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Technical report on pesticides in surface waters and groundwater in Europe

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Contents

1. Executive summary

A stable and reliable food supply in Europe has over recent decades become normal. This has been achieved in many cases by the use of pesticides to control pests, weeds, and diseases, plus fertilisers to supply additional nutrients. Pesticides play an essential role in the food production process, maintaining or enhancing crop yields in conventional arable farming. However, they can also lead to harmful effects in the environment, including aquatic ecosystems and risks to human health. There is now widespread concern about the addition of a substance to the environment designed to be toxic to some part of the ecosystem.

European policies aimed at reducing the potential risk from pesticides mainly lie under the Plants Protection Products Regulation (EC, 2009b), the Sustainable Use of Pesticides Directive (EU, 2009) and the Biocidal Products Regulation (EU, 2012). The Water Framework Directive (WFD) (EC 2000) and its daughter directives add legislation to protect water quality. There is however, little evidence to show whether this legislation has been effective, mainly because of a lack of data to demonstrate the actual risk of pesticides in surface waters and groundwater at the European level (EEA, 2018a). Addressing this gap is of high interest for policy, practitioners, and the public owing to potential risks pesticides present to both the environment and public health.

This technical report provides an overview of the information available on pesticide concentrations in surface and groundwaters in EEA countries.

EEA's Waterbase – Water Quality database contains the most reliable data available from across Europe. For the assessment, 180 pesticide substances were selected and characterised according to their usage, their Mode of Action (MoA), their chemical grouping, and their environmental quality standards (EQS) under consideration of the reported analytical limits of quantification (LOQ). The methods for the quality assurance of data, selection criteria and extraction, as well as the assignment of targets and calculation of exceedance rates under consideration of LOQ resulted in a unique database, and can be seen as a starting point on how to assess pesticide risk in surface waters and groundwater in Europe. EQS are based on European standards where available, and then on national EQS values (using the lowest value as a precautionary approach). The data suggest that for the period 2013 – 2017 for surface waters, 5 – 15 % of monitoring stations could be affected by herbicides and 3 – 8 % by insecticides. For groundwater the shares are about 7 % for herbicides and below 1 % for insecticides. Fungicides seem to be of lower importance.

This analysis contrasts with the results of status assessment of the 2nd River Basin Management plan 2016 under the WFD, which show 0.5% of all surface water bodies failing good chemical status because of pesticides, and 15% of groundwater bodies (EEA 2018).

The report also lists a number of other data sources for pesticides, especially scientific research and emissons data. They are diverse and often have limited spatial coverage, which make such data less representative for a European status assessment.

The aim of this work is to provide a baseline for what we know of measured concentrations of pesticides in water at the European level.

2. Introduction

2.1. Problem context

Pesticides are a topic of considerable policy interest across environmental, agricultural and human health legislation. There is widespread interest in pesticides from regulators, farmers and the public owing to potential risks they present for both the environment and public health. Under the Water Framework Directive, pesticides are second only to nitrates in causing most failures of good chemical status in groundwater (European Commission, 2019).

For a topic of such interest, at a European level we know surprisingly little about the actual levels of pesticides in surface and ground waters. The sorts of reasons impacting on our knowledge include:

- Countries monitor a number of different pesticides, but the reported data on pesticide concentrations in waters are very different in quality and quantity and therefore difficult to harmonise to obtain an established European overview.

- Pesticide use depends on the crop type, season, weather and equipment availability. Some estimates of pesticides in the environment are based on sales data, but this gives very little indication of actual use or concentrations and toxicity of pesticides in water.

- Monitoring and assessment of pesticides in surface waters is mostly done routinely, but pesticide peaks in surface waters can only be identified by event-based monitoring, such as following heavy rainfall.

- Pesticide pollution from point sources could also be attributable to substances used in biocide products (e.g. household products, facade paint, gardening), which enters the water cycle mainly through discharges from urban waste water treatment plants (UWWTP), storm overflow or urban run-off. There is limited understanding of the significance of such contributions relative to those from agriculture.

Alongside these specific issues, there is also concern about the role pesticides may play in mixture toxicity. Existing environmental quality standards apply to single substances but in the environment, organisms are exposed to chemical mixtures. We know little about the combined effects of such mixtures but there is a risk that chemicals could combine to reach harmful levels (EFSA, 2019; EEA, 2018a; Busch, 2016; Kortenkamp, et al., 2009b). Given the uncertainty but the knowledge that pesticides are harmful to at least part of an ecosystem, application of the precautionary approach would seem appropriate.

2.2. Aim and scope of the report

The aim of this technical report is to provide an overview of information available on pesticides in surface and groundwater, based on reported information. This report includes descriptions and assessments of available data from different data and information sources with a focus on the European level.

The focus of this report is on active pesticide ingredients in agricultural activities (see section 2.3 for definition). It needs to be mentioned, that once a substance reached the environment, it is not usually possible to ascertain the original source or use of it. Organisms experiencing the resultant mixture do not discriminate by source, though such information is helpful in identification of appropriate prevention measures. Other chemicals which may be present in the water are out of scope of this technical report.

2.3. Definition and classification of pesticides

According to FAO (2002), pesticides are defined as follows:

"Any substance or mixture of substances intended for preventing, destroying, or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals, causing harm during or otherwise interfering with the production, processing, storage, transport, or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances that may be administered to animals for the control of insects, arachnids, or other pests in or on their bodies. The term includes substances intended for use as a plant growth regulator, defoliant, desiccant, or agent for thinning fruit or preventing the premature fall of fruit. Also used as substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport" (FAO 2002).

EU legislation divides pesticides into plant protection products and biocides. The term *'pesticide'* is often used interchangeably with *'plant protection product (PPP)'*, however, pesticide is a broader term that also covers non plant/crop uses, for example biocides ([1]). These PPPs are products including 'pesticide substances' that protect crops or desirable or useful plants. They are primarily used in the agricultural sector but also in forestry, horticulture, amenity areas and in gardens. The products contain at least one active substance and have one of the following functions:

- protect plants or plant products against pests/diseases, before or after harvest;
- influence the life processes of plants (such as influencing their growth, excluding nutrients);
- preserve plant products;
- destroy or prevent growth of undesired plants or parts of plants.

EU countries authorize plant protection products on their territory and ensure compliance with EU rules (see section 2.5).

Overall, pesticides are grouped in different ways depending on the defining interest group, usage or others. Main classifications are usually based on a biological, chemical or technical basis. Whereas the biological goal seems to be very relevant e.g. the pests they control or the target organisms they kill, inhibit or destroy in one way or another, other important definitions derive from their chemical structure (e.g. organophosphate insecticides or neonicotinoids, organochlorine etc.) or their method of application. The definitions between these groups are rather fluid but most often the classification might clearly define all of the four main pesticide classes: *"an insecticidal acetyl-choline esterase inhibiting fumigant pesticide of the organophosphate substance class"* (Lewis, et al., 2016).

Based on the given definitions, grouping of pesticides within this report were based on their usage and their mode of action (MoA). This grouping is in a way comparable to the EFSA (European Food Safety Authority) based "Cumulative Assessment Group or CAG" ([2]).

([1]) Source: https://www.efsa.europa.eu/en/topics/topic/pesticides

([2]) Source: http://www.efsa.europa.eu/en/consultations/call/180508-0

According to their usage, the report focusses on the three groups (i) herbicides, (ii) insecticides and (iii) fungicides. The herbicides should control unwanted plants, insecticides are used to prevent unwanted insect infestation, and fungicides to kill parasitic fungi or their spores.

The classification according to the MoA of pesticides is oriented towards their effects in the non-human organisms. Table 2.1 lists the different MoA, which were assigned to the pesticides available under Waterbase – Water Quality in the time period 2007 – 2017 (see Annex 5).

Table 2.1 Groups of pesticides according to mode of action (MoA) and their effects to organisms

MoA – group	MoA – effects
Photosynthesis inhibition	The production of energy in the chlorophyll of plants is inhibited by these substances. As a result, the chemical bound energy of the plant is consumed and the plant dies.
Respiratory action	Various processes prevent the exchange of oxygen at membranes or the chemical binding of oxygen.
Cell membrane disruption	The selectivity at the cell membrane is disturbed so that it becomes more or less permeable.
Mitosis, Cell Cycle	Inhibition of growth by preventing cell division.
Neurotoxic	Prevents the transmission of stimuli or the back reaction in nerves.
Lipid metabolism	Inhibition of the enzyme, acetyl-CoA-carboxylase, which is responsible for controlling fatty acid metabolism and degradation. By inhibiting lipid biosynthesis, the development of the immature stages (larvae and nymphs) of certain insects and mites will be stopped, thus reducing fertility.
Plant Growth Regulator	Plant growth is regulated through the phytohormones that make individual plant parts grow stronger. Some substances inhibit the plant's longitudinal growth and promotes fruit growth. Other substances promote the growth of the green parts of the plant, while at the same time root growth stagnates. As a result, the plant dies due to the lack of nutrients in the plant.
Multi site activity	Inhibition might be due to relatively unspecific membrane damage to specific modulation of receptors or inhibition of enzymes or a mixture of all effects. Sometimes this also depends on the effective dose.
Signal transduction	Inhibition of transmission of molecular signals from a cell's exterior to its interior in fungi and plants.
Fungal spore inhibitor	The reproduction of fungi is disturbed.
Sterol biosynthesis inhibition	Inhibition of the important cell membrane component of the sterol type (typical MoA for fungicides).
Protein denaturation	Essential proteins are destroyed in fungi so that the metabolism is disturbed.

Note: Based on the used methods, data availability and data selection, only photosynthesis inhibition and neurotoxic MoA were assessed (see section 4.1.1.1)

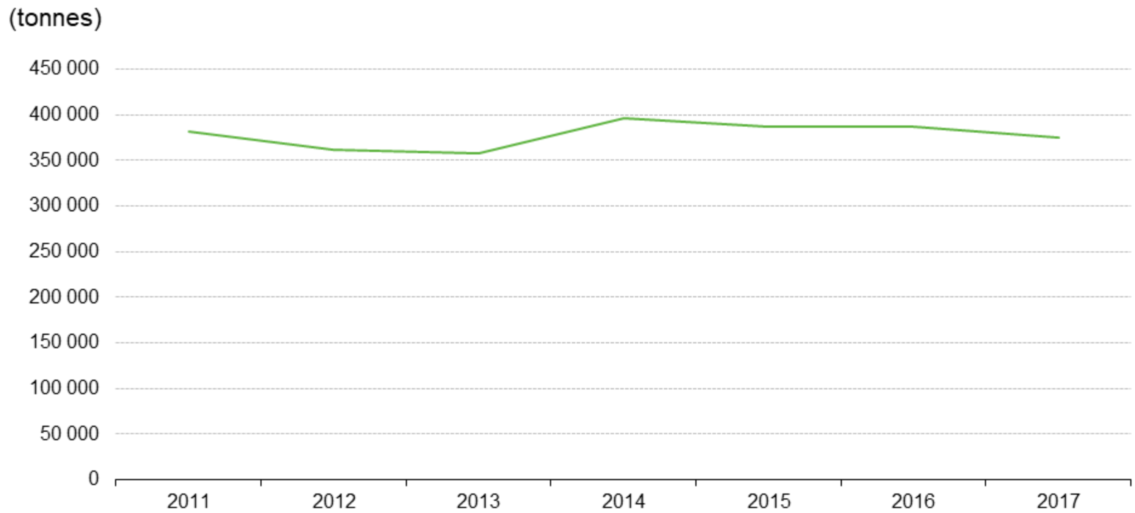
2.4. Sources, uses and sales of pesticides

Pesticides are substances contained as active ingredients in plant protection products and biocides. They must selectively act against specific pest organisms, but it is impossible to achieve absolute selectivity (i.e. where effects are limited to only the target species). Furthermore, some pesticides being toxic to humans and/ or harming the environment by contaminating soil, surface and ground water. Pesticide contamination of both surface and groundwaters can affect aquatic fauna and flora, as well as human health when pesticide polluted water is used for public consumption. Aquatic organisms are directly exposed to pesticides resulting from agricultural production or indirectly through trophic chains (Maksymiv, 2015).

The pesticide pollution from agricultural activities of surface waters or groundwater may have different sources: a) Diffuse losses, e.g. spray drift due to pesticide application, b) point sources from waste water treatment plants (run-off from farmyards connected to sewer systems), c) surface run-off from farmyards during cleaning of application techniques, and d) leaching to field drains or to shallow groundwater (Sandin, 2017; Aktar, et al., 2009). In addition to agricultural activities, other relevant sources for pesticides include forestry, municipial use (e.g. on roadside), grasslands (e.g. golf courses) and uses in gardens. Once pesticides reach streams, they can be widely dispersed into other streams, rivers, lakes, reservoirs, and oceans (USGS, 1997).

Population growth, increase in food consumption, and export of agricultural products (crops as well as meat) result in enhanced agriculture production, which mostly relies on extensive use of pesticides (FAO & IWMI, 2017). In Europe, the volume of pesticide sales has remained about constant since 2011 (Figure 2.1). The groups with the highest sales are fungicides, bactericides and herbicides (some 80% of the total pesticide sale). France, Italy, Spain and Germany sold together over 65 % of the total volumes reported in the EU (Agri-environmental indicator - consumption of pesticides - Statistics Explained 2019). However, the share of tonnes of pesticide sales does not allow any statement about the risk to human health and the environment.

Figure 2.1 Sales of pesticides, EU-28, 2011-2017



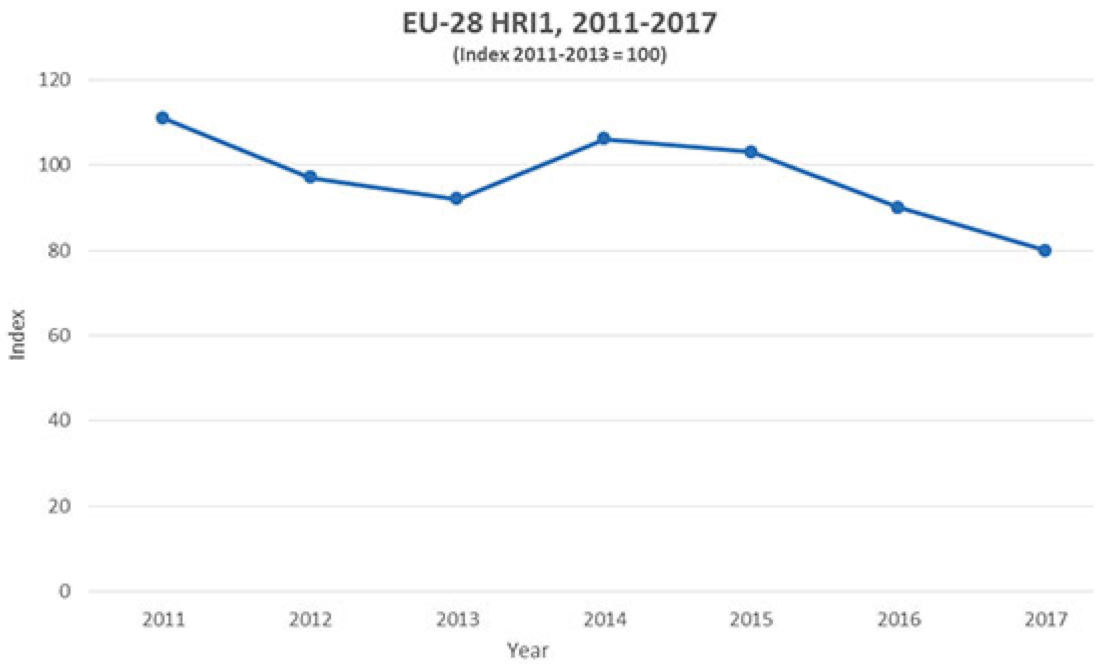
Note : This figure does not take into account confidential values. They represent < 3% of the total of sales over the entire time series.

