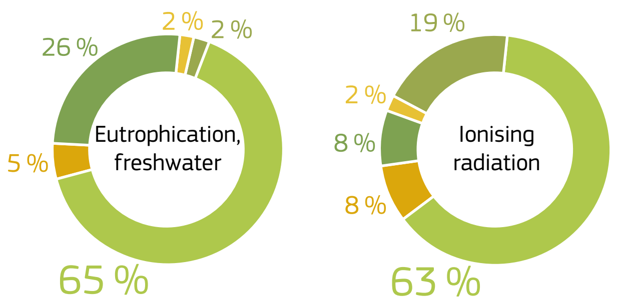


Note that the ZP targets for noise (reducing the share of people chronically disturbed by transport noise by 30 %), waste generation (significantly reducing waste generation, and reducing residual municipal waste by 50 %) and plastic litter (improving water quality by reducing waste, reducing plastic litter at sea by 50 % and reducing microplastics released into the environment by 30 %) are also associated with consumption. However, they are not assessed directly by an impact category of the consumption footprint, either because their impacts are not yet covered by LCA (noise, plastic litter) or they are assessed indirectly through the life cycle of consumed products (waste generation).

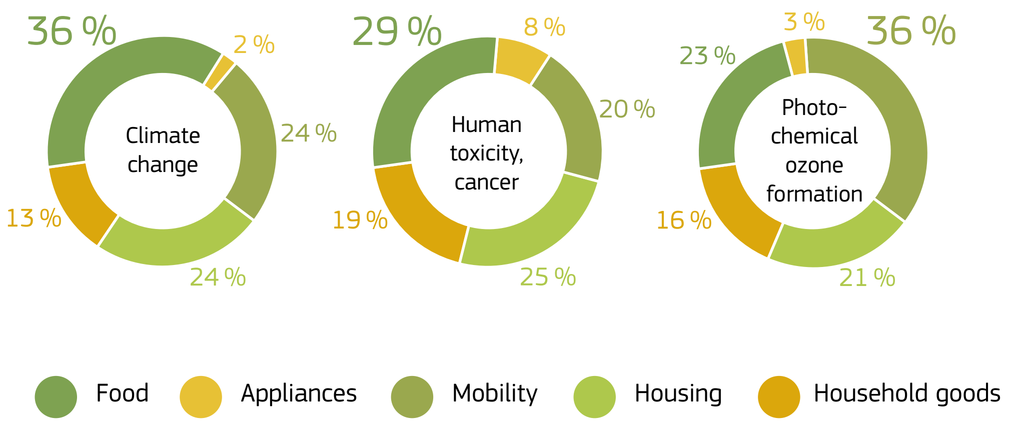
Impacts dominated by food consumption



Impacts dominated by housing



Impacts dominated by food, housing and mobility



Source: JRC, 2022a.

Figure 13. *Contribution of the different areas of consumption to the EF impact categories addressing environmental pollution, grouped by the major driver of impacts in terms of area of consumption (resource use EF impact categories and the single score were excluded).*

2.5.2.
Putting the zero pollution ambitions to the test

Future sustainable consumption patterns have been assessed against the planetary boundaries and the ZPAP targets, including a business-as-usual (BAU) baseline and an 'EU ambitions' scenario focused on the effects of the farm-to-fork (F2F) strategy, the clean vehicles directive and the renovation wave initiative (Figure 14).

The environmental impacts of EU consumption are projected to increase until 2030 due to the further development of the economy and associated consumption patterns. This will keep the EU consumption footprint beyond the planetary boundaries for several categories associated with environmental pollution. Under the 'EU ambitions' scenario, the projected evolution shows a slightly larger decrease (e.g. particulate matter), greater stability (e.g. terrestrial eutrophication) and a more limited increase (e.g. climate change) compared to the BAU scenario. However, apart from marine eutrophication, the ambitions do not show a significant effect of reducing the impacts to the extent of remaining within the planetary boundaries.

Regarding the ZPAP targets, while the third clean air outlook foresees that the health-related air pollution target can be met, one should bear in mind that this target is looked at from a territorial perspective, focussing on direct emissions occurring within the EU. However, from a consumption and supply chain perspective, pollution impacts also consider emissions associated with goods imported into the EU for consumption, i.e. that embed emissions generated outside the EU. The consumption footprint outlook indicates that further efforts are needed to ensure that, beyond reaching the ZP target of reducing the health impacts of air pollution within the EU, the EU production and consumption system does not shift environmental impact burdens to third countries[9]. Along the same line of argument, the impacts of pollution on ecosystems and biodiversity that are embedded in imports produced outside the EU should also be considered and reduced. Measures to reduce nutrient losses and chemical pesticides (including those in the F2F strategy) could be successful in improving freshwater eutrophication, although further efforts may be needed for marine and terrestrial eutrophication and freshwater ecotoxicity.

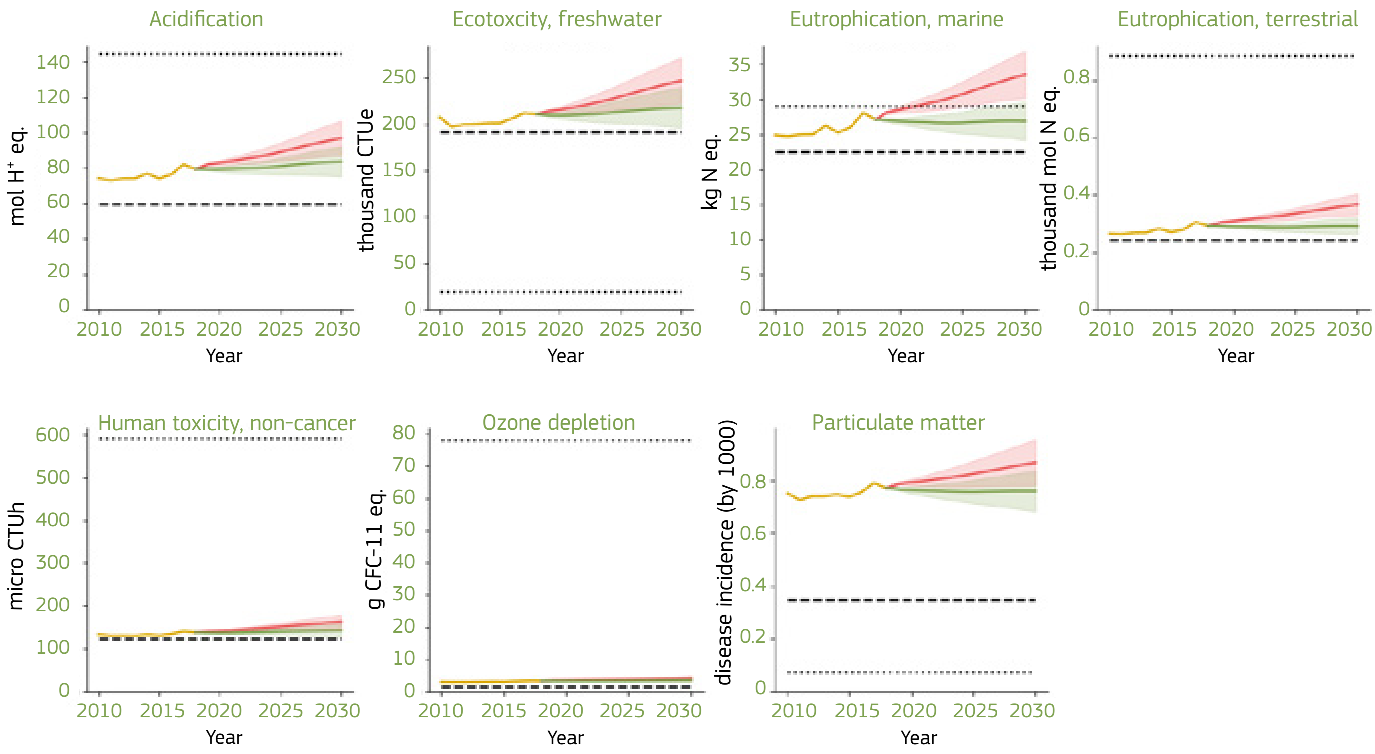
The two outlook scenarios were defined based on drivers of consumption patterns (e.g. macroeconomic indicators, consumer profiles such as dietary patterns and food waste, transport fleet and household stock). The BAU baseline is based on projections of gross domestic product (GDP), household consumption expenditure, transport fleet size and composition, and number of households.

"Further efforts are needed to ensure that EU production and consumption does not shift environmental burdens to third countries."

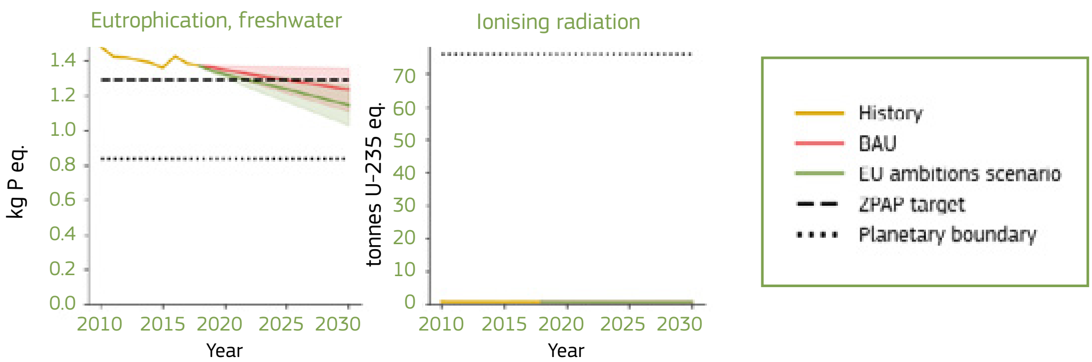
***Figure 14.** Evolution of the "business-as-usual" (BAU) and EU ambitions scenarios against the ZPAP targets (black dashed line) and the planetary boundaries (black dotted line), projected based on historical data for 2010-2018 (resource use EF impact categories and the single score were excluded).*

([9]) For the clean air outlook, the International Institute for Applied Systems Analysis (IIASA) used the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model, which estimates emissions of air pollutants by country. Therefore, the approach is domestic. By contrast, the consumption footprint takes a consumption approach, which also considers the environmental impacts embedded in imported products.

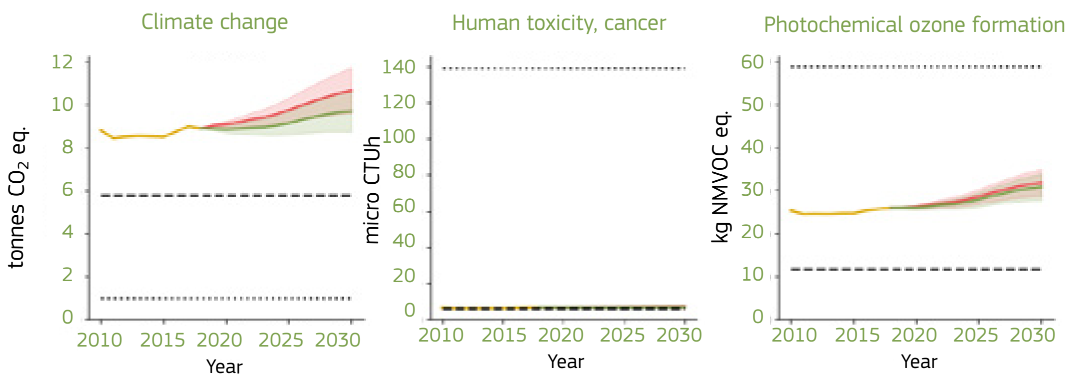
Impacts dominated by food consumption:



Impacts dominated by housing:



Impacts dominated by food, housing and mobility:

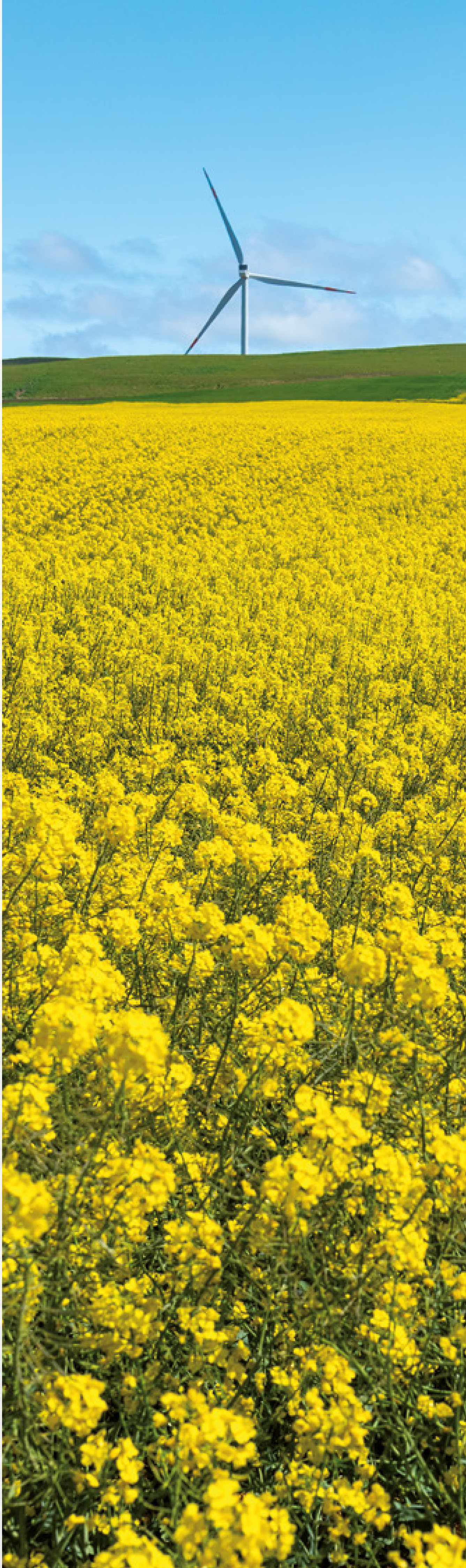


Source: JRC.

The 'EU ambitions' scenario addresses how current EU strategies and policies will change the drivers underpinning the hotspots of the consumption footprint, including the F2F strategy (i.e. reduction in food waste, nutrient and pesticides use, and shift to a plant-based diet), the clean vehicles directive (i.e. change of transport fleet composition) and the renovation wave initiative (i.e. improved efficiency of housing stock).

Future trends in consumption intensity are expected to keep growing in line with global megatrends (JRC, 2022b), with a more economically powerful middle class. While sustainable consumption had recently been on the increase, the COVID-19 pandemic has slowed this trend. To support the transition towards more sustainable consumption, the consumer footprint calculator (JRC, 2022c) allows citizens to quantify the impacts of their consumption patterns and identify which consumption patterns contribute most to their overall footprint.

There are also expected benefits of the uptake of the environmental footprint recommendations. The updated Commission recommendation on the use of the environmental footprint methods to measure and communicate the environmental performance of products and organisations over their life cycle was released in 2021, and the use of voluntary and mandatory schemes for products across different policies may represent an important consumption-oriented boost towards ZP. For example, the recent proposed regulation for establishing a framework for setting ecodesign requirements for sustainable products supports a transition towards making sustainable products the norm. This regulation is expected to help reduce pollutants and greenhouse gas emissions from the manufacturing value chains supplying regulated products to the EU internal market. Such policies will therefore help reduce the environmental pollution intensity per unit of product which, combined with limited consumption intensity and changes in consumption patterns, could help mitigate the overall environmental pollution impact of EU consumption.



"Although the environmental impacts of domestic EU consumption have decreased by 13 % over the past decade, the impacts of total EU consumption have increased by 4 % due to environmental impacts embedded in imported goods."

Transport noise outlook

2.6. Transport noise outlook

Long-term exposure to environmental noise is a widespread problem across Europe. Living in an area affected by transport noise is associated with poorer health, well-being and quality of life (WHO Europe, 2018). In 2017, about 18 million people in the EU were suffering from long-term high annoyance due to transport noise from road, rail and aircraft sources (EEA, 2022a).

One of the headline targets of the zero pollution action plan (ZPAP) is to reduce the number of people chronically disturbed by transport noise by 30 % by 2030 compared with 2017. To achieve this, the number of people highly annoyed would need to be reduced by 5.3 million compared with the reference year of 2017. This is likely to be particularly challenging given that the overall number of people exposed to harmful levels of noise has broadly remained stable since 2012 (EEA, 2020a).

This outlook assesses whether or not the zero pollution (ZP) target on noise can be met by 2030. To answer this question, the numbers of people highly annoyed by transport noise are projected under two scenarios, one conservative and one optimistic. Results suggest it is unlikely that the target will be met without further regulatory or legislative changes. The outlook is based on the European Environment Agency (EEA)'s briefing Outlook to 2030 – can the number of people affected by transport noise by cut by 30 %? (EEA, 2022b).

The full findings and methodology are described in the European Topic Centre on Human Health (ETC HE) and the environment report Projected Health Impacts from Transportation Noise – Exploring two scenarios for 2030 (ETC HE, 2022)

The projections were based on current noise regulations, implementation of measures reported in action plans reported under the environmental noise directive (END), recent studies on noise measures, and population and transport forecasts. The measures selected focus on currently available measures that countries and competent authorities are able to enforce/implement. Therefore, the outlook does not consider new or strengthened policies.

People chronically disturbed by noise can suffer a wide range of negative health effects, including annoyance, sleep disturbance and cardiovascular problems. In this outlook, progress towards the ZP noise target is measured by assessing changes in the number of people highly annoyed by noise from road, rail and aircraft at the EU level using data on population exposure collected under the END. High annoyance is considered to be a good indicator for measuring adverse health effects of noise as it can be a harbinger of more severe health problems. Therefore, this indicator is used as a proxy for chronic disturbance in this assessment. For further reference, the number of people highly sleep disturbed, the number of people exceeding the END thresholds and the number of people exceeding the World Health Organization (WHO) recommendations for road, railway, and aircraft was also explored in further detail in the ETC HE report (ETC HE, 2022).