Source : Eurostat (online data code : aei_fm_salpest09). https://ec.europa.eu/eurostat/statistics-explained/images/1/18/Sales_of_pesticides%2C_EU-28%2C_2011-2017_%28tonnes%29.png

Based on sales data, EEA developed the 'Total sales of pesticides' indicator under the 7th Environment Action Programme within priority objective 3 to safeguard the Union's citizens from environment-related pressures and risks to health and well-being (EEA, 2018a). It indicates no trends of pesticide sales (grouped by their usage) from 2011 to 2016. It is also stated, that: *"This indicator* *does not allow, at present, for a full evaluation of progress towards the 2020 objective as pesticide sales are not synonymous with the risk of harmful effects on humans and the environment"* (EEA, 2018a).

Beside the sales of pesticide information, EU developed the Harmonised Risk Indicator (HRI) to support the goals of the Sustainable use of pesticides Directive (EU, 2009). The HRI, published in 2019, considers the quantities of active substances placed on the market in plant protection products, and shows a decreasing trend from 2011 to 2017 of some 20% (Figure 2.2). This caused surprise among some ([3]).

Figure 2.2 Harmonised Risk Indicator 1



Note: A baseline of the average of three years 2011-2013 is used as the starting point against which subsequent values are compared.

Source: https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/harmonised-risk-indicators/trends-hri-eu_en

There is a need for the development of a management tool such as an indicator which would combine the information on concentrations in water with the ecotoxicological knowledge of the specific pesticide product or its active components. This way regulators and politicians would be able to search, detect, identify the most important (i.e. most toxic and in highest concentrations) pesticide in their region of interest and prioritise management actions.

([3]) Source: https://www.endseurope.com/article/1666559/commission-pesticides-data-draws-scepticism

2.5. Legislation and broader regulation on pesticides

The European Union tackles water pollution since the 1970s, e.g. Council Directive on pollution caused by certain dangerous substances discharged into the aquatic environment (EU, 1976), the Urban Waste Water Treatment Directive – UWWTD (EC, 1991), the Drinking Water Directive – DWD (EU 1998) or the Nitrates Directive (EU, 1991). Since 2000, the Water Framework Directive became the central instrument of water management and protection of EU waters (EC 2000). For substances (including pesticides), two daughter directives added quality standards to be achieved.

For source control, Directives and Regulations were set on substance level for a standardized registration including risk assessment or, for example, the usage of specific substances in agriculture as pesticides.

The following list of Directives and Regulations distinguishes between water policy and source control legislations including pesticide substances:

Water policy

- The Water Framework Directive (WFD) (EC 2000) sets a scheme for water management at river basin level. With regular six yearly planning and programmes of measures a good status of surface and groundwater is to be achieved.
- The WFD daughter Directives on Environmental quality standards in water policy – EQSD (EU, 2008) and on groundwater (EU, 2006a) set quality objectives and targets for pesticides in surface and groundwater.
- The Drinking water directive (EU 1998) sets quality objectives for pesticides at the tap.

Register and source control legislation according to pesticide substances

- Regulation on the European Pollutant Release and Transfer Register (E-PRTR) (EU, 2006b), which is the Europe-wide register that provides accessible key environmental data from industrial facilities in European countries including substances used as pesticides or biocides.
- The REACH Regulation (EC, 2006) aims to improve the protection of human health and the environment through identification and risk assessment of chemical substances, and to register the information in a central database.
- The Directive on the sustainable use of pesticides (EU, 2009) aims at reducing the risks and impacts of pesticide use on human health and the environment, and promoting the use of integrated pest management and alternatives such as non-chemical approaches.
- The Plants Protection Products Regulation (EC, 2009b) set out rules for the authorisation of plant protection products and their marketing, use and control. Based on this Regulation, the Seventh Environment Action Programme (EU, 2013) set the objective that, by 2020, the use of plant protection products should not have any harmful effects on human health or unacceptable influence on the environment, and that such products should be used sustainably.
- The Biocide Regulation (EU, 2012) focusses on the marketing and use of biocide products.

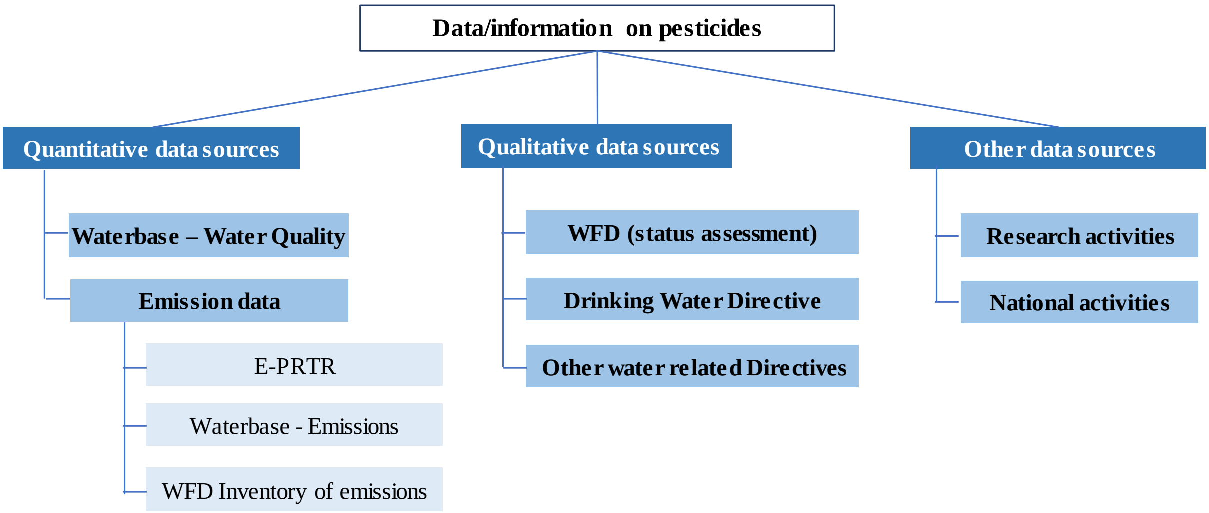
- The UN Stockholm Convention recommends the ban of specific substances, *inter allia* pesticides, to protect human health and the environment from persistent organic pollutants (UNEP 2018) ([4]).

([4]) List of persistent organic pollutants: http://chm.pops.int/TheConvention/ThePOPs/AllPOPs/tabid/2509/Default.aspx

3. Data and information sources

This section gives an overview of quantitative and qualitative data sources as well as other data overviews tackling the issue of pesticides, which were used for the technical report (Figure 3.1). These data and information sources were analysed in accordance to the availability of sufficient information on pesticides. The data assessments are presented in section 4 – status of information on pesticides.

Figure 3.1 Data- and information sources on pesticides, used in this report



3.1. Quantitative data sources

3.1.1. Waterbase – Water Quality

Waterbase – Water Quality ([5]) is a database containing water quality data in rivers, lakes and groundwater. The basic records reported into the database are disaggregated water quality data on the observed values, representing one sampling at specific monitoring site and day for a specific parameter. As of 2015, reporting disaggregated records is preferred, while in the preceding period, more data was reported as annual records – i.e. annual statistics for each monitoring site and substance. The updated versions of the database are published annually, with the version used in this report covering the data up to 2017.

The pesticide data of Waterbase – Water Quality have been reported by 34 countries of Europe, representing the monitoring network of Member States of the EU as well as other EIONET reporting countries.

The data on hazardous substances in water (including pesticides) from the Waterbase - Water Quality database were systematically assessed in the ETC/ICM technical report on Hazardous Substances in European Waters from (ETC/ICM 2015), covering the data for the period 2002-2011. The report

([5]) The version of 2019, published on April 2019 and used for this report, is available at https://www.eea.europa.eu/data-and-maps/data/waterbase-water-quality-2.

summarises the state and availability of the data and provides a useful display of the large dataset, but cannot be regarded as an assessment of the situation between the reporting countries. It was concluded that despite the quality check procedures in place, some data were still questionable owing mainly to issues such as unclear reporting of limit of detection (LOD) or limit of quantification (LOQ).

This report gives an updated assessment of the Waterbase – Water Quality data, also using a new approach in data selection and processing, explained in the following subsection.

3.1.1.1. *Selection of reference pesticides*

The report focuses on pesticides, which represent a current water pollution and are still being discharged through use. The selection of pesticides for evaluation was limited to substances that were reported in the period under review 2007 -2017, because temporal coverage of pesticides data starts increasing after 1990 and, in terms of available records per year, more notably increases after 2006, with the largest number of records available for 2013 and 2014. Furthermore, the following criteria were used for the selection of substances: (i) approved and approval expired during the investigation period 2007 – 2017; (ii) measured in three or more Member States; (iii) mainly used for agriculture (pesticides).

For building up the basis for an assessment, the list of substances was analysed in respect of different parameters. For this, each pesticide was checked in the Pesticides Properties Database (PPDP) (Lewis, et al., 2016). The outcome was a list with 180 pesticides including columns for chemical identifiers, their usage, the information about being it a parent substance or transformation product and their mode of action (MoA) to the pest organism (see Annex 5 and Annex 6). Based on this list, different assessments were made which are further shown in the paragraphs below and which are the basis for the development of a pesticide indicator to ease the river basin specific or site-specific monitoring and regulation of hot spots of contamination by a mixture of pesticides.

Only three main usage groups could be identified: herbicides (78 distinct pesticides), insecticides (72 distinct pesticides) and fungicides (23 distinct pesticides). The rest of substances were either transformation products/ metabolites (three) or could not be assigned to a specific usage or were multi-use pesticides.

In the PPDB database most of the pesticides are clearly assigned to a specific MoA. As the number of different MoA is very diverse it was decided to further simplify the grouping for easier analysis in this technical report. Thus, all substances which, for example, in one way or another modified nerve signalling or muscle activity (GABA receptors, AChE inhibitors or else) were allocated to the group of ‘neurotoxic compounds’. Similarly, all herbicides which inhibited photosynthesis – even if the exact position of the inhibition might be PS II or protoporphyrinogen oxidase inhibition or another mechanism - were assigned to the group of ‘photosynthesis inhibition’.

Based on the explained selection criteria, Table 3.1 shows an overview of the available data in the time period 2007 – 2017, which were used for the specific assessments. Overall, 180 substances were selected.

Table 3.1 Overview of selected substances and groups of available data reported under Waterbase – Water Quality on pesticides in time period 2007 - 2017

	Surface waters (rivers and lakes)	Groundwater
Number of total selected substances	180	159
Usage		
Number of herbicides	78	75
Number of insecticides	69	61
Number of fungicides	19	11

	Surface waters (rivers and lakes)	Groundwater
Number of 'others'	14	12
Mode of Action		
Number of neurotoxic	49	44
Number of photosynthesis inhibition	30	29
Number of 'others'	101	86

3.1.1.2. *Target setting*

Target setting for substances was identified by comparing their occurrence with environmental quality standards, groundwater quality standards and detection limits. The used targets of the pesticides are listed in Annex 6. For this, the following sources were considered:

Surface waters

- Environmental Quality Standards (EQS) of the pesticides listed under the priority substances of the WFD; AA-EQS (annual average EQS) which are protective against chronic toxicity and MAC EQS (maximum acceptable concentration EQS) which should protect against acute toxicity.

- The maximum acceptable detection limit, according to the Watch List under Commission Implementing Decision (EU) 2015/495 and Commission Implementing Decision (EU) 2018/840.

- Environmental Quality Standards (EQS) of the pesticides listed under the River Basin Specific Pollutants (RBSP); if available: AA-EQS and MAC EQS. The EQS value for RBSPs can vary between Member States (MS). For the assessments based on Waterbase – Water Quality data (see section 4.1.1.1), the lowest reported EQS for a substance was used. When three or more countries regulated a substance, it was handled as relevant and included into the surface water assessment.

Groundwater

- Groundwater Quality Standard of 0.1µg/l in accordance with the Directive 2006/118/EC (and referred to WFD) for each active substance in pesticides, including their relevant metabolites, degradation and reaction products.

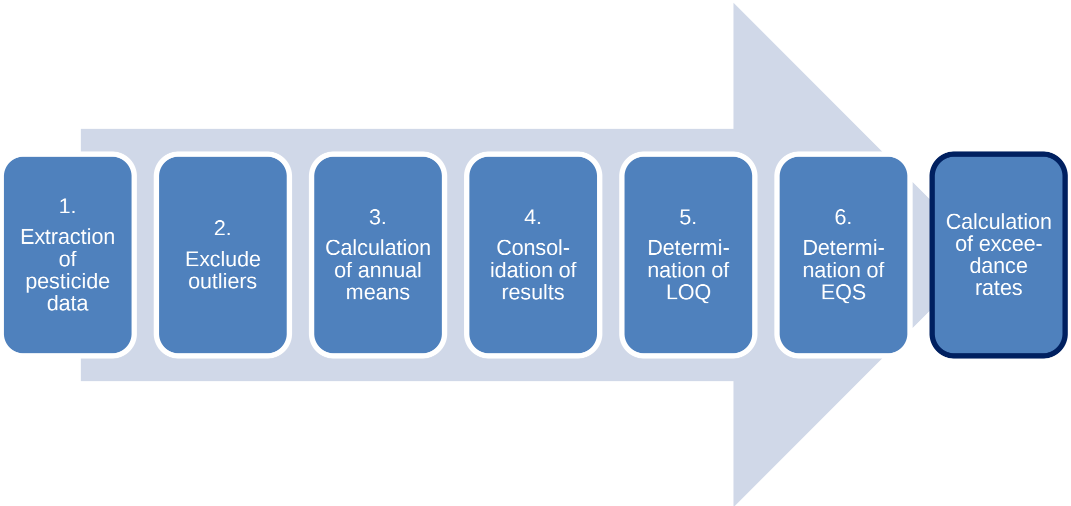
EQS set at European level, groundwater pollutant threshold values and watch list detection limits were used to identify the reported measurements or monitoring stations with exceedances.

In Annex 6, more detail is provided on the AA-EQS and MAC EQS values used.

3.1.1.3. *Extraction of the reference dataset on pesticides*

The dataset used in this report was extracted from Waterbase – Water Quality database with the following procedure (Figure 3.2).

Figure 3.2 Procedure to extract reference dataset on pesticides



1. Extraction of disaggregated ([6]) and aggregated ([7]) data records on pesticides defined in section 3.1.1.1 (above), for the period 2007–2017, excluding records flagged for low reliability ([8]) but including any records that may be outliers.

2. For both, aggregated and disaggregated data, calculate 95th percentile of values by monitoring site and substance; then exclude any records that are more than 1000-fold above the calculated 95th percentile of the corresponding monitoring site and substance. This should exclude errors arising from incorrect units.

3. Calculation of annual arithmetic means from disaggregated data – for one substance at one monitoring site. When a measurement is flagged as below LOQ, half of the LOQ was used for calculating annual mean (see Box 1 for more information on LOQ).
   Note that for groundwater data, there can be more than one monitoring site at a groundwater body, and no spatial aggregations are made. Instead here, each location was treated as an independent monitoring site.

4. Consolidation of data reported as aggregated and disaggregated to a consolidated table of annual records. If a country reported both aggregated and disaggregated records for a substance at a monitoring site for the same year, records derived from disaggregated data have the priority.

5. Determination of LOQ for each annual record;
   - *known LOQ:* in Waterbase – Water Quality, the LOQ of the analytical method used is requested to be reported with each single or annual record (for the latter, the highest LOQ in a series of measurements within a year should be reported, although typically the same analytical method is used at the site throughout the year);

([6]) See definition of the disaggregated data at http://dd.eionet.europa.eu/tables/9153.

([7]) See definition of the aggregated data at http://dd.eionet.europa.eu/tables/9323.

([8]) This indicates existing observations for which the user should also be aware of the low quality assigned. For example, the combination of data in the record (such as non-default unit of measurement) raises ambiguity which could not be cleared out with the reporting country at the time, indicating that the observed value may be wrong.

- *unknown LOQ but flagged as "below LOQ":* some records in the database are only flagged as "below LOQ"; for these, the actual LOQ is uncertain, but the fact that they are below means their EQS or threshold value exceedance can be determined (see next point);
- *no data or flags regarding the LOQ* are available for a record at all.