High annoyance is based on the exposure-response functions outlined in the WHO environmental noise guidelines (WHO Europe, 2018) and the number of people exposed to noise levels above 55 dB during the day-evening-night period (Lden) due to road, rail and aircraft noise in areas covered by the END.

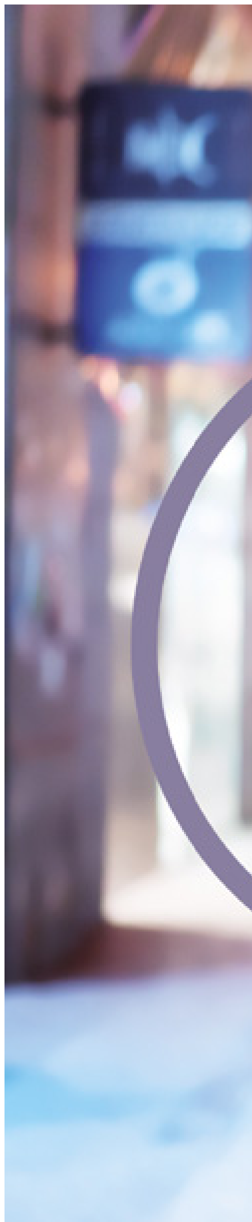
It should be noted that the projections are based on different hypotheses, assumptions and approximations, each of which has associated uncertainties. The projections assume uniform implementation of the measures in all countries. The potential for reduction in each country depends on how many actions and measures have already been implemented.

2.6.1. The zero pollution ambitions

Given the negative impact of noise on human health and the large number of people affected, reducing environmental noise is a key target under the ZPAP. Specifically, the aim is to reduce by 2030 the number of people chronically disturbed by noise from transport by 30 % compared with 2017.

To meet this objective, the European Commission has identified the need to:

- monitor progress towards achieving a 30 % reduction in the number of people chronically disturbed by noise by 2030,
- improve the noise-related regulatory framework on tyres, road vehicles, railways and aircraft at the EU level, and also at the international level,
- review progress in 2022 and consider if there is a need to set noise reduction targets at the EU level in the END,
- improve the integration of noise action plans into sustainable urban mobility plans, benefiting from an extension of clean public transport and active mobility.



“There are no prospects of achieving the noise target of 30 % reduction by 2030, as projected population growth and transport outweigh the benefits of foreseen the measures.”

	Conservative scenario 2030	Optimistic scenario 2030
	Scenario considering the implementation of current regulations and a small increase in mitigation measures following current trends	Scenario considering extensive mitigation measures and policies
Road — Inside urban areas	· Implementation of the regulation of the sound level of motor vehicles · **25 %** electrification of the fleet · Increased use of low noise asphalt ⬆ **5 %** · Increased use of noise barriers on major roads ⬆ **1.3 %**	· Implementation beyond the regulation of the sound level of motor vehicles · **50 %** electrification of the fleet · Increased use of low noise asphalt ⬆ **10 %** · Increased use of noise barriers on major roads ⬆ **3 %** · Reduction to 30 km/h speed limit in 30 % of major roads inside agglomerations
Road — Outside urban areas	· Implementation of the regulation of the sound level of motor vehicles · Increased use of low noise asphalt ⬆ **5 %** · Increased use of noise barriers on major roads ⬆ **1.3 %**	· Implementation beyond the regulation of the sound level of motor vehicles · Increased use of low noise asphalt ⬆ **10 %** · Increased use of noise barriers on major roads ⬆ **3 %**
Road — Result	**No change**	**- 2.7 m highly annoyed** ⬇ **-20 %**
Rail — Inside urban areas	· New urban rail infrastructure · Silent brake policy in major railways	· Minor increase in urban rail infrastructure · Silent brake policy in major railways · Maintenance and rail grinding
Rail — Outside urban areas	· Increase in speed and high-speed lines · Silent brake policy for freight transport · Increased electrification	· Minor increase in speed and high-speed lines · Silent brake policy for freight transport · Increased electrification · Maintenance and rail grinding
Rail — Result	**+ 800 000 highly annoyed** ⬆ **+ 35 %**	**+ 100 000 highly annoyed** ⬆ **+ 4 %**
Aircraft — Inside and outside urban areas	· Quieter aircraft · Improved landing and take-off procedures	· Quieter aircraft · Improved landing and take-off procedures · Night curfews · Other actions from noise balanced approach
Aircraft — Result	**- 300 000 highly annoyed** ⬇ **- 37 %**	**- 600 000 highly annoyed** ⬇ **- 71 %**

Inside urban areas — Outside urban areas — Inside and outside urban areas

Source: EEA.

Figure 15. *Overview of measures and degree of implementation for each source of transport noise included in the conservative and optimistic scenarios.*

2.6.2. Putting the zero pollution ambitions to the test

The numbers of people highly annoyed by transport noise are projected under two scenarios, one conservative and one optimistic. The conservative scenario assumes fulfilment of the current legal requirements to reduce noise at source, and the implementation of some non-binding mitigation measures by 2030. The optimistic scenario assumes implementation, by 2030, of a set of more ambitious noise mitigation measures that go beyond current regulations.

Figure 15 gives an overview of the measures included in the conservative and the optimistic scenarios. Different measures are included depending on the noise source and the type of area. In both scenarios, projections of population growth and transport activity are considered in combination with the implementation of the measures.

The results of this outlook assessment suggest that there is no possibility of achieving a 30 % decrease in the number of people chronically disturbed by transport noise by 2030, even with the implementation of the planned noise mitigation measures (see Figure 16). The optimistic scenario suggests that a reduction of only about 19 % in the number of people chronically disturbed by transport noise could be achieved. In contrast, under the conservative scenario, the number of people affected by noise could even increase by 3 %. This is because the projected growth in population and transport outweighs the benefits of implementing the measures outlined in the conservative scenario.

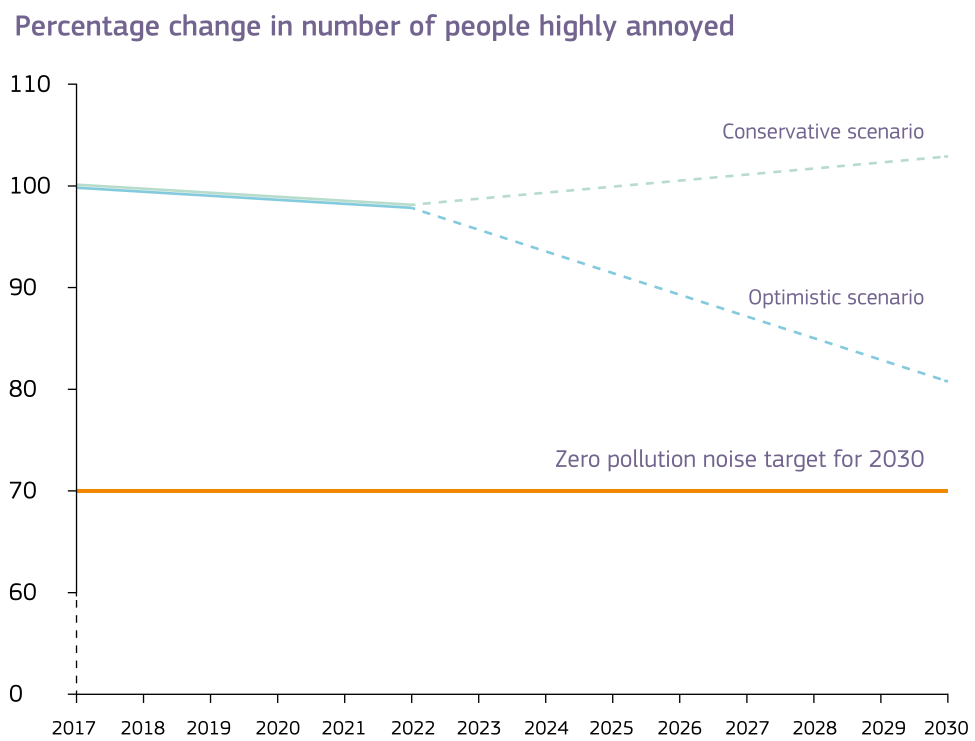


Figure 16. *Estimated percentage change in the number of people highly annoyed by noise from transport in the EU-27 from 2017 to 2030 under conservative and optimistic scenarios.*

Source: EEA.

Although the ZP target is unlikely to be reached for all sources of transport noise combined, projections differ for rail, road and aircraft. Figure 17 shows the projected percentage change from 2017 to 2030 in the number of people highly annoyed by noise from the three transport sources.