6. Determination of EQS or threshold value exceedance for each annual record:
    - for records with no data or flags regarding the LOQ, no EQS exceedance or threshold value was determined; this yields 68,764 groundwater annual records (1.89% of all groundwater records in the reference dataset) for which threshold value cannot be determined, and 24,682 surface water annual records (0.68% of all surface water records in the reference dataset) for which EQS exceedance cannot be determined;
    - exceedances in groundwater: if the mean calculated value is above LOQ and greater than the groundwater quality standard of 0.1 μg/l;
    - exceedances in surface waters:
        - the calculated annual mean value is above LOQ and greater than the AA-EQS;
        - the calculated annual maximum is above LOQ and greater than the maximum allowed concentration MAC EQS.

The data on 180 distinct pesticides were extracted with such process, collected at a total of 16,886 groundwater monitoring sites and 9,495 surface water ([9]) monitoring sites (accounting for 3.63 million annual records altogether). The list of pesticides by water category, the number of records, and the number of monitoring sites at which the substance was monitored, as well as the time period, is available in Annex 1 for groundwater and for surface waters in Annex 2. Figure 3.3 illustrates the number of pesticide-monitoring sites per year.

Box 1 Definition and explanation of LOQ

Limit of Quantitation (LOQ) as well as limit of detection (LOD) are terms used to describe the smallest concentration of a measurand that can be reliably measured by an analytical procedure (Armbruster, and Pry, 2008).

- LOD (Limit of detection): Analyte was found in the sample (content which can be distinguished from the blank test sample in which the analyte is absent).

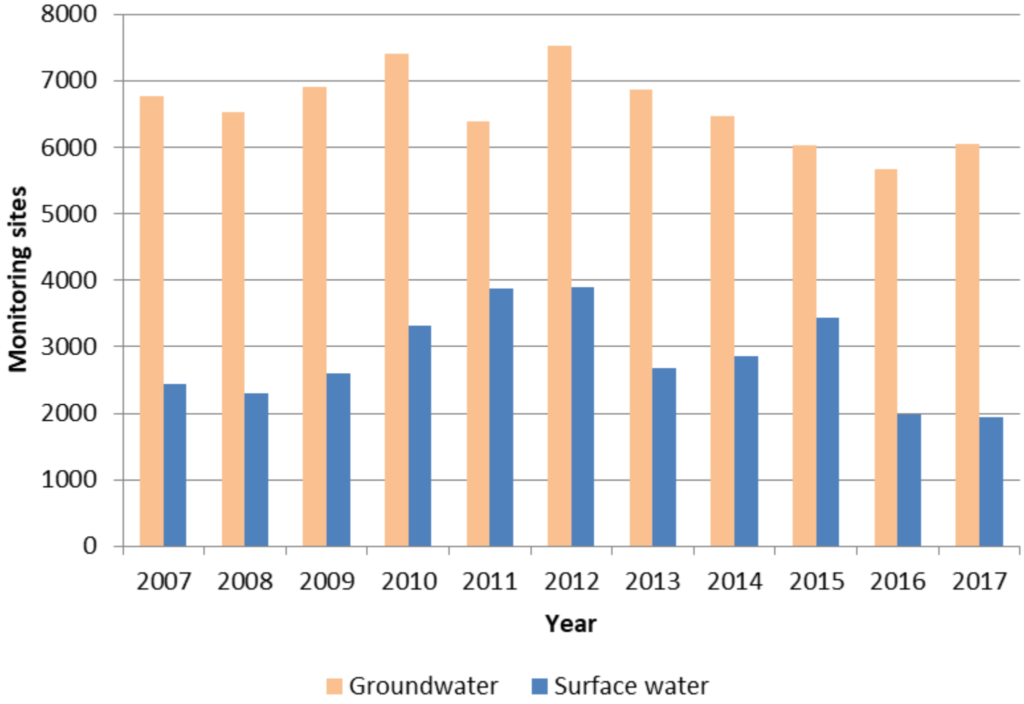
- LOQ (Limit of quantification): Analyte content which can be determined with a certain level of precision.

Within Waterbase – Water Quality, countries are recommended to report LOQ for each substance. Reporting of LOQ has not always carried out for example in case where in a country different methods with different LOQ for one substance were used.

LOQ becomes important, when higher than the environmental quality standard (EQS). In such cases it could not be decided, if the standard is met. For this report we have counted them as 'standard is met'. In a second step, we have the aim to summarise these records as 'unclear, if EQS is met'. This can be done, if our statistical checks have unravelled all values below LOQ.

([9]) Water categories of "groundwater" and "surface water" (the latter including both river and lake monitoring sites) are defined for the purpose of this report.

Figure 3.3 Number of pesticide monitoring sites by year for groundwater and surface water



Source: WISE SoE – Water Quality database, version April 2019.

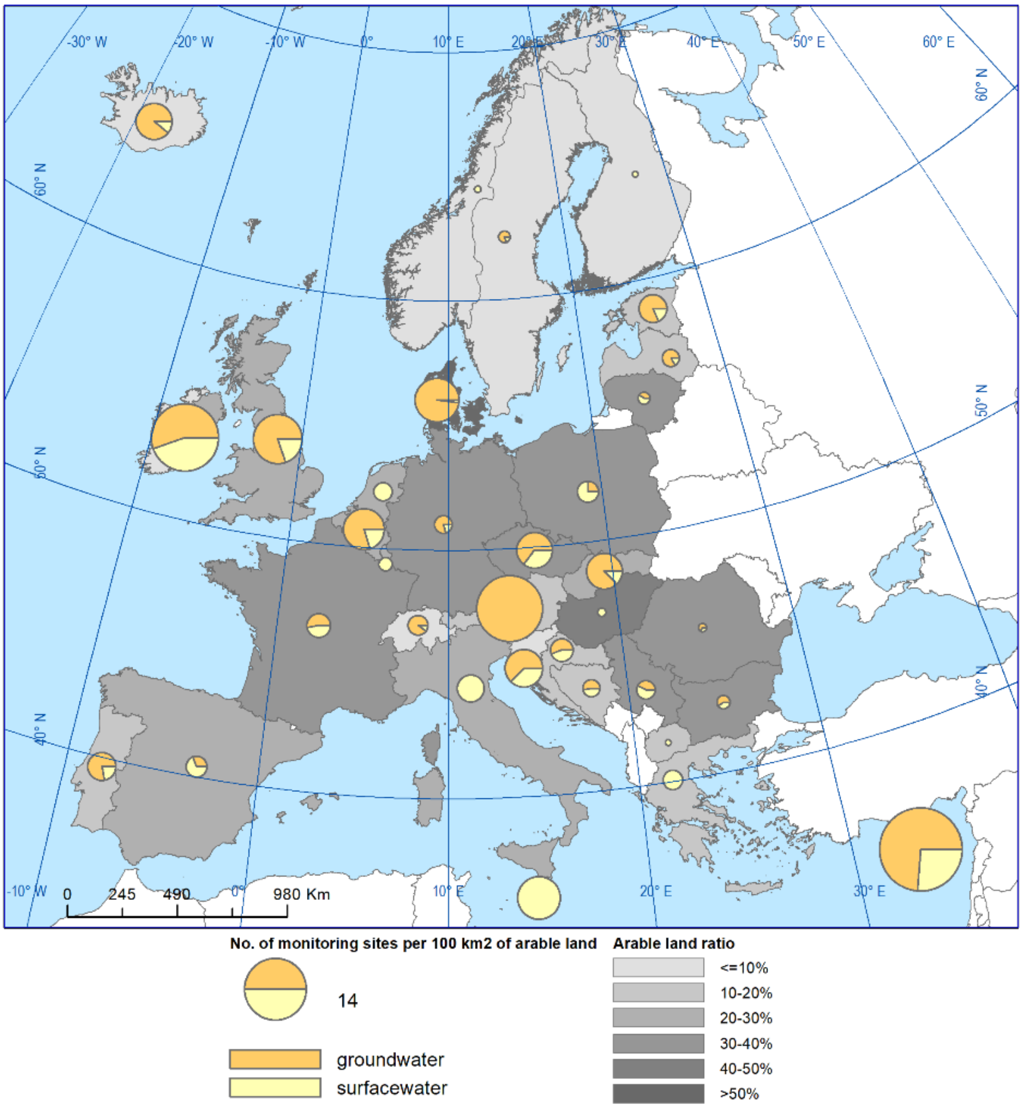
Figure 3.4 illustrates spatial coverage of available data on pesticide monitoring reported under Waterbase – Water Quality in the time period 2007 to 2017 for each country in relation to the arable land ratio. The arable land ratio was calculated based on the country area and the arable land area in this country.

According to the arable land ratio, Denmark and Hungary are the countries with more than 50% of arable land. Poland has 43%, and Germany, Czechia, Slovakia, Hungary, Romania, Serbia, Bulgaria and Lithuania with an amount between 30 and 40% arable land cover. Arable land includes intensively used, usually ploughed land. This includes non-irrigated arable land, permanently irrigated land and rice fields. Agriculture additionally uses permanent cropped land, pastures and heterogeneous areas ([10]).

The reported number of monitoring sites differs between countries. Whereas Austria (16), Cyprus (10), Malta (89), Ireland (16) and Iceland (47) reported more than 10 monitoring sites per hectare arable land in the time period 2007 to 2017, the mean of reported monitoring sites for all other countries is 2.2. A list of available data on arable land use ratio, monitoring sites as well as number of reported pesticides is given in Annex 3.

(10) CORINE land cover land use definitions: https://land.copernicus.eu/eagle/files/eagle-related-projects/pt_clc-conversion-to-fao-lccs3_dec2010

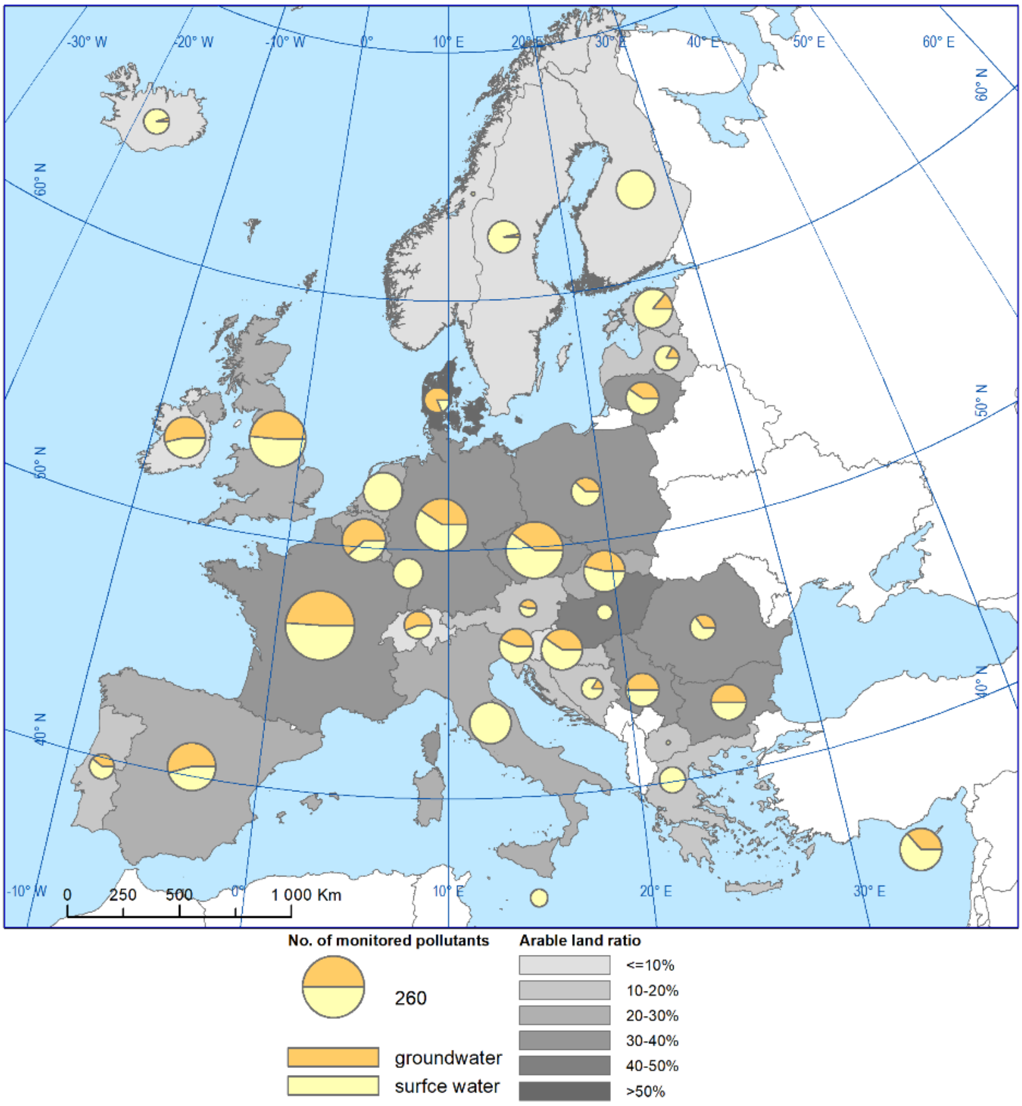
Figure 3.4 **Number of reported monitoring sites on pesticides per 100 km^2 arable land in European countries in the time period 2007 to 2017**



Source: WISE SoE – Water Quality database, version April 2019; Eurostat and Corine Land Cover data on arable land ratio.

Figure 3.5 shows the number of monitored pesticides for each country in the time period 2007 to 2017. The number of reported pesticide substances varies between 1 (Norway and North Macedonia) and 319 (France). Overall, there is neither correlation between the reported monitoring sites under consideration of the amount of arable land, nor the number of reported monitoring sites and reported monitored pesticide substances.

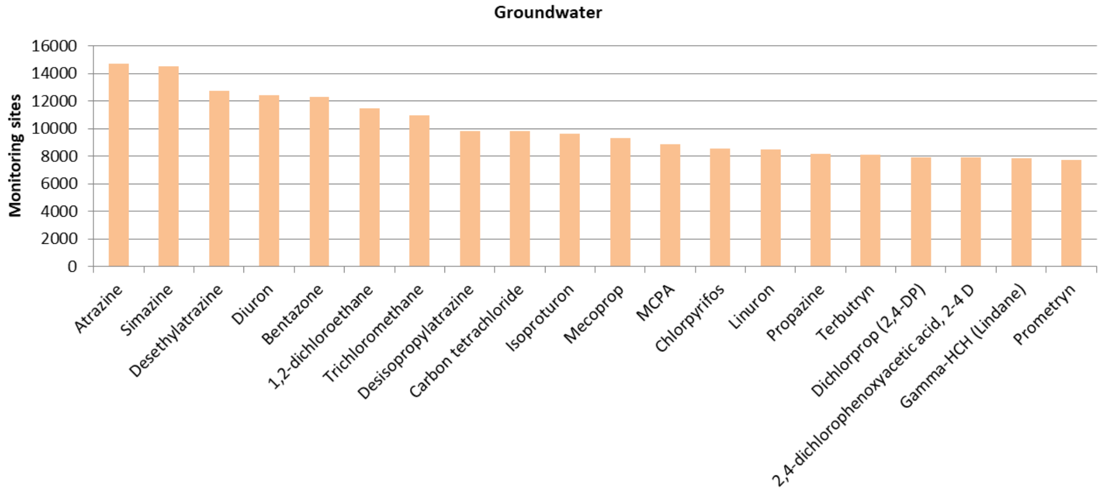
Figure 3.5 Number of reported monitored pesticides in European countries in the period 2007 to 2017

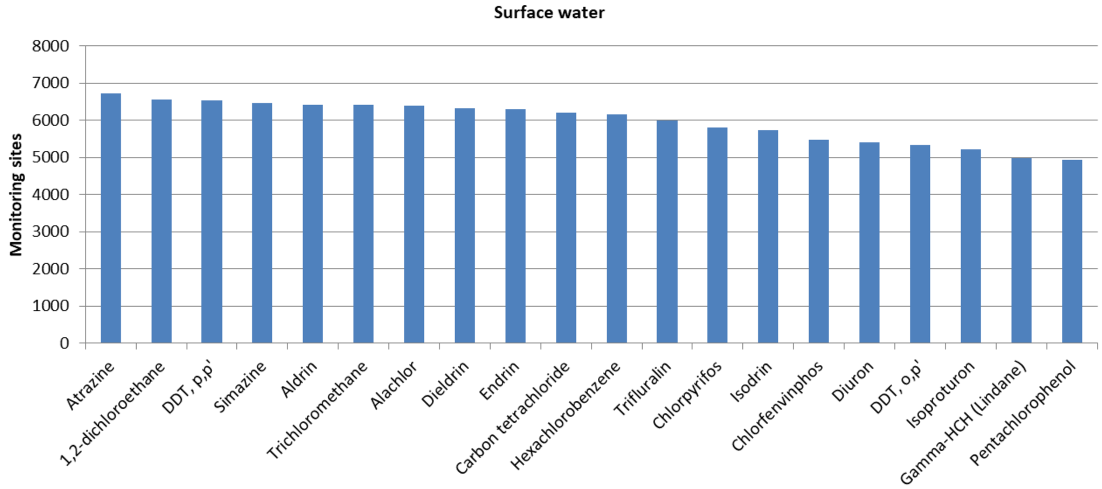


Source: WISE SoE – Water Quality database, version April 2019; Eurostat and Corine Land Cover data on arable land ratio.

Figure 3.6 illustrates 15 pesticides with the largest number of monitoring sites for groundwater and surface water, respectively. For groundwater, atrazine, simazine, desethylatrazine, diuron, and bentazone are the five most often reported pesticides in the dataset. In surface waters, 11 substances were reported as monitored at more than 6 000 monitoring sites.

Figure 3.6 Number of monitoring sites for the pesticides with the most frequently reported number of monitoring sites in groundwater and surface waters





Source: WISE SoE – Water Quality database, version April 2019.

3.1.2. Emission data

Table 3.2 shows an overview of the emission data with European coverage on pesticide loads considered in this report. The data comprise different reporting obligations and consider partly different sources of emissions to waters.

Table 3.2 Overview of used emission data

Data source	Reporting obligation		Sources of emissions to waters		
	mandatory	voluntary	Industry	UWWTP*	Diffuse sources
E-PRTR	x		x	x	
Waterbase – Emissions		x	x	x	x
WFD Inventory of emissions	x		x	x	x

*Urban waste water treatment plants

3.1.2.1. *E-PRTR*

E-PRTR – the European pollutant transfer and release register (EU, 2006b) is a European-wide register of pollutant releases to air, water, and on land. It covers 33 countries (EU28, Iceland, Liechtenstein, Norway, Serbia and Switzerland) since 2007. Some records are also available for 2001 and 2004 based on former EPER database (EPER - European Pollutant Emission Register) was established in 2000. It was replaced by current E-PRTR in 2006. Emissions from both point and diffuse sources are collected, but no information on pesticides from diffuse agricultural sources is available. Countries report facilities with economic activity listed in Annex I of the Directive and substance loads from point sources above threshold values given in Annex II of the Directive. All facilities under activity *4.d Chemical installations for the production on an industrial scale of basic plant health products and of biocides* should be included, other facilities should report discharging into water if it exceeds the given limit (1 kg per year for most of the pesticides). The database contains annual releases (kg per year) per facility.

Main pesticide discharge from facilities is not caused by those manufacturing pesticides but from urban wastewater treatment plants, which receive inputs from a range of sources (see section 2.4). It needs to be stated, that within the E-PRTR, that only the discharge of large facilities needs to be reported (e.g. waste water treatment plants above 100 000 population equivalents), and not all of them reported pesticides in their effluent.

Table 3.3 shows the list of pesticide emissions to water, the number of records (emission load from one facility within one year for given pollutant – e.g. if the emission load from two facilities is reported every year for ten years, it will result in twenty records, and the number of countries, in which these releases were reported under E-PRTR. Furthermore, information on monitoring time period, if the specific substance is still approved (**Y**es or **N**o), and the count of monitored facilities are listed.

Table 3.3 Pesticide emissions to water reported under E-PRTR

Pesticide	No. of records	No.of MS	No. of years monitored	start	end	approved	No. of facilities 2017
Alachlor	26	7	10	2007	2017	N	3
Aldrin	103	4	11	2007	2017	N	11
Atrazine	77	13	11	2007	2017	N	6
Chlordecone	12	3	6	2008	2014	N	?
Chlorfenvinphos	8	4	4	2007	2011	N	?
Chlordane	5	1	4	2008	2017	N	1
Chlorpyrifos	24	5	8	2007	2017	Y	5
DDT	24	5	11	2007	2017	N	3
Dieldrin	117	5	11	2007	2017	N	12
Diuron	1136	12	11	2007	2017	Y	122
Endosulfan	19	5	8	2007	2017	N	3
Endrin	82	5	11	2007	2017	N	8
Ethylene oxide	7	4	6	2009	2017	N	2
Heptachlor	15	2	10	2007	2017	N	3
1,2,3,4,5,6-hexachlo-rocyclohexane (HCH)	80	8	13	2001	2017	N	7
Isodrin	98	6	11	2007	2017	N	9
Isoproturon	336	11	11	2007	2017	N	20

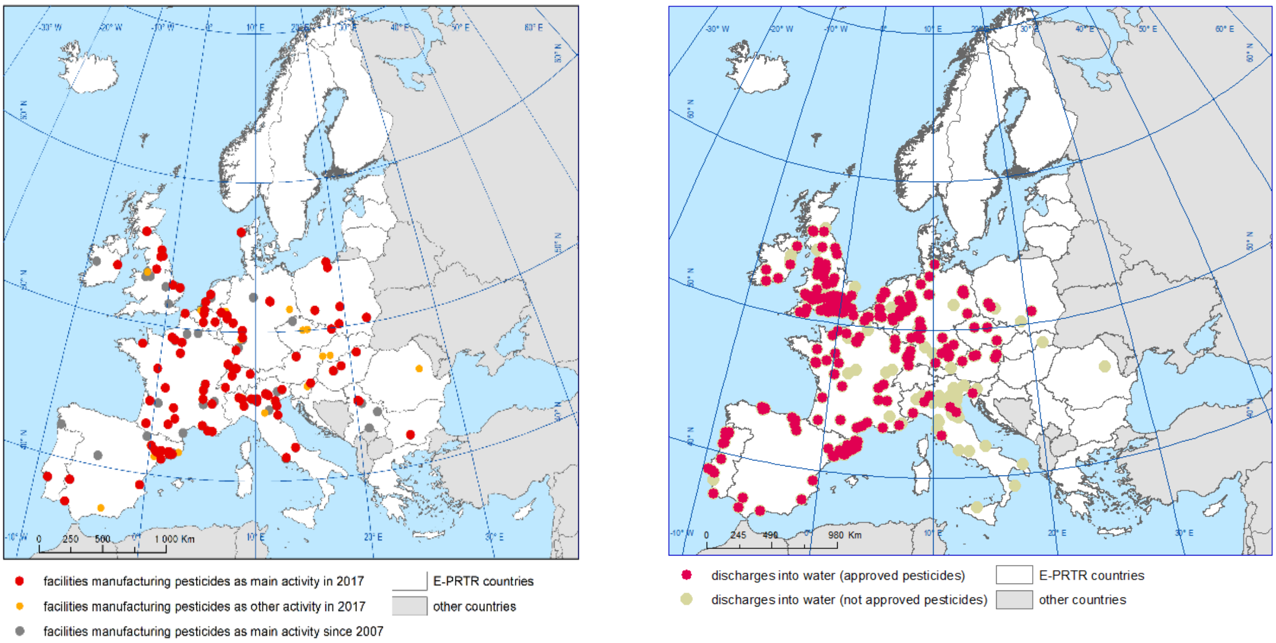
Pesticide	No. of records	No.of MS	No. of years monitored	start	end	approved	No. of facilities 2017
Mirex	2	2	2	2008	2011		
Simazine	82	9	11	2007	2017	N	6
Trifluralin	15	3	10	2007	2017	N	2

Note: 4.(d) means facilities including chemical installations for the production on an industrial scale of basic plant health products and of biocides; *Water* includes marine waters as well as freshwater (surface waters and groundwater).

Source: https://prtr.eea.europa.eu/#/home (EEA 2019)

Figure 3.7 shows the facilities with pesticide production and the pesticide discharge from these facilities in the time period 2007 to 2017.

Figure 3.7 Facilities with production of pesticides (PRTR activity 4.d) as main or other activity (left) and facilities discharging pesticides into water in the years 2007–2017 (right)



Note: E-PRTR countries = countries reported data under E-PRTR. The points only show facilities, where discharge of pesticides was reported and not the amount of discharge from these facilities.

Source: https://prtr.eea.europa.eu/, (EEA 2019)

Table 3.4 shows the number of facilities, which reported pesticide discharge in 2017. In contrast to 38 other facilities, 185 wastewater treatment plants are listed with discharge of pesticides into waters.

Table 3.4 Number and type of facilities reported under E-PRTR discharging pesticides into water in 2017

Activity Code	Activity name	Count of facilities
1.(a)	Mineral oil and gas refineries	2
4.(a)	Chemical installations for the production on an industrial scale of basic organic chemicals	4

4.(e)	Installations using a chemical or biological process for the production on an industrial scale of basic pharmaceutical products	2
5.(a)	Installations for the recovery or disposal of hazardous waste	13
5.(c)	Installations for the disposal of non-hazardous waste	14
5.(f)	Urban waste-water treatment plants	185 (10 countries)
6.(b)	Industrial plants for the production of paper and board and other primary wood products	3

Source: https://prtr.eea.europa.eu/, (EEA 2019)

3.1.2.2. *Waterbase - Emissions*

Under the reporting obligation of WISE SoE – Emissions (WISE 1), EEA countries report every two to three years, and they provide the loads per year for specific substances on country, river basin, or subunit level. For the reporting, the emission load can be assigned to different types of sources. The countries can report emissions from point sources every year, and every three years from diffuse sources. The reporting has been carried out by 19 countries, but only some of them reported pesticide loads. If so, pesticide loads were mainly reported by industrial and urban waste water treatment plants (Table 3.5).

Table 3.5 Pesticide emissions reported under Waterbase - Emissions in the time period 2008 to 2017

Emission source	Number of countries
I – Point sources - Industrial waste water	15
I3 – Point - Industrial waste water - treated	14
I4 – Point - Industrial waste water - untreated	5
NP – Diffuse	1
NP1 – Diffuse - Agricultural emissions	3
NP2 – Diffuse - Atmospheric deposition	2
NP3 – Diffuse - Un-connected dwellings emissions	2
NP5 – Diffuse - Storm overflow emissions	2
NP7 – Diffuse - Other diffuse emissions	2
NP72 – Diffuse - Transport emissions	2
O – Point - Other point emissions	7
O2 – Point - Waste disposal sites	7
O3 – Point - Mine waters	3
O4 – Point - Aquaculture	2
PT – Point sources	5
U – Point - Urban waste water	9
U1 – Point - Urban waste water - untreated	3
U11 – Point - Urban waste water - untreated - less than 2000 p.e.	1
U12 – Point - Urban waste water - untreated - between 2000 and 10000 p.e.	1
U13 – Point - Urban waste water - untreated - between 10000 and 100000 p.e.	1
U14 – Point - Urban waste water - untreated - more than 100000 p.e.	1
U2 – Point - Urban waste water - treated	9
U21 – Point - Urban waste water - treated - less than 2000 p.e.	3

Emission source	Number of countries
U22 – Point - Urban waste water - treated - between 2000 and 10000 p.e.	7
U23 – Point - Urban waste water - treated - between 10000 and 100000 p.e.	8
U24 – Point - Urban waste water - treated - more than 100000 p.e.	10

Source: https://www.eea.europa.eu/data-and-maps/data/waterbase-emissions-7

3.1.2.3. *WFD Inventory of emissions*

Limited information on pesticides was reported by the first inventory of emissions according to the EQSD (EU, 2008), and reported in the 2nd river basin management plans of the WFD, and only a low number of member States reported pollutant release from agriculture or riverine load (Table 3.6).

Table 3.6 Overview of pesticides of the WFD Inventory of emissions according to the WFD 2016 reporting

Chemical substance	No. countries with valid emissions values above 0	No. countries reporting pollutant releases from agriculture	No. countries reporting riverine load
CAS_115-29-7 - Endosulfan	6	2	2
CAS_118-74-1 - Hexachlorobenzene	8	2	3
CAS_122-34-9 - Simazine	6	1	2
CAS_1582-09-8 - Trifluralin	6	1	2
CAS_15972-60-8 - Alachlor	4	1	1
CAS_1912-24-9 - Atrazine	6	1	2
CAS_2921-88-2 - Chlorpyrifos	6	1	3
CAS_309-00-2 - Aldrin	2	0	0
CAS_330-54-1 - Diuron	8	1	2
CAS_34123-59-6 - Isoproturon	7	2	2
CAS_465-73-6 - Isodrin	2	0	0
CAS_470-90-6 - Chlorfenvinphos	3	1	2
CAS_50-29-3 - DDT, p,p'	4	1	1
CAS_60-57-1 - Dieldrin	2	0	0
CAS_608-73-1 - Hexachlorocyclohexane	6	2	3
CAS_72-20-8 - Endrin	2	0	0
EEA_32-02-0 - Total cyclodiene pesticides (aldrin + dieldrin + endrin + isodrin)	2	1	0
EEA_32-03-1 - Total DDT (DDT, p,p' + DDT, o,p' + DDE, p,p' + DDD, p,p')	2	1	0

Source: ETC 2018 (11)

(11) WFD-dataset review, background document, Prepared by ETC/ICM-Deltares in 2018

3.2. *Qualitative data sources*

3.2.1. Water Framework Directive

Pesticides in waters are covered by several parts of the reporting:

- Surface water body: Priority Substances (PS) for the assessment of chemical status, and River Basin Specific Pollutants (RBSP) for the assessment of ecological status.
- Groundwater body: Groundwater pollutants for the assessment of chemical status
- WFD Inventory of emissions: Emissions to water under consideration of different sources (see section 3.1.1).

3.2.2. Drinking Water Directive

The Drinking Water Directive (DWD) sets a concentration limit of 0.1 µg/l for individual pesticides, and of 0.5 µg/l for the total sum of pesticides. Because pesticides are present on a regular basis and in low concentrations, exposure to these chemicals is generally chronic. The health risk is difficult to assess, because data on acceptable doses for chronic exposure are scarce and the low concentrations involved are difficult to monitor (European Environment Agency 2016).