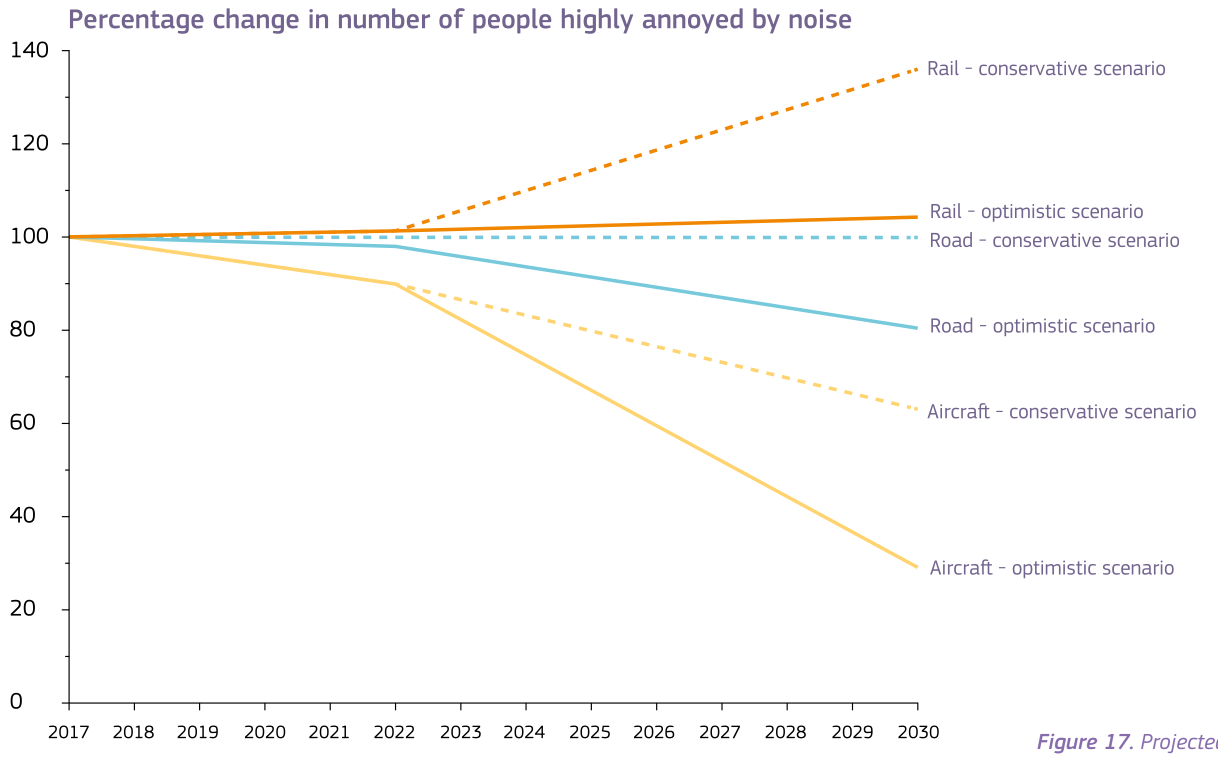
Based on the scenarios modelled, the following statements can be made.

- The number of people highly annoyed by road traffic noise is projected to remain the same under the conservative scenario, or to decrease by up to 20 % under the optimistic scenario.

- The number of people highly annoyed by rail noise is projected to increase in both scenarios, and by up to 36 % under the conservative scenario. This increase is mainly driven by a projected substantial growth in rail activity.

- The number of people highly annoyed by aircraft noise is projected to decrease significantly, by up to 71 % under the optimistic scenario. This decrease is due to the fact that most of the people affected by aircraft noise are in the 55–60 dB band and below. Therefore, the measures applied move a large number of people below the END thresholds.

The main obstacle to reaching the ZP target is the large number of people exposed to road traffic noise, with road traffic being by far the most prevalent source of noise. In 2017, more than 14 million people were highly annoyed by road traffic noise, compared with 2.5 million for rail noise and 1 million for aircraft noise. This suggests that increased efforts need to be made to reduce the number of people highly annoyed by road traffic noise in the EU. Although the scale of the impacts of rail noise is much less than that of road traffic noise, increased efforts also need to be made to outweigh the negative health impacts resulting from projected growth in rail activity, new rail infrastructure and faster trains. In terms of aircraft noise, even if the number of people highly annoyed is reduced as much as the scenarios project, a very high number of people will still be exposed to levels of aircraft noise considered harmful to health by the WHO (EEA, 2022b).



Source: EEA.

***Figure 17.** Projected percentage change from 2017 to 2030 in the number of people highly annoyed by noise from rail, road and aircraft under conservative and optimistic scenarios in the EU-27.*

To achieve greater progress in reducing noise pollution, more efforts are needed to address noise from road transport. Although actions described in END action plans tend to focus on high noise hotspots, in order to reach the ZP objective, measures would need to target not only areas with acute noise problems, but also areas where noise levels are more moderate. Therefore, the use of measures that reduce noise at the source is of high importance. New EU regulations tackling noise at source and setting out obligations to act upon critical levels could help to reduce the number of people affected by noise. For instance, a binding obligation to use quiet tyres by 2030 could reduce the number of people affected by noise by approximately an additional 9 % in the conservative scenario and an additional 5 % in the optimistic scenario. In addition to this, a single measure cannot deliver the ZP target on noise. A combination of measures will be needed, including measures at the source, better urban and transport planning, and significant reductions in road traffic in cities. These results agree with previous studies on the health benefits of noise mitigation measures:

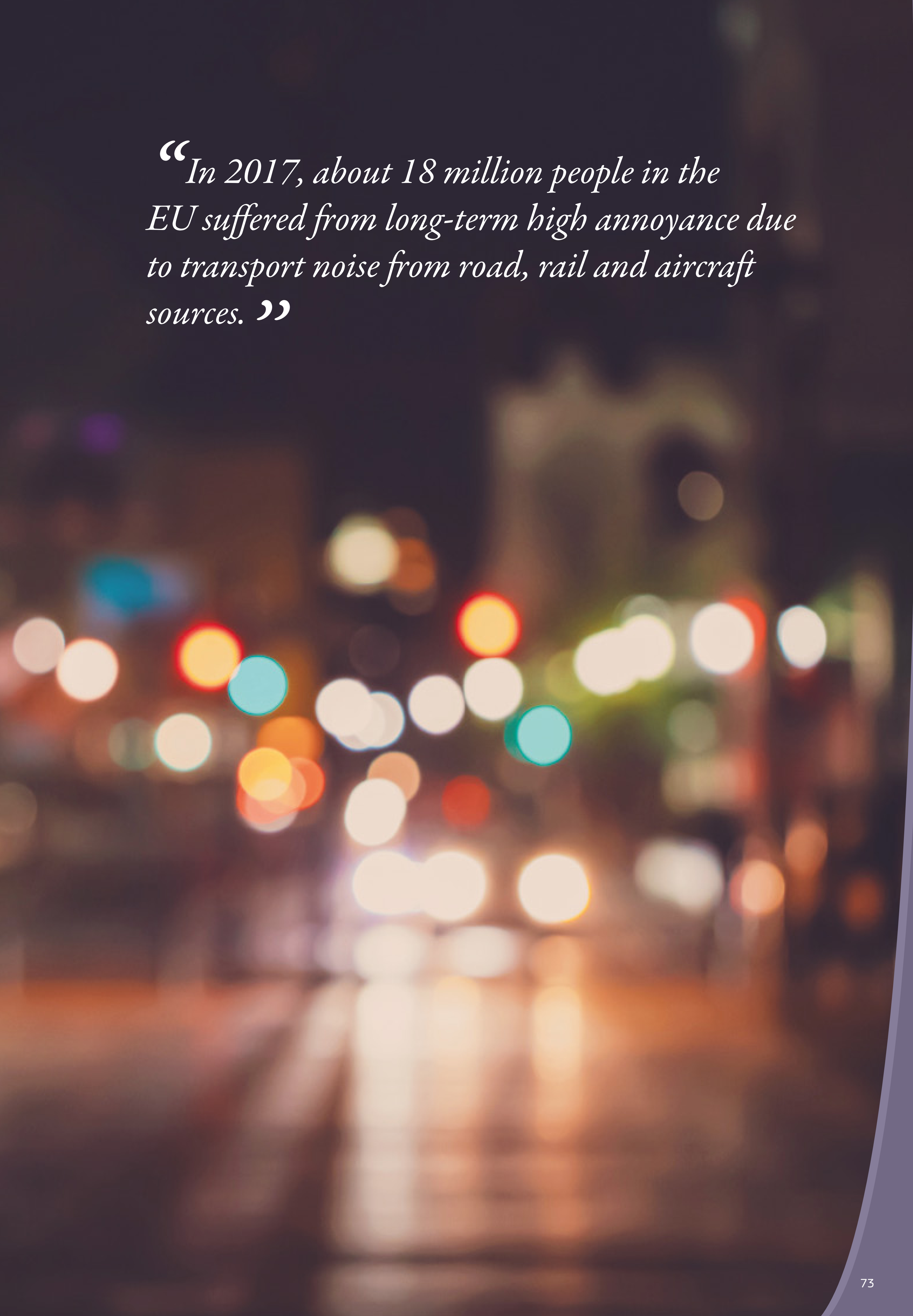
Between 2019 and 2021, the European Commission commissioned a study to assess the health benefits that could be achieved by different noise abatement measures for road, rail and air traffic (European Commission, 2021). The 'Phenomena' study modelled the benefits of potential noise measures, some of which were accompanied by tighter or revised regulations. The project concluded that a reduction of 20 % or more could be achieved with a combination of different noise measures, including revised and strengthened EU policies.