Under the Drinking Water Directive countries report every three years on the quality of drinking water. The data are localised at ‘Water supply zones’, which are the places where the water is used with no information on where it comes from. Exceedances of selected pollutants from drinking water standards are reported. Last reporting in 2018 cover years 2014-2016, next is due to 2021. Results from the years 2010-2013 were described in the Commission report (EC 2016). For reporting purposes, a short list of pesticides as well as total pesticides was agreed between European Commission and Member States:

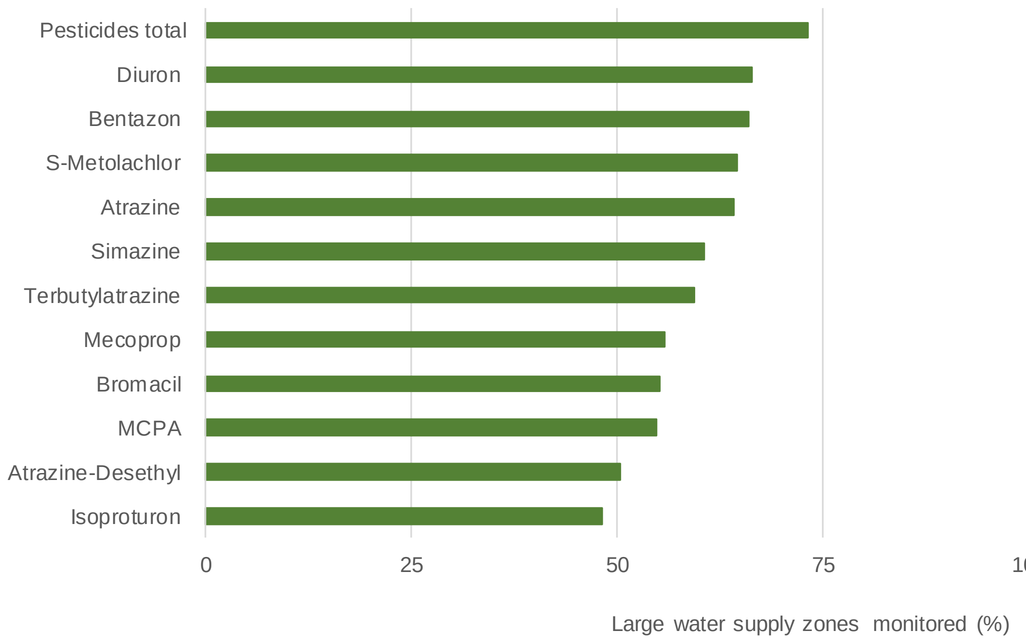
- Atrazine CAS 1912-24-9
- Atrazine-Desethyl CAS 6190-65-4
- Bentazon CAS 25057-89-0
- Bromacil CAS 314-40-9
- Diuron CAS 330-54-1
- Isoproturon CAS 34123-59-6
- MCPA CAS 94-74-6
- Mecoprop CAS 93-65-2, former CAS 7085-19-0
- Pesticides total (this parameter includes also other national monitored pesticides beside the short list)
- Simazine CAS 122-34-9
- S-Metolachlor CAS 87392-12-9
- Terbutylatrazine CAS 5915-41-3

The short list is a harmonised approach and makes reporting comparable but does not show the full picture of all pesticides and all relevant metabolites in a country. Member States monitor a considerable number of pesticides and metabolites (degradation and reaction products) in drinking water that are chosen at national level and are thus specific for each Member State. However, only those pesticides that are likely to be present in a given supply need to be monitored.

For the presented short list of pesticides, the number of records with exceedances for each water supply zone and the compliance rate is available.

Based on available data of DWD reporting of the time period 2014 - 2016, the short list of pesticides was monitored in about 60 % out of 9500 large Water Supply Zones in Europe, (Figure 3.8). This is an increase in comparison to the period 2011 - 2013, when pesticides were monitored in below 30% of Water Supply Zones (European Environment Agency 2016). Based on the amount of monitored Water Supply Zones, no information on pesticide risk of drinking water can be derived. The compliance rate of pesticides is shown in section 4.2.2.

Figure 3.8 Share of water supply zones, in which pesticides were monitored according to the Drinking Water Directive 2016



Source: DWD reporting 2014-2016, https://rod.eionet.europa.eu/obligations/171

3.2.3. Other Water related Directives

The data flows for other water related Directives do not include pesticide data:

- Urban Waste Water Treatment Directive (91/271/EEC)
- Bathing Water Directive (2006/7/EC)
- Nitrates Directive (91/676/EEC)
- Floods Directive (2007/60/EC)

3.3. Other data sources

There are many studies which have investigated pesticide pollution. Other data of European or worldwide coverage focused on the collection and assessment of pesticide contaminations were considered for the literature analysis (Table 3.7). Furthermore, pesticides data sources of European countries on pesticides are available, which focus on the registration of plant production products (see Annex 4). Box 2 shows an example on specific monitoring program for pesticides in Germany.

Overall, data availability from scientific projects are diverse and their quality may vary. Furthermore, sampling sites or research activities were mainly focussed on specific areas or model regions, which make comparison with routinely monitored sites rather difficult. The findings of such research projects can help to fill knowledge gaps but are less useful to fulfil data gaps in studies of temporal and spatial pesticide contamination.

Table 3.7 Overview of other data sources attributed to pesticide registration, research and national activities

Data source	Link to database	Contents
Food and Agriculture (FAO)	http://www.fao.org/faostat/en/#data/RP	The Pesticides Use database includes data on the use of major pesticide groups (Insecticides, Herbicides, Fungicides, Plant growth regulators and Rodenticides) and of relevant chemical families
		This domain contains data on pesticides and covers two different categories: pesticides traded in form or packaging for retail sale or as preparations or articles, and pesticides traded as separate chemically defined compounds
EU	https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&language=EN	EU-wide pesticides database on active substances, products and residues to fulfil regulation on maximum residue levels of pesticides in or on food and feed of plant and animal origin (EU, 2005)
	https://sitem.herts.ac.uk/aeru/ppdb/en/search.htm	The PPDB is a comprehensive relational database of pesticide chemical identity, physicochemical, human health and ecotoxicological data. It has been developed by the Agriculture & Environment Research Unit (AERU) at the University of Hertfordshire for a variety of end users to support risk assessments and risk management.
European and Mediterranean Plant Protection Organization (EPPO)	https://www.eppo.int/ACTIVITIES/plant_protection_products/registered_products	List of databases on registered plant protection products in the EPPO region
West Palaearctic Region Section (WPRS)	https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&language=EN	Pesticide side effect database of the West Palaearctic Region Section (WPRS) with information on effects of plant production products on beneficial arthropods obtained.
Norman	https://www.norman-network.net/	NORMAN organises the development and maintenance of various web-based databases for the collection & evaluation of data / information on emerging substances in the environment
EuroMix 2015-2019	http://www.euromixproject.eu/	Data and research results on chemical mixture not solely proposed by the JRC. Results will be relevant for

Data source	Link to database	Contents
		national food safety authorities, public health institutes, the European Food Safety Authority (EFSA), the European Chemical Agency (ECHA), industry, regulatory bodies and other stakeholders.
AQUAREHAB 2009-2013	https://www.wur.nl/en/show/aquarehab-1.htm	The project developed innovative rehabilitation technologies for soil, groundwater and surface water to cope with a number of different priority contaminants incl. pestizides in the Netherlands.
SOLUTIONS 2013-2018	https://www.solutions-project.eu/	According to the issue of pesticides, different results of SOLUTIONS project are relevant, e.g. • effect-based techniques as tools suitable for the different purposes of water quality monitoring • the use of non-target methods Assessment of toxicity effects of chemical mixtures in waters
National research or program on specific pesticide monitoring	Norway	https://www.researchgate.net/publication/227635339_Ten_Years_of_Pesticide_Monitoring_in_Norwegian_Ground_Water
	Norway	http://www.oecd.org/chemicalsafety/pesticides-biocides/1934217.pdf
	Sweden	Long-term Data from the Swedish National Environmental Monitoring Program of Pesticides in Surface Waters. https://dl.sciencesocieties.org/publications/jeq/articles/48/4/1109
	Denmark	Groundwater monitoring. https://www.geus.dk/media/20715/grundvand_1989-2017.pdf
	France	Pesticides: evolution of sales, usage and presence in rivers since 2009. https://www.statistiques.developpement-durable.gouv.fr/pesticides-evolution-des-ventes-des-usages-et-de-la-presence-dans-les-cours-deau-depuis-2009
	The Netherlands	Surface water taxation due to the use of some plant protection products in agriculture, 2005-2017.https://www.clo.nl/indicatoren/nl0518-belasting-van-het-oppervlaktewater-door-het-gebruik-van-gewasbeschermingsmiddelen-in-de-landbouw?ond=20900
	Switzerland	National specific monitoring on surface water quality. https://www.newsd.admin.ch/newsd/message/attachments/56290.pdf

Box 2 **Example on pesticide research project:**
Nationwide monitoring of small streams in Germany

One of the objectives of the German National Action Plan (NAP) on Sustainable Use of Pesticides (to implement Directive 2009/128/EC) requires a representative sampling of small water bodies. Furthermore, by the year 2023, 99 % of the event-driven monitoring samples of one year should comply with the regulatory acceptable concentration (RAC) regulated within the authorization of pesticides.

Streams may be sampled for chemical analysis once a month, with pesticides seldom being found, even during the application period. However, when samples are taken event controlled with a rise of the water level of 5 cm and after pesticide application (= “event-driven”), pesticides are found much more often. Until now, such sampling was made in scientific studies only, e.g. (Liess, et al., 1999; Moschet, et al., 2014; Gustavsson, et al., 2017). To determine the proportion of RAC exceedances for the German NAP, a concept was developed for the representative monitoring of pesticides in small waters in the agricultural landscape (Szöcs, et al., 2017). The German Environment Agency (UBA), together with the Helmholtz-Centre for Environmental Research (UFZ) and in close cooperation with the state authorities, has conducted two sampling campaigns in 2018 and 2019.

The aim of the monitoring program is to realistically assess the input of agriculturally used active substances into small water bodies, which are currently not monitored within the Water Framework Directive (2000/60/EG). Catchments with an area of <30 km², an agricultural proportion of > 40 %, and a distance of at least 3 km to wastewater treatment plants upstream of the sampling sites were selected. The distribution of the 120 sites across the individual Federal states of Germany was based on the respective percentages of agricultural land. Each site was sampled once between spring to early summer over the course of the two years. To accurately capture the pollution of the waters and assess the resulting risk to the aquatic community, automatic, event-driven sampling after the occurrence of rain events - in addition to grab sampling - was put into practice. A uniform substance list of over 90 active substances and 40 metabolites was analysed.

The first results of the sampling campaign 2018 at 60 monitoring sites indicate that measured pollution exceeds RACs for one or several substances in more than 50 % of the event-driven samples. These exceedances occurred at more than 80 % of the monitoring sites. At about 40 % of the sites 5 or more RAC exceedances occurred. Rain events triggering the sampling devices occurred at 90 % of the sites within the sampling period from spring to early summer even in the very dry year 2018, capturing at most 9 consecutive events at two sites.

11 of the monitored pesticides are regulated under the WFD with maximum EQS. With event-driven sampling at 6 % of the monitoring sites were found 17 exceedances of these EQS. With regular monthly grab sampling at 3 % of the monitoring sites were found 8 exceedances only.

3.4. Data availability, gaps and uncertainties

Waterbase – Water Quality database includes the largest volume of concentration measurement data available from the European Environment Agency, covering about 180 different pesticides. Data include single measurement (so called “disaggregated”) data and aggregated data (including yearly mean, minimum, maximum and limit of quantification [LOQ] of pesticide concentrations).

The most prominent uncertainties in the Waterbase – Water Quality dataset are inconsistent reporting of limit of quantification (LOQ) values and inconsistent time series of the data from individual monitoring sites. Due to different requirements of European reporting, the LOQ has been reported either as flags or different values (inconsistent reporting of full LOQ values vs half-LOQ values according to the requirements of the European water quality directives, e.g. Directive 2009/90/EC), and in some cases no data regarding the LOQ is available for a record at all (see also section 3.1.1.3). This increases uncertainty in determining measurements that are below LOQ, needed for analyses such as EQS exceedance. Also, LOQ values that were indeed reported vary within the substance, in various cases within the country and year as well. Another inconsistency lies in reporting of the data from the same monitoring sites through time, which would compose consistent time series of comparable data. Instead, the data for many monitoring sites were not reported for more than a few years, which disperses spatial and temporal coverage of the dataset and makes trend analysis less credible.

Emission data (E-PRTR, Waterbase - Emissions, Inventory of emissions) offer limited information on pesticides. Their substance lists are restricted and do not include many pesticides. E-PRTR thresholds, which set volume limits below which it is not necessary to report, mean that only the largest sources are reported. Diffuse sources - which are likely to be very important for pesticides - are not included or only roughly estimated in these inventories. For most substances the inventories include only a very low share of all emissions of the addressed substances.

Qualitative data on pesticides according to the chemical and ecological status assessment under the **Water Framework Directive** is restricted at European level to the six yearly WFD reporting cycle. Latest 2016 reporting requirements included substances causing failure of chemical status of surface water bodies. For these priority substances EU-wide EQS (ecological quality standard) values were regulated and therefore failings of good chemical status are comparable. This is also valid for groundwater pollutants to assess the chemical status of groundwater bodies. Much more pesticides are listed under the river basin specific pollutants to assess the ecological status of surface waters. For those substances, EQS were regulated on a national basis and therefore differ between Member States. Assessments with these EQS might be not comparable.

Qualitative data reported under the **Drinking Water Directive (DWD)** focus on a short list of pesticides and their compliance with the DWD even though EU Member States monitored a broad range of pesticides in their countries. The compliance rate for each substance is attributed solely to large Water Supply Zones, whereas the reporting of compliance for decentralised small wells is not obliged under the Directive (and will also not monitored on regular frequency). Furthermore, the point of compliance (and monitoring) is not the raw water from the drinking water source rather than the point of human consumption after treatment. While the amount of compliance will give a hint to main pesticide problems within EU Member States, data are hardly comparable to other databases.

4. Status of information on pesticides

4.1. *Assessments and results of quantitative data sources*

4.1.1. Waterbase – Water Quality

4.1.1.1. *Pesticides in surface waters*

Based on the above explained methods (see section 3.1.1), Table 4.1 shows the specific substances reported under Waterbase – Water Quality with the highest rate of exceedances ordered in usage groups. The EQS for each substance used for the calculation of the exceedance rate are listed in Annex 6.

The total number of records within the group of herbicides in the time period 2007 – 2017 is 157 341, and the substance with the most exceedance rate is Glyphosate (15.6%) even though the number of records is relatively low (6 257). With some 20 000 records, Trifluralin and Diuron, which are listed as a priority substance under WFD, show less exceedance rates with 2.2 and 1.0%. Four substances show exceedance rate >5% (Table 4.1).

Insecticides include a total of 69 different substances. The number of records of the listed 17 substances with the highest exceedance rate is 116 358 (out of some 500 000 records), whereas Heptachlor and alpha-Endosulfan have the highest records in the given time period. Nine substances show exceedance rates >10% (Malathion, Heptachlor, Dichlorvos, Heptachlor epoxide, Imidacloprid, Cypermethrin, Fenitrothion, Parathion, Dicofol). 16 out of 69 substances show an exceedance rate of >5%.

Only 19 substances are listed under the usage group of fungicides with an overall number of records in time period 2007 – 2017 of 59,295. The mean exceedance rate of all 19 fungicides is low with 0.2% and only the substances Hexachlorobenzene and Metalaxyl have exceedance rates of more than 1%.

Table 4.1 Number of reported substances with the most reported rate of exceedances in surface waters, grouped by usage in the time period 2007 – 2017

Group	Substance	Number of records (year-monitoring sites)	Rate of exceedance (%)	EQS used for calculation (µg/l)
Herbicides	Glyphosate	6257	15.6	0.1
	Diflufenican	719	6.7	0.009
	Bifenox	5499	6.6	0.012
	Metolachlor	12062	6.2	0.3
	Desethylterbuthylazine	8515	4.3	0.1
	Terbuthylazine	12984	2.7	0.2
	Desethylatrazine	9464	2.4	0.1
	Ethofumesate	7751	2.2	0.1
	Trifluralin	20218	2.2	0.03
	Oxadiazon	2350	1.6	0.088
	MCPA	13870	1.6	0.1
	Linuron	16058	1.3	0.1
	2,4-dichlorophenoxyacetic acid, 2-4 D	9330	1.1	0.1
	Bentazone	9130	1.0	0.1

Group	Substance	Number of records (year-monitoring sites)	Rate of exceedance (%)	EQS used for calculation (µg/l)
	Diuron	19583	1.0	0.2
Insecticides	Malathion	7479	29.2	0.0008
	Heptachlor	11847	20.7	0.0000007
	Dichlorvos	9773	16.4	0.0006
	Heptachlor epoxide	8479	15.9	0.0002
	Imidacloprid	2394	15.5	0.0083
	Cypermethrin	5326	15.4	0.00008
	Fenitrothion	9317	14.8	0.0009
	Parathion	8777	13.7	0.0002
	Dicofol	7600	13.3	0.0013
	Endosulfan	7084	8.7	0.005
	Hexachlorocyclohexane	4583	8.3	0.02
	Omethoate	5803	7.8	0.0008
	Parathion-methyl	8446	7.0	0.005
	Permethrin-cis+trans	2426	6.8	0.001
	Alpha-Endosulfan	15083	6.7	0.005
	Methiocarb	1272	5.0	0.002
	Thiacloprid	669	4.8	0.0083
Fungicides	Hexachlorobenzene	19771	2.0	0.05 (MAC EQS)
	Metalaxyl	7304	1.5	0.1
	Fenpropimorph	6181	0.5	0.02
	Epoxiconazole	5069	0.2	0.1
	Propiconazole	6226	0.1	0.1
	Carbendazim	4769	1.0	0.15

Note: The number of records for one substance is an aggregate of samples taken at one site, in one year. MAC = Maximum.

Figure 4.1 shows the rate of exceedance over the time period from 2007 to 2017 of the three groups insecticides, herbicides and fungicides. This assessment is based on the number of monitoring sites, because the effects of these three groups hamper three different aquatic organism groups. For this reason, the exceedance per year and sampling site is crucial for the assessment.

The results show highest rates of exceedances from 2007 to 2012 with a peak in 2012 by insecticides. In 2012, at some 50% of all sampled monitoring sites, exceedances seem to occur. After 2012, rate of exceedance of insecticides decreased significantly to 5% of all monitoring sites in 2017. The reason might be a bias of values lower the levels of detection (LOQ). These LOQ’s were not reported from many sites, substances or countries. So we had to detect values lower than LOQ from checks of the data (e.g. many aggregated data sets, in which we found that minimum and maximum had the same values, told us that all values were below LOQ and LOQ was reported as minimum and maximum). It might be that the rules of these checks did not catch all these values lower LOQ.

In 2009 the EQS of priority substances came into force, among them several very low EQS values for insecticides listed as priority substances. The COM decision on technical specifications for chemical analysis and monitoring set LOQ’s for the analysis method at one third of the EQS values (EC, 2009a). This requirement led to development of improved analytical methods and lower LOQ’s. It is supposed that exceedance rates during the years following 2012, when Member States were monitoring for the River Basin Management Plan reporting in 2016, might be more reliable as they would be less biased by values below the LoQ. Assessments for some insecticides with very low EQS values should therefore be on data from after 2012. The same effect might be true for fungicides. They show the lowest exceedance rates over the whole time period and since 2013, the rate of exceedance decreased to less than 1% per year. Fungicides are seldom seen as a water quality problem.

Exceedance rates of substances used as herbicides also varied over the years, but a break or linear increasing or decreasing trend is not visible. Because most herbicides have usually higher EQS in the range of the drinking water standard and a much longer analysis history, the above mentioned effect of LOQ's are rather seldom. Since 2014 herbicides show exceedances at more monitoring stations than insecticides.

The issue of analysis results below LoQ, LoQ below EQS and missing LoQ reportings needs more investigation. It should be mentioned, that the exceedance rates of the three groups are assigned to a relatively low number of substances. This follows the fact, that usually one substance is responsible for the toxicological effect.

Figure 4.1 Rate of exceedances of the three usage groups of pesticides from 2007 to 2017 in surface waters

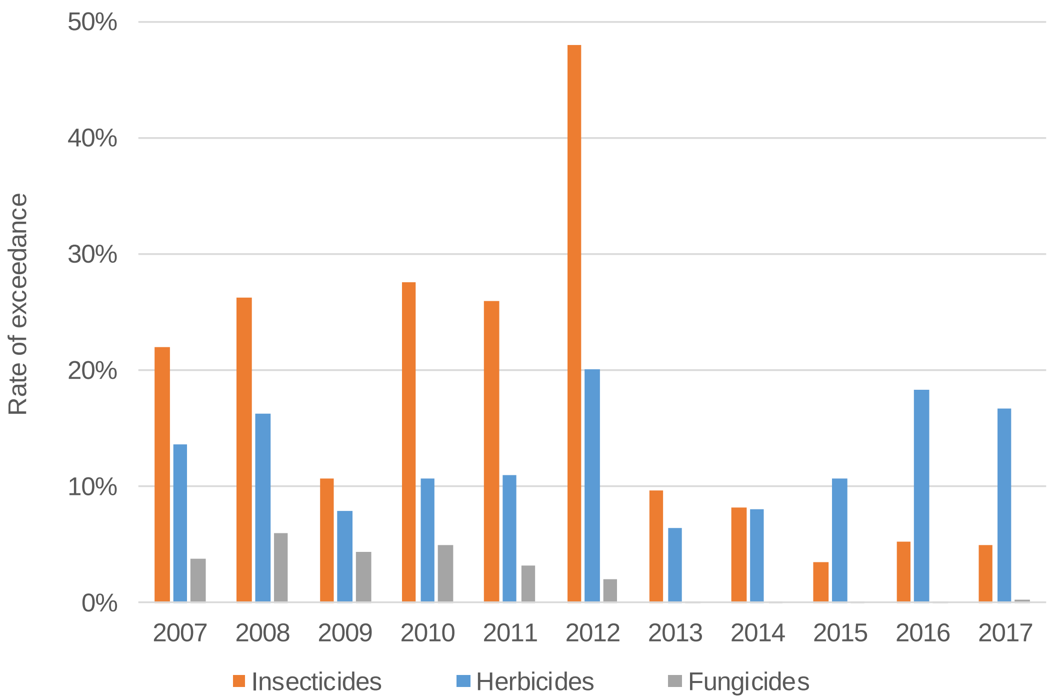
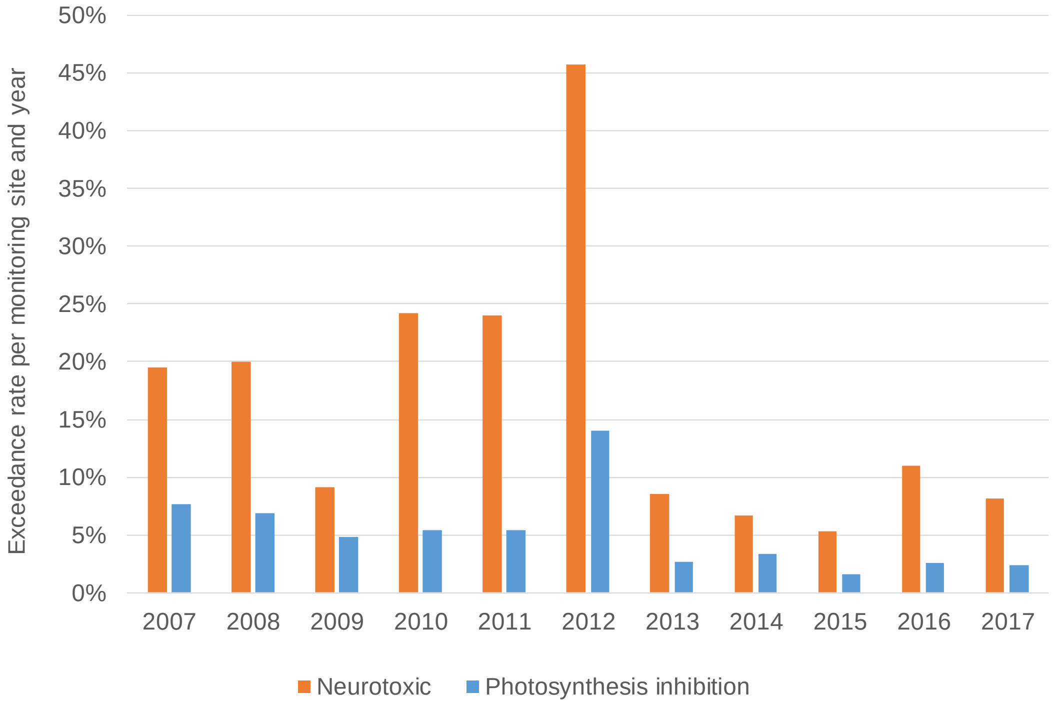


Figure 4.2 shows the result based on the grouping according to Mode of Actions (MoA). Based on the available data and the methods for the pesticide selection, only the two groups of substances showed many EQS exceedances: neurotoxic and photosynthesis inhibitors. Because neurotoxic substances are used as insecticides, and photosynthesis inhibiting pesticides are herbicides, results of MoA grouping of pesticides show nearly same amounts of exceedances as presented on pesticide usages. Also, the above discussed problenms are valid of values lower than LoQ as reason for probably uncertain exceedances before 2012 for neurotoxic insecticides.

Figure 4.2 Rate of exceedances per monitoring site; MoA grouping of pesticides from 2007 to 2017 in surface waters



Note: Based on data from WISE 4 in the time period 2007 – 2017 and the grouping, only information on neurotoxic and photosynthesis inhibition substances are available.

4.1.1.2. *Pesticides in groundwater*

Table 4.2 shows in analogy to the results of pesticide substances in surface waters (section 4.1.1.1), the number of substances and their exceedance rate for groundwater.

The total number of records within the group of herbicides in the time period 2007 – 2017 is some 1,400,000, and the substances with the most exceedance rate are Deisopropyldeethylatrazine (4.9%), Desethylatrazine (3.49%) and 2,6-dichlorobenzamide (3.10%). Only five substances show exceedance rate >1% (out of 75).

Reported insecticides include a total of 61 different substances. The total number of records of the 61 substances in the time period 2007 - 2017 is 850,327, and some 219,000 records of the 11 listed insecticides in Table 4.2. Here, only two substances – Demethon-S-methyl and 1,2-dichloroethane – have exceedance rates > 2%. The exceedance rate of all other substances is less than 1%.

None of the selected substances assigned to the group of fungicides show exceedance rates > 1%. In the time period 2007 – 2017, 113,688 records were reported from the 11 selected fungicides.

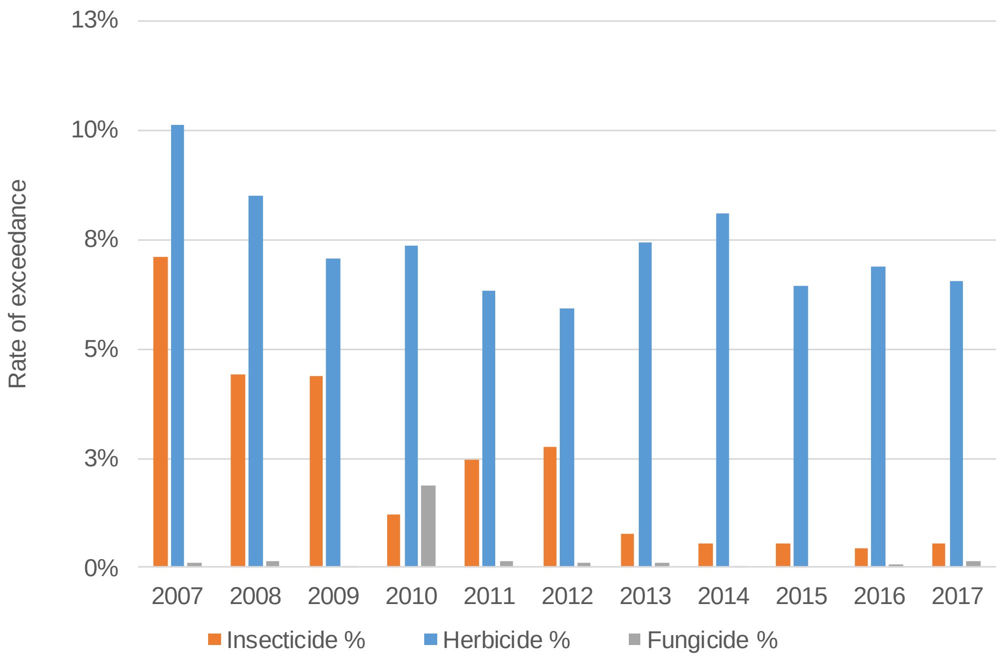
Table 4.2 Number of reported substances with the most reported rate of exceedances in groundwater, grouped by usage in the time period 2007 – 2017

Group	Substance	Number of records	Rate of exceedance (%)
Herbicides	Deisopropyldeethylatrazine	13436	4,90
	Desethylatrazine	59184	3,49
	2,6-dichlorobenzamide	17054	3,10
	Bentazone	45363	1,42
	Atrazine	63941	1,26
	Dichlobenil	22136	0,83
	Glyphosate	14954	0,78
	Desisopropylatrazine	43349	0,57
	Metolachlor	19130	0,51
	Hydroxyatrazine	11697	0,49
	Aminomethylphosphonic acid (AMPA)	14177	0,71
Insecticides	Demeton-S-methyl	4972	2,92
	1,2-dichloroethane	44518	2,21
	Carbon tetrachloride	32129	0,98
	Isodrin	23227	0,78
	Pirimicarb	22054	0,75
	Endrin	27154	0,69
	Dimethoate	25504	0,59
	1,2-dibromoethane	2561	0,55
	Chlordecone (Kepone)	3031	0,46
	Heptachlor epoxide	13765	0,31
	Beta-HCH	19879	0,30
Fungicides	Epoxiconazole	9199	0,30
	Hexachlorobenzene	24891	0,18
	Metalaxyl	23873	0,08
	Propiconazole	11593	0,06
	Fenpropimorph	19000	0,02

Notes: The used groundwater quality standard for all substances was 0.1 µg/l. The number of records is an aggregate of samples taken at one site, for one substance, in one year; typically composed of (more) disaggregated but also aggregated reported records.

Figure 4.3 shows the rate of exceedance over the time period from 2007 to 2017 of the three groups insecticides, herbicides and fungicides in groundwater monitoring stations. The results show by far highest rates of exceedances of herbicides with a probably slightly decreasing trend from 8–10% in 2007-2009 to 7–8 % in 2015 - 2017. The exceedance rates at monitoring stations occurs also for insecticides, but this might have the same LoQ-based reasons as discussed for surface waters. The rate starts with 2–7.5% until 2012 and decrease to 0.5% after 2012. Fungicides show, like the results in surface waters, the lowest exceedance rates over the whole time period with a small peak in 2010 (which cannot be interpreted in detail). Overall, the exceedance rates at groundwater monitoring stations are much lower than exceedance rates in surface waters.

Figure 4.3 Rate of exceedances of the three usage groups of pesticides from 2007 to 2017 in groundwater



In groundwater, the assesment according to MoA grouping is not relevant, because groundwater assessment is not based on the effects to aquatic organisms but the EQS is derived from protection of drinking water from all pesticides.

4.1.2. E-PRTR

Table 4.3 shows the pesticide load in 2017 reported under the E-PRTR for pesticides. As shown in the table, Simazine is by far the substance with the highest load, due a facility in Spain which is emitting 99,5 % of the Simazine pollution. Diuron is the second most emitted pesticide under PRTR which is widely in use.

Table 4.3 Total pesticide load to water reported under E-PRTR in 2017
(n.d. = no data or information available)

Pollutant Name	No. of records	No.of MS	Total 2017 (kg)	No. of facilities 2017	Treshold releases (kg/year)
Alachlor	26	7	19.4	3	1
Aldrin	103	4	61.9	11	1
Atrazine	77	13	61.1	6	1
Chlordecone	12	3	n.d.	n.d.	n.d.
Chlorfenvinphos	8	4	n.d.	n.d.	n.d.
Chlordane	5	1	1.3	1	1
Chlorpyrifos	24	5	27.6	5	1
DDT	24	5	25.4	3	1
Dieldrin	117	5	67.9	12	1
Diuron	1136	12	389.9	122	1
Endosulfan	19	5	25.4	3	1
Endrin	82	5	52.0	8	1
Heptachlor	15	2	25.4	3	1

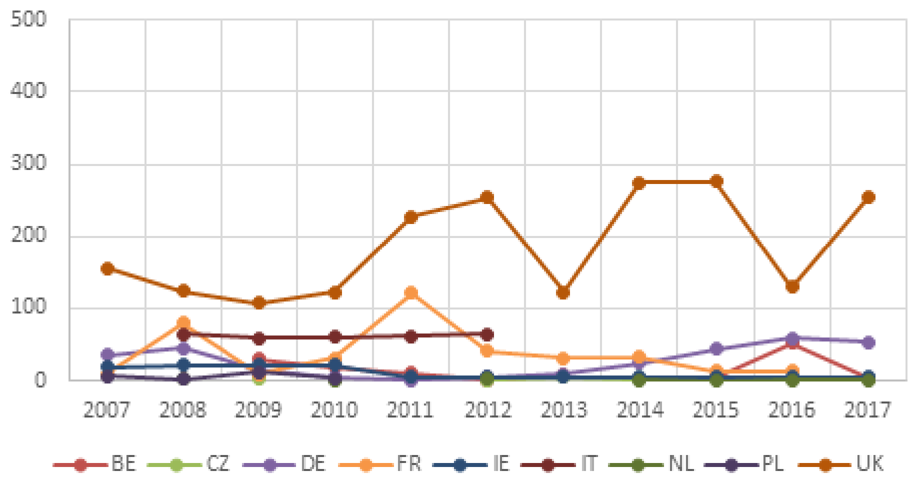
Pollutant Name	No. of records	No.of MS	Total 2017 (kg)	No. of facilities 2017	Treshold releases (kg/year)
1,2,3,4,5,6-hexachlorocyclo hexane (HCH, Lindane)	80	8	71.6	7	1
Isodrin	98	6	54.4	9	1
Isoproturon	336	11	47.1	20	1
Mirex	2	2	n.d.	n.d.	n.d.
Simazine	82	9	6 623	6	1
Trifluralin	15	3	20.1	2	1

Source: E-PRTR .16, published in 2019 including 2017 data

Most of the E-PRTR pesticides are not in use anymore: Simazine, DDT, Lindane, Mirex, Aldrin, Dieldrin, Endrin and Isodrin are banned under the Stockholm POP convention, Isoproturon was banned in 2016, respectively. Still in use, but also restricted are Chlordane and Diuron, respectively. Additionally, a substance banned as pesticide might be still used as a biocide, if the approval of the biocide usage group is not finalised, in which this substance is included in one of the products.