More specifically, the project estimated that quieter roads, quieter tyres, lower vehicle sound limits and increased electrification accompanied by the necessary regulatory changes could reduce the health burden from road traffic noise by 18–24 % by 2030. The results also suggested that the health burden of railway noise could be reduced by 37–52 % with smoother and quieter vehicles and tracks. For aircraft noise, the best single measure for reducing health effects due to noise from aircraft was found to be the introduction of a night curfew in all airports. If applied, the health burden reduction was estimated to be 30–60 % by 2030. A higher health burden reduction of about 44–46 % could also be achieved using a combination of measures such as improved take-off procedures, dispersion/concentration of flights, the phasing out of the noisiest aircrafts and the accelerated replacement of fleets with quiet aircraft.

Although the outlook presented in this section does not consider new regulatory changes and differs from those modelled by the Phenomena study, the results also suggest that, to achieve a substantial reduction in the number of people disturbed by noise, further regulatory and legislative measures are needed.

Finally, to increase the impact of transport noise mitigation measures while optimising costs and efforts, combined strategies and policies could be designed for mitigating noise together with other environmental hazards linked to transport (EEA, 2020a).

"In 2017, about 18 million people in the EU suffered from long-term high annoyance due to transport noise from road, rail and aircraft sources."



Foresight outlook

2.7. Foresight outlook

The world of 2050 will obviously not be the world of today, and there is no single linear pathway between now and the future. Rather, multiple opportunities and challenges will emerge and fade, creating different ways of fulfilling the vision of zero pollution (ZP). Foresight helps to understand the possible future consequences of current trends, to detect new signals of change and to determine their potential developments.

2.7.1. The zero pollution ambitions

The zero pollution action plan (ZPAP) proposes a vision for the world in 2050 of a healthy planet for all, where air, water and soil pollution are reduced to levels no longer considered harmful to health and natural ecosystems and that respect the boundaries our planet can cope with, thus creating a toxic-free environment. As part of the action plan, the monitoring and outlook framework document proposes the development of a systematic, cross-cutting foresight capacity for ZP.

Foresight facilitates the development of systemic understanding and generates plausible and coherent pictures of the future, ranging from alternative scenarios (normative or exploratory) to vision building (Störmer et al., 2020). Building on modelling and projections, foresight helps imagine different, possible, multi-faceted futures.

Several foresight activities have already been carried out that can inform the ZP ambition – these involve horizon scanning, technology assessment and scenario building. Some, such as the EU Environmental Foresight System (FORENV) horizon scanning exercise, relate directly to the ambition. Others focus on broader European Green Deal topics – the twinning of the green and digital transitions, a circular, sustainable bioeconomy and sustainable futures. Together, they help to foresee some of the changes that we expect to come, identifying opportunities arising from the green and digital transitions and looking at the societal dimension of the necessary change through scenarios.

“New pollution monitoring methods will improve the availability of accurate information on pollution.”

2.7.2. Putting the zero pollution ambitions to the test

Figure 18. Ten emerging issues identified in the FORENV project.

The FORENV horizon scanning of emerging environmental issues relating to the ZP ambition identified ten emerging issues. These were combined into five clusters of developments, which suggest the emergence of new drivers and sources of pollution alongside opportunities to reduce the pollution burden of some sectors (European Commission, 2022a).

Urban settlement patterns and demographic change: implications for pollution

Will regenerative buildings and living materials in Europe helps deliver the zero pollution ambition?

Purpose-driven business: will the emergence of initiatives such as certified 'B' corporations play a major role in realising zero pollution?

Will regenerative agriculture emerge as a key trend in Europe that helps deliver the zero-pollution agenda?

Will new ways of pollution information provision influence behaviours towards low pollution lifestyles that go beyond current trends towards low/zero waste?

Low pollution food: will new, less polluting, methods of producing protein, fats and tissues emerge to replace traditional agriculture?

An accelerating race to space: what will be the direct and indirect pollution impacts?

The COVID-19 pandemic has led to increased interest in resilience. Will a resilient Europe also be a zero pollution one?

Will new innovations in synthetic biology emerge that accelerate pollution reduction and mitigation?

Our growing digital consumption could challenge the 'zero pollution' ambition

Source: FORENV.

Pervasive digital tools and lifestyles. As life and work become more digitalised, remote work and 'virtual lifestyle services' increasingly reduce physical consumption of goods and services, a trend that will increase with new tools such as virtual and augmented reality. This will lead to reduced pollution by economic and social activity, but raises the issues of the growing demand for resources, electronic waste and energy consumption. How can the wider implications of the use of resources, water consumption, land use, biodiversity and the pollution impacts of new technologies be better understood and addressed?

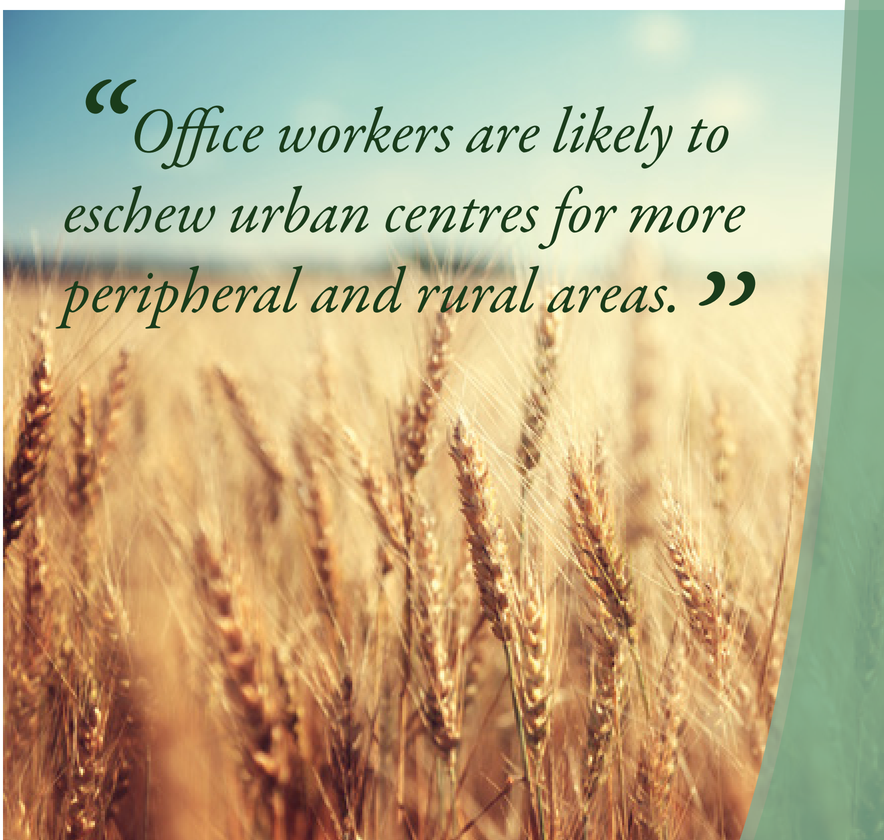
Transformations in where and how we live and work. More flexible work patterns, the focus on health and welfare, along with climate change and future disasters could lead to an exodus of office workers from urban centres to urban peripheries, small towns and rural areas. The revitalisation of areas that currently face depopulation, and the repurposing and redesigning of urban centres, could lower the impact of human activity. However, the repurposing itself, growing inequalities and larger catchment areas of cities, and more economic activity in rural areas could have an adverse effect. Will 'urbanised' hubs emerge in areas outside cities, and how can the pollution risks from these be managed?