Based on E-PRTR data, one possible assessment is shown in Figure 4.4. Because of the high aggregation (e.g. mean value of each years, measurement of effluent concentration etc.) loads of Diuron gives hardly any trend over the time period from 10 years. In Belgium, loads under consideration of the used data, are much higher than in the other selected countries. Additionally, one should have in mind, that emissions from diffuse sources and smaller facilities are not counted in E-PRTR.

Figure 4.4 Trend of Diuron loads (kg/a) from waste water treatment plants in EU Member States



Note: Example of total discharges into water by countries over 10 years (based on raw data)

Source: E-PRTR v.16 (https://prtr.eea.europa.eu/)

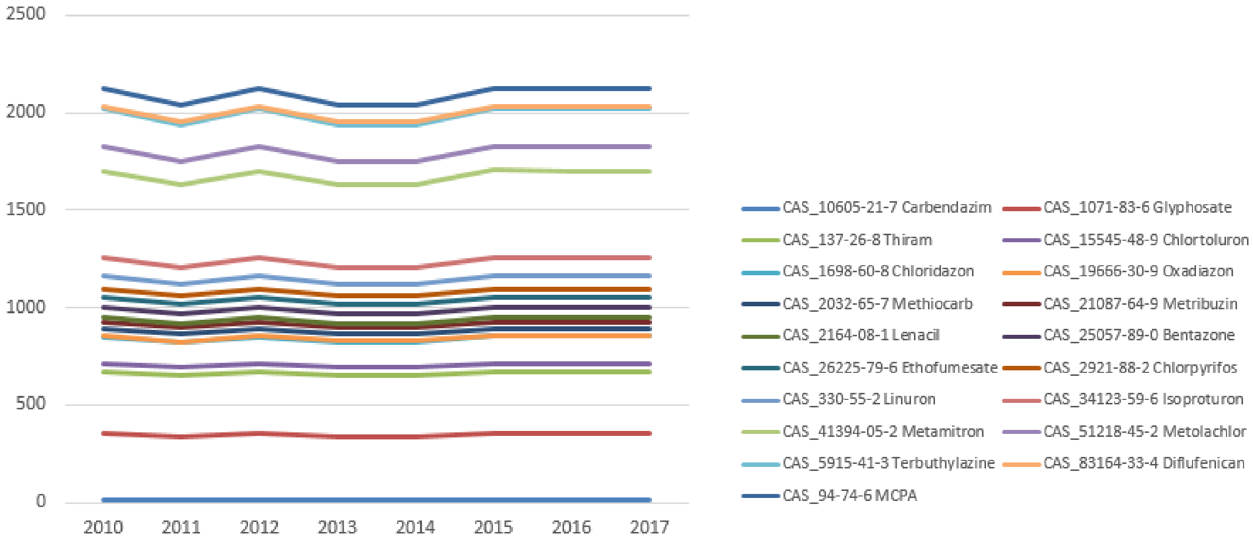
4.1.3. Waterbase - Emissions

As already described in section 3.1.2.2, only few Member States reported pesticide emissions under the Waterbase - Emissions database.

Two countries (Belgium and the Netherlands) reported an estimate of pesticide releases from agriculture. This estimate is based on the national model NMI3 for the Netherlands and the WEISS model developed and used in Belgium. The model NMI 3 is based on the development of emission factors using different pathways and the sales data of pesticides. It is described in the national emission register ([12]). The WEISS model was developed under the WEISS project and combines data on pesticide use, crop distribution and pathway factors ([13]).

Figure 4.5 shows an example of the Waterbase - Emissions data for pesticides. According to this database, the amount of pesticides doesn't show any trend over the last 10 years. It needs to be noted, that Waterbase - Emissions is not a mandatory reporting but at present provides the most valuable database for emissions from diffuse sources.

Figure 4.5 Trend of pesticide releases from agriculture (kg/year) in RBD Maas and Schelde (Belgium) reported under WISE 1 (kg/year)



Source: https://www.eea.europa.eu/data-and-maps/data/waterbase-emissions-7, cit. 19.6.2019.

4.2. Assessments and results of qualitative data sources

4.2.1. Water Framework Directive

According to the implementation of the WFD, 621 surface water bodies are still failing to achieve good chemical status in the second RBMPs due to pesticides, of which most of them are Isoproturon (198), MCPA (159) and Metolachlor (139) (Table 4.4). 571 water bodies improved from failing to achieve good chemical status in the first RBMP as a result of these substances meeting the relevant standards (EEA 2018).

([12]) http://www.emissieregistratie.nl/erpubliek/documenten/Water/Factsheets/Nederlands/Emissies%20landbouwbestrijdingsmiddelen.pdf, cit. 28.7.2019

([13]) http://weiss.vmm.be/

Table 4.4 List of pesticides most frequently exceeding EQS in surface water bodies in the EU 25 (out of 111 105 water bodies)

Pollutant	Type / Use of chemical	No of Member States with EQS exceedance	No. of WBs exceeding	Priority substance (PS / RBSP)
Hexachlorocyclohexane	Insecticide	10	104	PS
Isoproturon	Herbicide, biocide	7	198	PS
MCPA	Herbicide	6	159	RBSP
Metolachlor	Herbicide	6	139	RBSP
Terbuthylazine	Herbicide	6	51	RBSP
2-4 D (2,4-Dichlorophenoxyacetic acid)	Herbicide	4	18	RBSP
Malathion	Insecticide	4	13	RBSP
Parathion	Insecticide	4	7	RBSP

Source: EEA (2018)

Table 4.5 shows the number of groundwater bodies failing to achieve good chemical status due to pesticides within the 2nd RBMP 2016.

Based on the 2016 WFD reporting, nearly 80% of all groundwater bodies in Luxembourg are significantly affected by herbicides, and some 50% in Czech Republic; Some 24% of all groundwater bodies in Belgium and 17% in France are affected by pesticides from agriculture. These amounts are far higher than in all other Member States.

Table 4.5 Share of groundwater bodies failing to achieve good chemical status due to pesticides and biocides (%)

Member State	Pesticides and biozides	Herbicides	Insecticides	Fungicides	Metabolites	Pesticides
Austria	0.2	0.0	0.0	0.0	0.2	0.0
Belgium	27.1	3.5	0.0	0.0	3.7	23.6
Czech Republic	48.4	48.4	0.2	0.0	17.1	0.0
Denmark	3.2	0.0	0.0	0.0	0.0	3.2
Estonia	1.7	0.0	0.0	0.0	0.0	1.7
Finland	2.3	2.0	0.2	0.1	1.7	0.8
France	17.1	0.0	0.0	0.0	0.0	17.
Germany	8.0	3.3	0.0	0.0	3.4	4.0
Hungary	0.4	0.4	0.0	0.0	0.0	0.0
Italy	16.0	10.7	4.3	0.3	11.3	0.0
Luxembourg	78.9	78.9	0.0	0.0	0.0	0.0
Netherlands	0.5	0.0	0.0	0.0	0.0	0.5
Slovakia	1.2	1.2	0.0	0.0	0.0	0.0
Slovenia	2.1	2.1	0.0	0.0	0.0	0.0
Spain	2.2	0.6	0.1	0.0	0.0	1.6
Sweden	2.4	0.0	0.0	0.0	0.0	2.4
United Kingdom	4.6	3.6	0.7	0.0	0.0	0.5

Note: 'Pesticides' (last column of the table) are not the sum of the afore mentioned specific substance groups. These are substances reported under code EEA_34-01-5 = active substances in pesticides, including their relevant metabolites, degradation and reaction products.

Source: EEA (2018b)

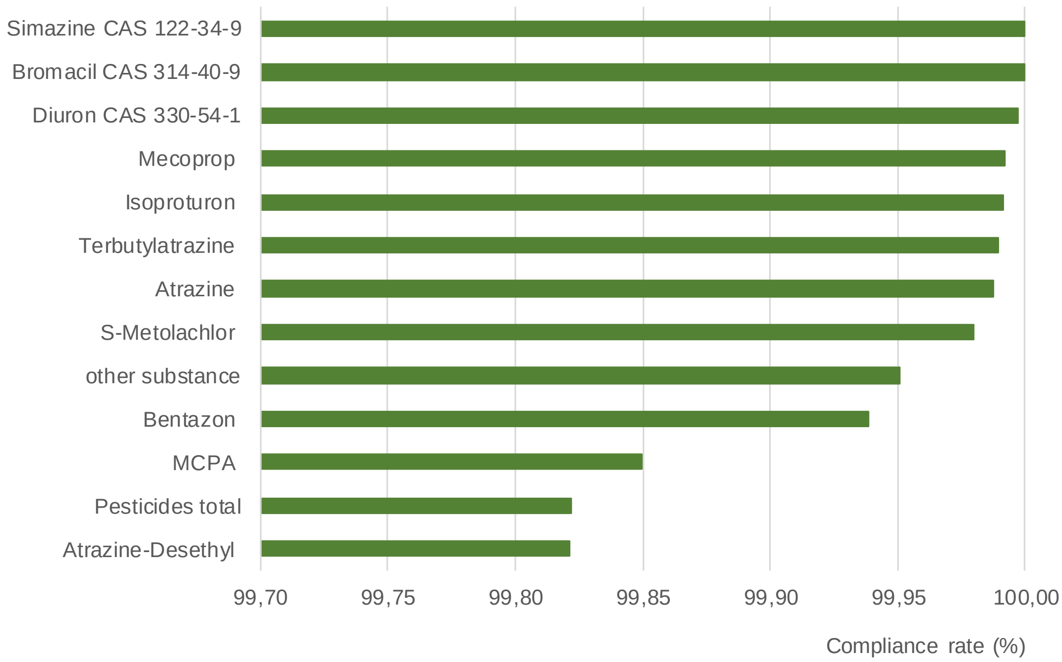
Based on the published data of the WFD (EEA 2018), most reported substances caused a failure to achieve good chemical status in groundwater were pesticides. AMPA, MCPA and Glyphosate were mainly reported as substances listed under the RBSP causing failure to achieve good ecological status in surface waters. Among these, Glyphosate and its metabolite AMPA were reported only from one Member State. The priority substance Tributyltin, a biocide mainly used to combat marine biofouling, affected the most surface water bodies (some 700).

4.2.2. Drinking Water Directive

Based on data of the last reporting period between 2014 to 2016 under the Drinking Water Directive, Figure 4.6 shows the compliance rate of pesticide monitoring. The compliance rate was calculated based on number of samples between 2014 and 2016 in all Water Supply Zones and the number of samples non-compliance (exceedance of threshold).

Based on this, the compliance rate with the list of pesticides (see section 3.2.2) is high and varies between 99.82 up to 100%. In contrast to other environmental reporting requirements, compliance requirements for drinking water are measured in tap water.

Figure 4.6 Compliance rate of pesticides in the EU reported under the Drinking Water Directive in the reporting period 2014-2016



Source: DWD reporting 2014 to 2016

5. Measures

Once pesticide pollution reachs surface waters and groundwater with effects on water quality, measures need to be carried out to improve water quality and reduce risks to human healts and the environment. The planning of measures to reduce pesticide pollution is carried out within the program of measures under the WFD as well as part of the National Action Plans for the implementation of the sustainable use of pesticide Directive. Furthermore, mitigation measures for the protection of water used for drinking water are part of the drinking water directive obligations. The following sections described types of measures under the different directives and present examples on the successful implementation to reduce pesticide pollution in waters and soil.

5.1.1. Measures under the Water Framework Directive

The planning of measures to improve water body status and to reach the environmental objectives is part of the river basin management planning under the WFD. Such measures are planned within the program of measures (PoM) for implementation during the current management cycle. Measures are distinguished between basic measures, which comprise the minimum waterbody protection and development requirements, already defined in existing directives, and supplementary measures. Supplementary measures are those measures designed and implemented in addition to the basic measures where they are necessary to achieve environmental objectives and comprise for example construction and rehabilitation projects, as well as legal, administrative or management instruments and training measures (BMU/UBA, 2016).

For the reporting of the planning of measures in the PoM, 25 Key Types of Measures (KTM) were defined (European Commission, 2016). Those KTM are measures that are expected to bring the substantial improvements to reach the objectives. One KTM comprise often more than one measure. The number of measures assigned to a specific KTM depends on national planning of measures.

In the Program of Measures (PoM) within the 2nd RBMP under the Water Framework Directive, the Key Types of Measures (KTM) addressed directly or indirectly to pesticide reduction in surface waters and groundwater:

KTM 3: Reduce pesticides pollution from agriculture

KTM 12: Advisory service for agriculture

KTM 13: Drinking water protection measures (e.g. establishment of safeguard- or buffer zones)

Based on the EU Commission consultation report (EC, 2019), the majority of Member States (21) ordered a total of 285 basic measures into KTM 3, six Member States ordered 25 measures into KTM 12, and 19 Member States ordered 243 basic measures into KTM 13 (Table 5.1). Between 15 and 16 Member States ordered 354 supplementary measures into these key types. In comparison to the total amount of basic measures (12 800), only 4% can be assigned to mitigation measures to reduce pesticide contamination; this is also valid for supplementary measures with only 3.5 %. Whereas “basic” measures are mandatory in all Member States, supplementary measures especially in agriculture are mostly applied on a voluntary basis.

Table 5.1 Overview of reported basic and supplementary measures for three key type measures assigned to reduce pesticide pollution in groundwater and surface water

	Basic measures		Supplementary measures	
	Number of MS with reported measures	Number of reported basic measures	Number of MS with reported measures	Number of reported supplementary measures
KTM 3: Reduce pesticides pollution from agriculture	21	213	16	102
KTM 12: Advisory service for agriculture	6	25	15	181
KTM 13: Drinking water protection measures	19	243	16	71

Source: EC, 2019

5.1.2. Measures under the Drinking Water Directive

In accordance with the Drinking Water Directive, Member States are obliged to implement mitigation measures in case of exceedances of the DWD listed substances. Furthermore, monitoring programmes including measurements in the catchment, risk assessments (e.g. drinking water safety plan), and finally treatment need to be done. The target value of the pesticides within the DWD is 0.1µg/l for any single pesticide substance or 0,5µg/l for the sum of all pesticides. In case of exceedances, the authorities are responsible to do research, what the source is, how to regulate it and stop the emission or discharge. In most cases, exceedances will be reduced by blending water sources or selecting other abstractions.

Protecting raw water is particularly important. Critical groundwater bodies need special attention from specific measures for drinking water. That cannot be the task of the competent authority or water suppliers alone. Rather, they need to cooperate with various stakeholders closely to a plan and implement measures in the catchment area. To protect drinking water against pollution from the catchment area, there must be well-integrated links between the DWD, the implementation of the water safety plan approach and the WFD (European Environment Agency 2016).