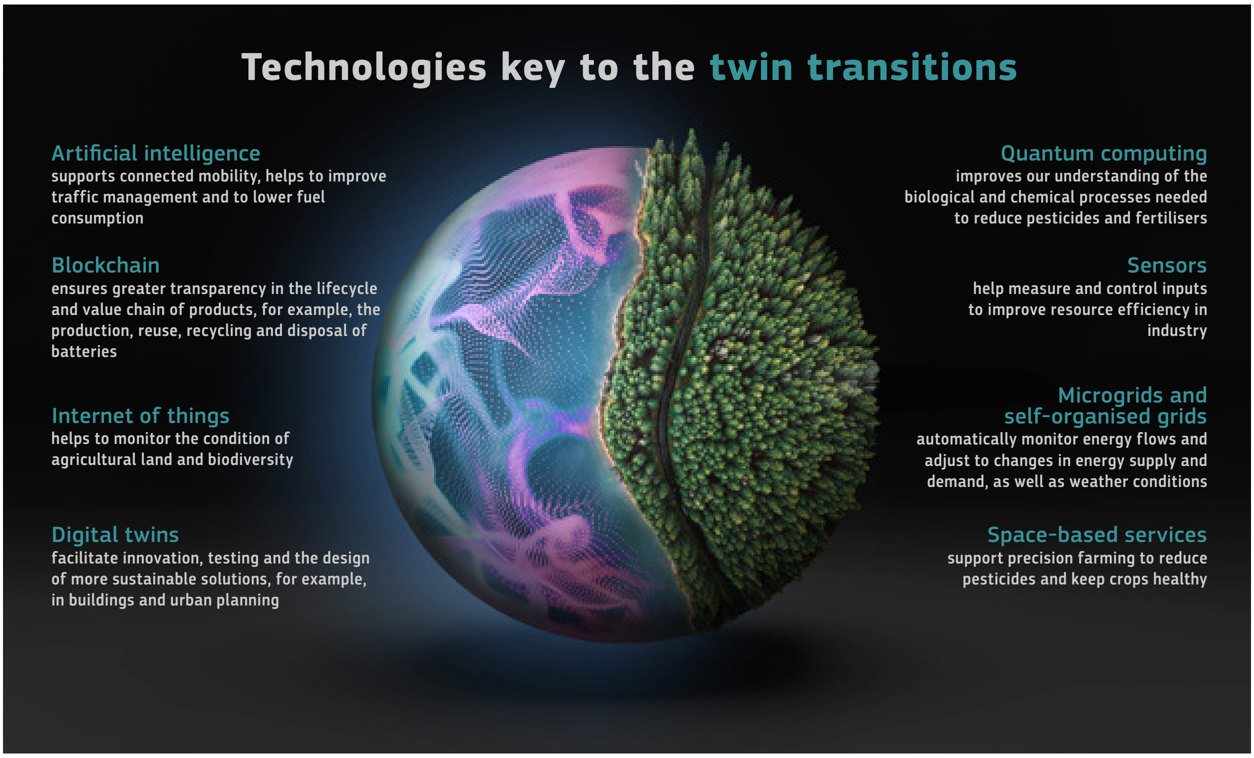
New pollution monitoring and data methods. New sensors, new sources of data, and more complete and transparent monitoring will lead to more readily available and accurate information on pollution. This could put increased pressure on businesses for accountability and transparency of their environmental impacts (which could potentially be transformed into a competitive advantage) but also lead to behavioural change by consumers. Will new ways of providing pollution information influence behaviours towards low pollution lifestyles that go beyond current trends towards low or zero waste?

Living buildings and new materials. The increased prevalence of a new range of building materials (e.g. living, biogenic, composites), together with the use of sensors and advanced manufacturing, could lead to more regenerative buildings that could self-repair or even grow, provide a source of food and combat air or chemical pollution through absorption. How can the use of new and living materials be encouraged in retrofitting and refurbishing older buildings?

Multi-faceted food system revolutions. An increasing interest in adopting regenerative agricultural approaches, alongside other food system developments such as cellular agriculture and synthetic biology, will have far-reaching implications for agriculture. These approaches and developments could reduce the use of agricultural chemicals, (reducing runoff to water bodies) and reduce long-distance transport, but could require new inputs and more energy. Low pollution food: will new, less polluting, methods of producing protein, fats and tissues emerge to replace traditional agriculture?

Digital technologies feature strongly in all five clusters and can act as a catalyst for the green transition (Muench et al., 2022). Monitoring and tracking can provide real-time information, enabling simulation and forecasting to improve efficiency (e.g. digital twins that can simulate the entire life cycle of a product or process). With digital technologies, systems management can cope with increasing complexity while optimising operations, for example in smart cities. Finally, digital information and communication technologies enable new levels of interaction. Data and data analysis will be the backbone of the green and digital transitions. Constant improvements in technologies such as sensors and the internet of things can help to collect and act on such data.





Source: European Commission.

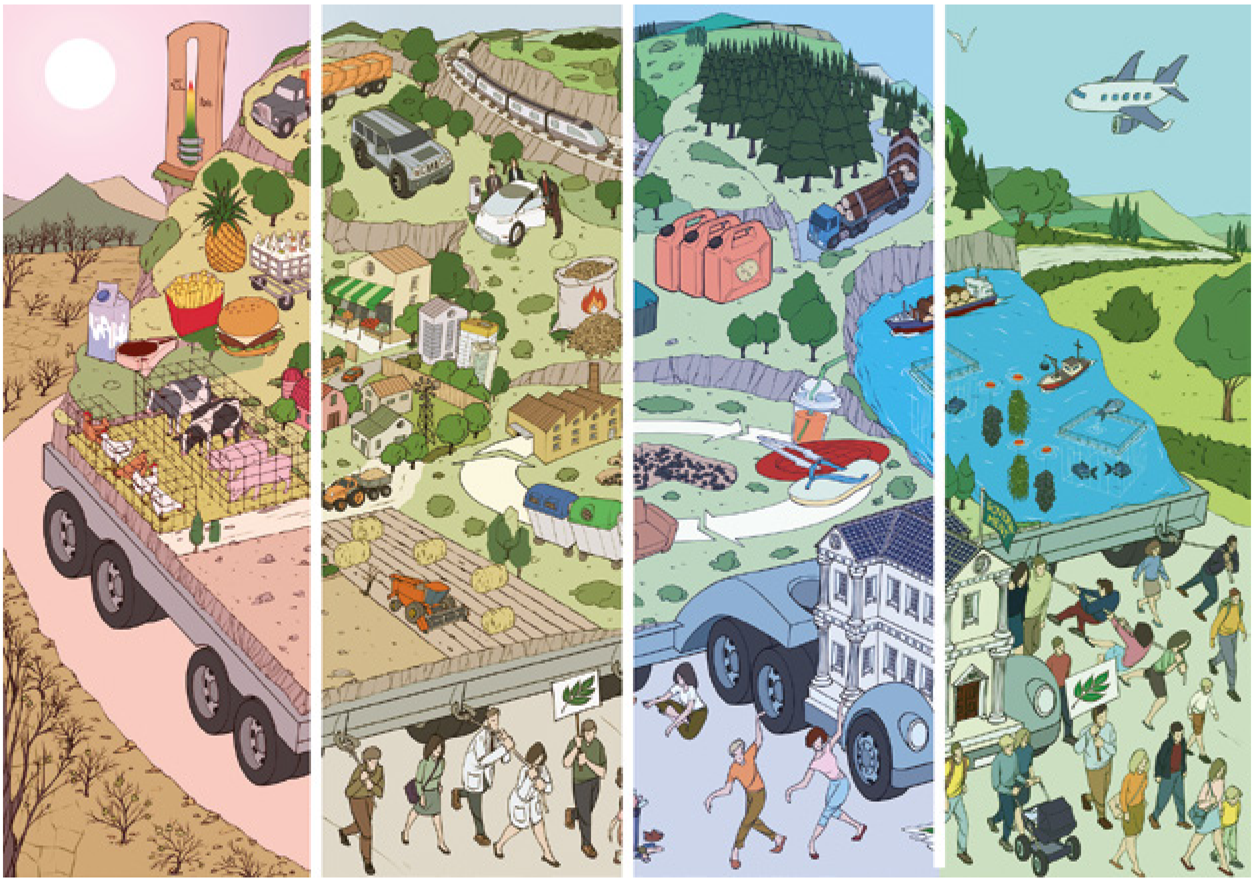
Figure 19. *Key technologies enabling the twin (green and digital) transitions.*

Digital technologies will support the green transition in different ways, depending on the sector. In the agricultural sector, better systems management can increase productivity and reduce environmental impacts through more precise applications of feed, water, energy, fertilisers and pesticides. Virtualisation can eliminate certain physical space and travel needs, for example through remote meetings or online shopping, or revolutionising the building and construction sector. In the energy sector, digital information and communication technologies facilitate communication between stakeholders and technical elements in an increasingly complex energy system. Monitoring and tracking provide information on the parts and materials used in products in energy-intensive industries, to enable better maintenance, recycling and reuse. Also, simulation and forecasting can help optimise traffic flows in the mobility and transport sector to limit congestion and pollution. The key requirements for the green and digital transitions to reinforce each other include an innovation infrastructure, coherent and reliable technology ecosystems, the creation of enabling markets, adequate standards and ensuring the ethical use of technology.

The emerging trends and the green and digital transitions offer pathways towards a more sustainable Europe. However, depending on the political and socioeconomic context, many alternative scenarios for these pathways are plausible. The long-term scenarios look to the sustainability of the EU bioeconomy by 2050, focusing particularly on two uncertainties: to what extent policies and/or consumers will drive the transition to greater sustainability (from reactive to proactive, see Figure 20). Four scenarios describe the world, Europe and the bioeconomy in 2050 and their contribution to the EU bioeconomy strategy and to the United Nations sustainable development goals (SDGs). Scenario ‘Do it for us’: Policies foster radical change in supply systems, but society resists significant changes in consumption away from business as usual (BAU). Scenario ‘Do it together’: The political system, society and industry cooperate to achieve climate neutrality and the SDGs. Scenario ‘Do it ourselves’: The political system proves unable to implement significant climate and SDG policies. However, consumers change their behaviour under the thrust of influential social movements and influenced by dramatic crises. The resulting change in demand leads to supply system adaptation. Scenario ‘Do what is unavoidable’: Lifestyles adhere to BAU patterns, but consumption increases. The political system proves unable to implement proactively relevant policies, limiting itself to reactive measures. With active policies but passive societies, in the ‘Do it for us’ scenario the policy targets are almost met, but with strong trade-offs in the non-targeted areas, such as biodiversity and social inequalities.

When citizens and consumers are active, but policies lag behind (as in the 'Do it ourselves' scenario), the lack of a wider framework for transformation makes progress through socio-cultural movements more inconsistent, localised and fragile (Fritsche et al., 2021).

Do it for us | **Do it together** | **Do it ourselves** | **Do what is unavoidable**



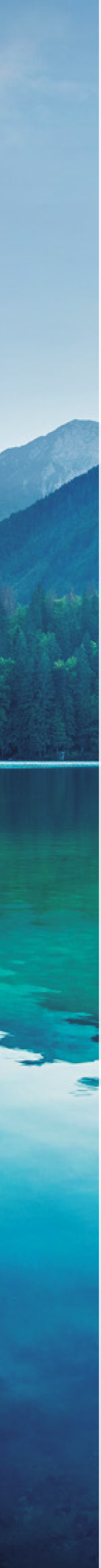
Source: Knowledge Centre for Bioeconomy, JRC.

Figure 20.
The illustration of four bioeconomy 2050 scenarios that describe the world, Europe and the bioeconomy in 2050 and their contribution to the EU bioeconomy strategy and to the United Nations sustainable development goals (SDGs).
See text for explanation.

> *"New drivers and sources of environmental pollution are likely to emerge in the future, as are opportunities to reduce the pollution burden of some sectors."*

Figure 21.
Illustration of the four sustainable Europe 2050 scenarios. See text for explanations.

Source: EEA.



The integrative approach of taking both policies and consumers as vectors of change in the 'Do it together scenario', while most successful, is also deemed the most challenging. It requires innovation and transformation in technology, governance and society – through exploration, experimentation, inclusive approaches and open reflections on possible alternatives and lessons learnt.

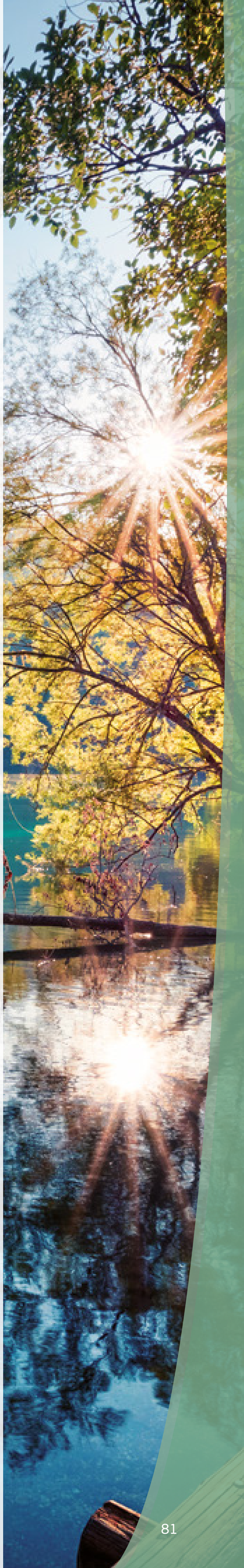
Beyond the pathways and policy choices, foresight also helps to imagine what a sustainable EU could actually look like. The EEA scenarios for a sustainable Europe in 2050 offer four contrasting images of sustainable futures evolving from some of today's most prominent discourses on sustainability (Figure 21, EEA, 2022c). The 'Technocracy for the common good' imagines an EU where sustainability is primarily achieved through ICT-enabled monitoring and control of social and ecological systems at the national level. On the other hand, the EU has a central role in the 'Unity in adversity' scenario, where severe environmental, climate and economic crises empower stringent common regulatory measures. Another image focuses on 'The great decoupling' of GDP growth from adverse environmental impacts through innovations and technological breakthroughs, especially in the bioeconomy. Finally, the Ecotopia scenario features significantly scaled-back consumption and resource use through local empowerment and reconnecting with nature.

The outlook for the zero pollution ambitions

A solid understanding of past trends, the current situation and projected developments with respect to air, water and soil pollution provide a good starting point to prepare for a ZP future. However, the world of 2050 may be very different from that of today. Horizon scanning and technology assessment point out new developments that may be transformative or disruptive. Scenario approaches provide a broader understanding of potential pathways and outcomes. They help shape effective actions across a whole range of future situations.

The action plan objective of developing a cross-cutting foresight capacity for ZP could focus on the following actions.

- Maintaining a regular horizon scanning of emerging issues related to pollution and developing more specific pollution-related aspects of general sustainability foresight studies.
- Combining quantitative projections and modelling approaches with more qualitative foresight scenarios that integrate the air, water and soil pollution dimensions.
- Backcasting from the future to imagine the milestones and indicators necessary to fulfil the ZP ambition and identify preferred pathways towards a ZP future.



3. Conclusions

This first zero pollution outlook report on air, water and soil, which includes additional chapters on nutrients, consumption footprint, transport noise and foresight, comes to the following conclusions.

Air

Air quality remains a major concern in many parts of Europe, even though emissions of air pollutants have been reduced over the past decades. Air quality limits as set by EU legislation for particulate matter, nitrogen dioxide, and ozone continue to be exceeded, especially in urban areas. Consequently, the number of premature deaths and other diseases attributable to air pollution remains high.

The key 2030 zero pollution targets for air are to:

- reduce by more than 55 % the health impacts (premature deaths) of air pollution and
- reduce by 25 %, the EU ecosystems where air pollution threatens biodiversity.

The third clean air outlook shows that it is possible to reach the health-related target, provided that the agreed clean air measures are implemented, as well as the more ambitious climate and energy policies of the fit for 55 package. In such a situation, the number of premature deaths due to air pollution would decrease by 66 % between 2005 and 2030.

The outlook for the ecosystem target is rather more bleak. The third clean air outlook shows that, if all agreed measures as well as the fit for 55 and the agricultural part of the industrial emissions directive proposals were implemented, the area of EU ecosystems under threat from air pollution would only decrease by 20 % in 2030 compared to 2005. The main area of concern is ammonia emissions from agriculture. However, the 25 % target seems to be achievable if more stringent air policies are implemented, such as aligning EU air quality standards more closely with the latest World Health Organization (WHO) guidelines, as put forward by the Commission in its proposal to revise the ambient air quality directives.

Water

Aquatic ecosystems are the final recipients of many pollutants arising from different anthropogenic activities (e.g. agriculture, industrial activities, urban processes). Several of these pollutants are originally delivered into other components of the Earth system (soil or air).

The key 2030 zero pollution targets for water are to:

- reduce by 50 % plastic litter at sea and by 30 % microplastics released into the environment,
- reduce by 50 % nutrient losses, the use and risk of chemical pesticides, the use of the more hazardous ones, and the sale of antimicrobials for farmed animals and in aquaculture.

The latter target indirectly impacts the receiving hydrosphere (rivers, lakes and seas). Based on an integrated modelling framework, analysis by the JRC found the following.

Nutrients: Application of very ambitious measures can help reduce nitrogen (N) and phosphorous (P) inputs into marine ecosystems by 32 % and 17 %, respectively, compared to their current values. The zero pollution target (50 % reduction) would be achieved only in four of the ten EU marine regions analysed for N, and in two of the ten for P. Strategies need to address N and P reductions together, as an imbalance of the N:P ratio in EU marine regions can favour the blooming of phytoplankton species.

The results also clearly show that nutrient reduction measures have more impact in coastal waters than in open seas. The data also suggest that the agreed nutrient targets and additional EU measures may not be enough to eliminate the impacts of nutrient pollution.

The reduction of nutrient emissions will strongly depend on the effectiveness of measures adopted in agriculture under the new common agricultural policy or in the context of the revision of the industrial emissions and urban wastewater directives.

Chemicals: The available data and modelling results available for the Black Sea marine basin show that reducing the use of chemical pesticides by 50 % by 2030 translates into a decrease in marine concentrations of -56 % (shelf sea) to -12 % (open sea), depending on the persistence of the pesticide. Persistent chemical substances can accumulate in different environmental compartments (such as soil, sediment and even biota). The results also show that climate change might lead to variations in hydrological conditions, potentially counteracting the impacts of policy measures. These aspects should be considered when evaluating the impacts of policy measures designed to reduce the chemical pollution of natural aquatic ecosystems.

Plastics: In the Mediterranean Sea, while only 24 % of all macrolitter originates from EU countries, this litter pollutes 40 % of non-EU beaches, which shows the high interconnectivity of the litter pollution in this marine region. A total ban on single-use-plastic items in the EU would reduce total litter by 14 %, far less than the zero pollution target of 50 %. Moreover, this target would only be achieved in about 8 % of the basin surface and about 44 % of all beaches. A complete ban on plastic littering in the EU would reduce total litter by 25 % in 50 % of the basin surface and 54 % of beaches. Consequently, the EU cannot, by itself, achieve the zero pollution target in the Mediterranean Sea, but should lead by example in eliminating plastic pollution and become a source of inspiration for neighbouring regions.

Soil

The overall risks from soil pollution to human health and environmental well-being are understood. However, there is still a need for better quantification of these risks by considering emerging pollutants together with more comprehensive and harmonised monitoring.

Soil health is expected to improve as a result of the implementation of planned EU actions and strategies. For example, the overall use of pesticides – particularly hazardous ones – is expected to fall as a result of increased organic farming and other objectives of the farm-to-fork strategy, and the concentration of heavy metals is expected to decline due to reduced application of metals to soil.

The adoption of the integrated nutrient management action plan and the proposal for the safe use of processed manure above the threshold established for nitrate-vulnerable zones by the nitrates directive should lead to a more efficient use of nutrients, and hence a reduction in the loss of nitrates and phosphates from soil to water and air.

Nitrogen pollution rates should fall if the farm-to-fork strategy is fully implement and its target of reducing fertiliser use by at least 20 % by 2030 is reached.

Global plastic pollution in both terrestrial and aquatic environments is significant and increasing. Projections for 2060 indicate a doubling of plastics introduced into the terrestrial environment, from 22 million tonnes (Mt) in 2022 to 44 Mt in 2060. Concentrations of microplastics in soil are expected to further increase, particularly due to the incorporation of sewage sludge.

Modelling tools to be developed as part of the EU soil strategy will help make future projections of observed soil pollution.

Ultimately, implementing adequate management of contaminated sites and halting sources of diffuse pollution is a challenging and ongoing task that must be undertaken if we are to reach the target of healthy soils by 2050, as proposed by the new EU soil strategy for 2030 (COM(2021) 699 final).

Nutrients

Nutrients, specifically nitrogen (N) and phosphorous (P), are fundamental elements for growing plants and sustaining life on Earth. They pollute the environment when present in excessive amounts in water, soils and the atmosphere. At the EU level, the forthcoming integrated nutrient management action plan will explore further policy measures to improve nutrient use efficiency and reduce losses to the environment, as well as explore novel techniques for recovering and recycling nutrients.

With the measures modelled in the scenarios addressed (including improvements in domestic wastewater treatment, reduction of N atmospheric emissions and measures under the CAP 2023–2027 and to achieve the biodiversity (BDS) and farm-to-fork strategies), the nutrient load in European seas could be reduced by about 30 % for N and 20 % for P. While these projected reductions are substantial, they are still below the BDS target of a 50 % reduction in losses.

A combination of policy measures in different sectors, combined with broader societal changes addressing different fluxes in the nutrient cycles, will be necessary to achieve the zero pollution ambitions. Impacts on all environmental compartments and feedbacks should be considered. Novel techniques for recovering and recycling nutrients from waste streams, together with reinforced targets to reduce waste along the food production and consumption chain, should further help reduce nutrient losses to the environment.

Consumption footprint

The consumption footprint quantifies the environmental impacts of the consumption of goods and products at the EU and Member State levels, based on a set of 16 life-cycle-assessment-based indicators.

While the environmental impact of EU consumption has increased by 4 % over the past decade, mainly due to a growth in the intensity of food consumption and mobility, the EU's domestic impacts have decreased by 13 %. This indicates that the EU is introducing environmental impacts embedded in imported goods, while reducing domestic environmental impacts through the positive effect of territorial EU policies.

The environmental impact of EU consumption is projected to keep increasing until 2030, in line with economic development and associated consumption patterns and intensity. As a result, the EU's consumption footprint will remain beyond the planetary boundaries for several categories associated with environmental pollution. The projected evolution shows improvements under the 'EU ambitions' scenario compared to the business-as-usual scenario with, for example, a slightly larger reduction in particulate matter, greater stability in terrestrial eutrophication and a more limited rate of climate change. However, the EU ambitions scenario shows no significant effect in reducing the environmental impacts to a level that would bring the EU consumption footprint back within the planetary boundaries.

Transport noise

Long-term exposure to environmental noise is a widespread problem across Europe. In 2017, about 18 million people in the EU suffered from long-term high annoyance due to transport noise from road, rail and aircraft sources. One of the headline targets of the zero pollution action plan is to reduce the number of people chronically disturbed by transport noise by 30 % by 2030 compared with 2017. The results of this outlook assessment suggest that there are no prospects of achieving this target, even if a substantial set of additional noise mitigation measures is implemented. Optimistic scenarios suggest a reduction of only about 19 % in the number of people chronically disturbed by transport noise. This is because the projected growth in population and transport outweighs the benefits of implementing the planned measures.

The main obstacle to reaching the zero pollution target is the large number of people exposed to road traffic noise, by far the most common source of noise pollution. While the number of people severely annoyed by railway and aircraft noise is lower compared to road traffic noise, a very large number of people still are and will be even more exposed to levels of noise that the World Health Organization considers to be harmful to health, as new rail infrastructure and faster trains are introduced.

Foresight

Foresight helps to understand the possible future consequences of current trends, to detect new signals of change and to determine their potential developments. It also helps imagine alternative pathways and new trends that could reshape societies and economies over the medium and long term, to inform the zero pollution action plan and measure its progress with respect to its ambitions.

Transformation will occur in all sectors of life due to digitalisation, changes in lifestyle, work patterns and new materials. All these transitions will have an impact on pollution and can benefit human health and the environment if they are guided by the zero pollution ambition. New models and monitoring tools will improve the availability and accuracy of pollution information.

Overall, to reach the zero pollution targets considered in this report, in most areas more effort is needed. The information provided in this first outlook report are derived from modelling or foresight studies and are subject to uncertainties, in some cases due to significant knowledge gaps. Climate change may also have an impact on the extent to which the targets yield the expected effects due to the presence of additional stressors in the environment. Moreover, geopolitical developments such as the economic and energy crisis may also affect the results of the zero pollution outlook. While the conclusions should therefore be treated with discretion, they can give an indication of whether we are on the right track.

In the next zero pollution outlook, in 2024, we plan to further integrate air, water, soil and noise pollution and improve the models and forecasts with a better understanding of the interdependence of environmental compartments, the impact of climate change and other impacting conditions, and by increasing the number of analysed compartments and regions. We will also consider new insights and progress in the implementation of policy measures.

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List of acronyms and abbreviations

BAL	Baltic Sea
BAU	business as usual
BDS	biodiversity strategy
BLK	Black Sea
CAP	common agricultural policy
CFC-11 eq.	chlorofluorocarbon-11 equivalent
CO_2	carbon dioxide
COVID-19	Coronavirus Disease 2019
CTUe	Comparative Toxic Unit equivalent
CTUh	Comparative Toxic Unit for humans
dB	decibel
DG ENV	Directorate-General for Environment
EC	European Commission
EEA	European Environment Agency
EEC	European Economic Community
EF	environmental footprint
Eionet	European Environment Information and Observation Network
EMODnet	European Marine Observation and Data Network
END	environmental noise directive
ETC HE	European Topic Centre on Human Health
EU	European Union
F2F	farm to fork
FORENV	EU Environmental Foresight System
GAINS	Greenhouse Gas and Air Pollution Interactions and Synergies
GDP	Gross Domestic Product
H+	hydron
H_2	hydrogen gas (dihydrogen)
HAS	high ambitious scenario
IIASA	International Institute for Applied Systems Analysis
ICT	information and communication technology
IED	industrial emissions directive
INMAP	integrated nutrient management action plan
IPCC	Intergovernmental Panel on Climate Change
JRC	Joint Research Centre
JRC-DT	JRC-Digital Twin
Kg	kilogram
LCA	life cycle assessment
Lden	noise levels above 55dB during the day-evening-night period
LUCAS	Land Use and Coverage Area frame Survey
MED-E	Eastern Mediterranean

MED-W	Western Mediterranean
MSFD	marine strategy framework directive
Mt	million tonnes
MTFR	maximum technically feasible reduction
N	nitrogen
N_2	nitrogen gas
N_2O	nitrous oxide
ND	nitrates directive
NEC	national emissions ceiling directive
NH_3	ammonia
NMVOCs	Non-methane volatile organic compounds
NO_2	nitrogen dioxide
NO_{3-}	nitrate
NOx	nitrogen oxides
O_3	ozone
OPT10	Scenario used for the clean air outlook: the optimisation is performed to achieve the grid-based annual mean $PM_{2.5}$ concentration below 10μg/m^3 – this scenario foresees a closer alignment of EU air quality standards with the 2021 WHO air quality guidelines (WHO, 2021).
P	phosphorous
PM_{10}	coarse particulate matter
$PM_{2.5}$	fine particulate matter
RCP4.5	representative concentration pathway 4.5
REF	reference
SDG	sustainable development goal
SO_2	sulphur dioxide
SSD	sewage sludge directive
SUP	single use plastic
TgN/y	teragrams of nitrogen per year
TgP/y	teragrams of phosphorous per year
U-235	uranium-235
UNEA	United Nations Environment Assembly
UNECE	United Nations Economic Commission for Europe
UWWTD	urban waste water treatment directive
WFD	water framework directive
WHO	World Health Organization
WISE	Water Information System for Europe
ZP	zero pollution
ZPAP	zero pollution action plan

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