The EU project FAIRWAY under the HORIZON 2020 program deals with those challenges. The goals of the project with a duration from 2017 to 2021 and a funding budget of about 5 Million Euro is to review approaches for protection of drinking water resources against pollution by pesticides and nitrate, and to identify and further develop innovative measures and governance approaches for a more effective drinking water protection. The project partners are researchers, farm advisers and consultancies and is built on 13 case studies in 11 different EU countries FAIRWAY project (2019) ([14]).

Three case studies, in Ireland, United Kingdom and the Netherlands focus on pesticide contamination in drinking water resources.

In the Derg catchment in **Ireland**, MCPA arising from spray drift on agricultural land threatens the drinking water resources. Within this catchment, a farm incentive scheme as a voluntary initiative was developed that goes beyond the requirements that already apply to farms in the context of the

([14]) Project homepage: https://www.fairway-project.eu/

pesticide legislation, the EU Water Framework Directive, the Drinking Water Directive and other Regulations. In this scheme, several mitigation measures were included:

- Technical advice/ education
- Application of herbicides with weed lickers (automatoc weed detection and chemical application system)
- Development of a farm water safety plan
- Riparian buffer strips
- Fencing of riparian areas
- Herbicide substitution
- Biobeds (a pit filled with organic matter to avoid pesticide waste into soil and water)
- Stock fencing.

Furthermore, monitoring of water and soil is carried out. As the project is still ongoing, results of the effectiveness of the implemented measures are not yet available.

In the Anglian region of the **UK**, there was serious contamination in surface waters with metaldehyde, a molluscicide used against slugs in crops such as potatoes, oilseed rape and cereals. It is difficult to remove metaldehyde in water treatment, leading to challenges in the supply of drinking water. This case study focusses on the social science to reducing on-farm pesticide use, collecting comparable data in areas with metaldehyde challenges, and testing a new network engagement ([15]) between the included stakeholders FAIRWAY project (2019).

In the Noord-Brabant case study of the **Netherlands**, 11 of the 39 abstraction sites for drinking water are impacted by pesticides. Here, a contract between farmers and the province is put in place including an agreement on reduced use of pesticides. The farmers implement measures, and they choose pesticides with low environmental impact using the 'Environmental Yardstick for Pesticides', and register their pesticide use. The municipalities have reduced their pesticide use to zero on hard surfaces and they aim for zero use in parks, sport pitches and golf areas FAIRWAY project 2019.

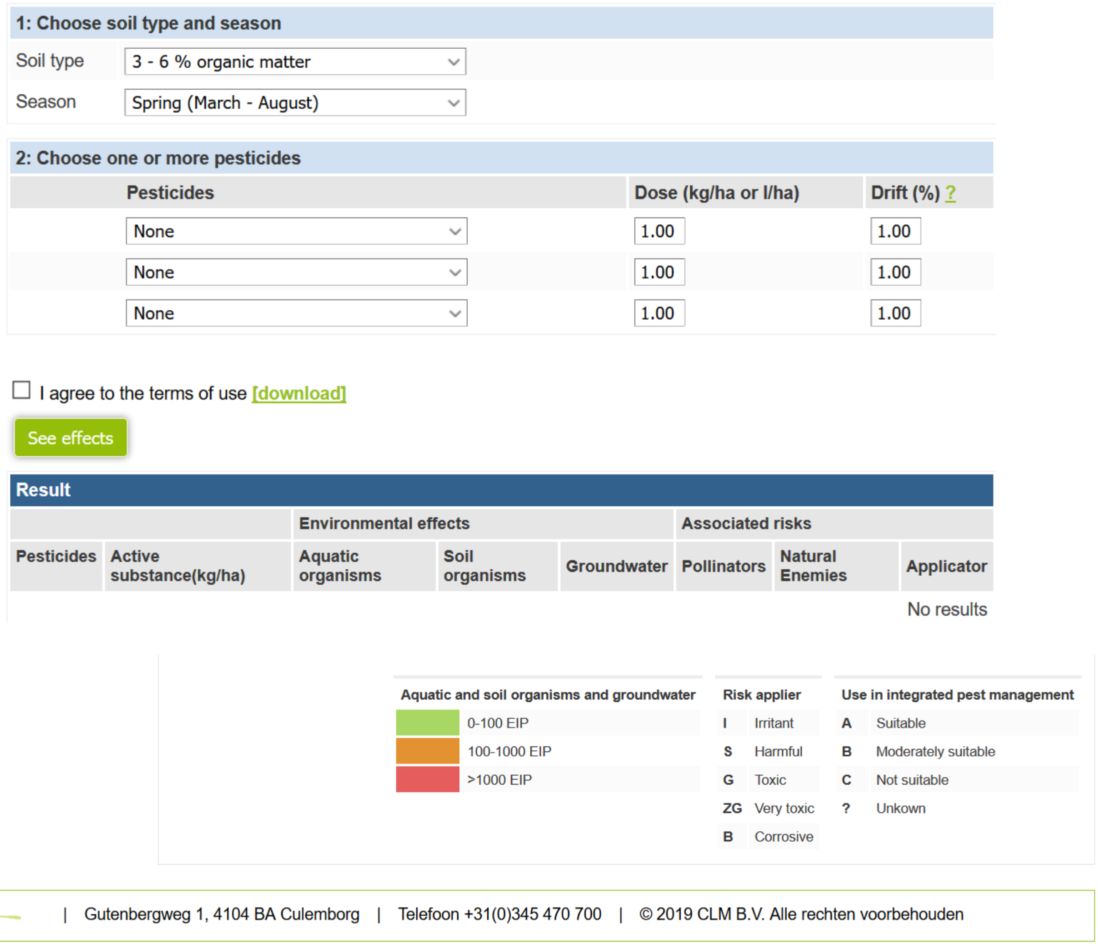
The developed of the 'Environmental Yardstick for Pesticides' ([16]) provides an overview of the environmental pressures generated by all crop protection agents permitted on the Dutch market. It enables the user to compare these agents and chooses the least harmful crop protection strategy. The Yardstick is also explained in a short and simple video on how to use and where to find the relevant information ([17]). It can be downloaded as an App on smartphones and tablets. In the program, the user can include the specific pesticide resulting in a classification of risk for soil and water (Figure 5.1).

([15]) Detailed information under: https://www.anglianwater.co.uk/business/help-and-advice/working-with-farmers/slug-it-out/

([16]) Project homepage: https://www.pesticideyardstick.eu/

([17]) Video: www.youtube.com/watch?v=RCYYWumSQh4

Figure 5.1 Example of a Yardstick for the use of pesticides in farmlands and municipalities



Note : EIP = Environmental Impact Points. Depends on the toxicity of a pesticide for aquatic organisms, and spray drift to watercourses depending on the application technique. Furthermore, factors like wind speed, wind direction, crop size, distance to the watercourse, temperature and atmospheric humidity play a part in the amount of drift.

Source: https://www.pesticideyardstick.eu/en/bereken-open-teelt.html

5.1.3. Measures under the Directive for the sustainable use of pesticides

According to the Directive 128/2009/EC for the sustainable use of pesticides, European Member States had to develop National Action Plans (NAP). The Directive itself also builds on other legislation, like the requirements of the Water Framework Directive to protect surface waters and groundwater as well as protected areas for the use of drinking water.

The Directive includes specific chapters and articles, which are the basis for the development of the NAP including the conceptual framing of measures. This includes, for example training for professional users (e.g. certificates), special requirements for sales of pesticides, information and awareness raising. Especially the last two aspects have a high priority to inform the general public on the risks according to acute or chronic effects of pesticides (EU, 2009). Next to these aspects, inspection of equipment in use as well as specific practices and uses are mentioned. According to this, Article 11 of the Directive leads to *Specific measures to protect the aquatic environment and drinking water*. These measures shall support and be compatible with the Water Framework Directive:

- Measures giving preference to pesticides that are not classified as dangerous for the aquatic environment.

- Measures giving preference to the most efficient application techniques.

- Use of mitigation measures which minimize the risk of off- site pollution caused by spray drift, drain-flow and run-off.

- Reducing as far as possible or eliminating applications on or along roads, railway lines, very permeable surfaces or other infrastructure close to surface water or groundwater or on sealed surfaces with a high risk of run-off into surface water or sewage systems.

A screening of the implemented NAP of Member States shows a number of specific measures related to the above-mentioned requirements. Some of the specific measures given in the NAPs are ([18]):

- Establishment of untreated buffer zones to protect surface waters

- Establishment of sanitary protection zones to protect drinking water, in which the use of pesticides is forbidden

- Increasing monitoring by water authorities and inspections

- Preservation of coastal vegetation during regular works to maintain watercourses

- Strict approval of pesticides

- Regional advisory service

- Research, e.g. Study of pesticide wash off in soils, establishment (spread) of cultivation mode and/or plant edges to prevent wash-off and soil erosion

- Establishment of a National Pesticides and Drinking Water Action Group

- Ban, prohibition or restriction in use of pesticides or stricter policy for the presence of pesticides in surface waters

- Implementing the use of herbivorous fish to limit aquatic plants in basins (Walloon fish farms)

Based on the EU overview report on the implementation of Member States measures to achieve the sustainable use of pesticides (European Commission and Directorate-General for Health and Food Safety 2017), it is stated, that in the 28 Member States 500 000 samples of surface waters, groundwater and drinking water were annually analysed (in comparison to 80 000 food samples, which are tested for pesticide residues).

([18]) All available NAPs were screened, and the most valuable types of measures listed. Source: https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/nap_en

Within the report, examples for an improved implementation of regulations, actions and measures – named as *best practices* – were analysed in six out of 28 Member States:

- Target setting: Denmark to reduce the pesticide load by 40 % by the end of 2015 compared with 2011. This target was met according to the Pesticides Load Indicator (PLI), which is based on sales data (Ministry of Environment and Food of Denmark 2017). Germany plans a 20 % reduction in the environmental risks associated with pesticide use by 2018, and a 30 % reduction in risk by 2023.

- Restrictions and permissions: The Netherlands have pioneered the implementation of emissions reduction plans (ERPs). Where pesticides are detected in surface waters, the product authorization holders are obliged to draft and implement these plans to improve the situation. Sweden has a system of permits for pesticide use along roads, very permeable surfaces and sealed surfaces; this is also implemented in Germany.

- Buffer zones: Sweden requires a minimum buffer zone of 12 meters around wells used to abstract drinking water. In addition, sprayers cannot be filled or cleaned within 30 meters of water courses or wells. Denmark and Germany delineate buffer zones.

- Information: The Netherlands developed a set of 17 factsheets outlining practical measures for reducing emissions of pesticides to surface water, which are publically available online.

The European Union Network for the implementation and Enforcement of Environmental Law (IMPEL) published a report, where measures and instruments used in Belgium (Flanders), England, Ireland, Netherlands, Scotland and Sweden to reduce pesticide residues in surface waters and groundwater were compared (Thorén, 2017). Measures were differentiated between legal obligations of Water Framework Directive, Drinking Water Directive, and measures under the Directive for the sustainable use of pesticides. Based on this, Belgium sets out several different measures with focus on restrictions in buffer zones, which are set at 2 to 30 meters depending on the size of the water as well as the land use in the area. England implements a *Catchment sensitive farming programme*, investigates impacts of agricultural practices and successes of measures as well as encourages good practice. This programme also links to grants for measures ([19]).

([19]) Source: https://www.gov.uk/guidance/catchment-sensitive-farming-reduce-agricultural-water-pollution

6. Conclusions and future perspectives

We lack an overview of the status of pesticides in Europe's waters. There are a number of reasons for this gap, with the omission nevertheless representing a significant cause for concern in our attempts to protect and improve water quality. Improving our understanding will take time, but by starting the process, the aim of this report is to set in train the developments necessary to achieve that overview.

Pesticide monitoring in surface waters and groundwater of the EU Member States and reporting to the EEA is nowadays oriented on the monitoring obligations under the WFD. Additionally, regional monitoring efforts are made to tackle regional problems. Such monitoring is often designed together between environmental, drinking water and agricultural administrations and stakeholders. These monitored pesticide concentrations together with information on agricultural activities (including pesticide usage) could be the basis for regional management of environmental contamination of pesticides.

This report has considered the data available for pesticides in waters at European level. There are relatively few datasets that are comparable across Europe, leading to the current work focusing on those data reported under WISE SoE water quality (WISE 4).

The pesticide concentration data found in the Waterbase - Water Quality database were investigated for pesticide groups (herbicides, insecticides and fungicides), pesticide substances (including metabolites), monitoring sites (including major and minor rivers and water bodies). Additionally, but seldom reported, the limits of quantification were of interest. Our statistical checks to unravel concentration values lower than the limits of quantification (LOQ) are an example of the need to improve harmonisation of the reporting. At present, with the assumption that remaining uncertainties within these checks could be solved, we consider that the existing data could be used to describe pesticide concentrations. Comparison with environmental quality standards (EQS) could allow these data to describe the pesticide risk.

The Waterbase – Water Quality database on pesticide concentrations in the different European countries differ widely in terms of numbers of substances reported but also monitored stations. Different LOQs also hint towards the use of different chemical analytical techniques. Hence, to improve comparability, harmonisation with regard to monitored substances, density of monitoring stations and methodology is warranted. More streamlining of approaches towards data collection and monitoring, (such as the application of common analytical quality rules, such as those under the WFD (EC, 2009) would improve comparability. Focusing effort at relevant times, e.g. monitoring only before, at and after the pesticide application season, rather than continuously, could facilitate effective use of scarce resources.

Enhanced monitoring and further harmonisation of data collection would be beneficial for more specific management to protect water quality. Together with agricultural area usage, one would be able to compare the relative contribution and thus toxic pressure of pesticide usage types (e.g. corn herbicides, wheat insecticides) for a specific region, as a basis for management. Additional analysis of spatial and temporal distribution would increase understanding of the risks and management options. Pesticide metabolites (transformation products) should be considered, as these substances not only hint to their 'mother' substance, but many of these still have toxic potential (assigned to an EQS) and therefore increase the overall toxicity to organisms.

Data availability from scientific projects seems to be very diverse and their quality may also differ. However, even though not using harmonised procedures, these projects may provide important input with regard to relevant substances and novel assessment techniques. Thus, the comparison of the Waterbase – Water Quality database deliveries to EEA and the data reported in scientific literature may be challenging.

The implementation of measures to reduce pesticide pollution is crucial for the sustainable management of surface waters and groundwater. Information on quantitative effects of reduction measures are also relevant to indicate the progress to reach environmental objectives, but available data on this are rare. Other data sources mainly focus on strategies (e.g. National Action Plans). The implementation of measures and monitoring is of particular importance when evaluating the success and the effectiveness of measures. It is also necessary to improve the harmonization between the different policies tackling pesticides in waters and the environment. For successful implementation of measures to reduce pesticide pollution, funding instruments are also a basis, and this could be a part of the next phase of the Common Agricultural Policy.

One goal of this technical report is to show possible uses of the Waterbase – Water Quality database for further developments towards a pesticide indicator. Depending on the goal of any managing or monitoring action in surface or groundwater, different ways can be used to assess the risks due to pesticides. The historically developed and used way by regulatory bodies is the assessment of risk by using the single substance approach only. This means that EQS (or other threshold values) are used for risk assessment.

In human pharmacology and toxicology, the concept of mixture toxicity effects of many different substances which are applied at the same time is known. Adopting and applying this concept seems to be one possible solution to address contamination by pesticides in the environment. One published mixture approach is based on the Toxic Unit (TU) system. This TU is recommended to be used for risk assessment in the aquatic ecosystem. The TU is defined by the ratio of the concentration of a substance to its actual toxicity. Behind that concept stands the idea that the toxicity of a mixture of many similar acting substances can be assessed by adding up each substance effect concentration. This approach is most often known in scientific literature as the “concentration addition (CA)” approach.

Such an indicator also could for example combine toxicity risk assessment of monitored pesticide concentrations with agricultural area uses to identify the most problematic usages and pesticide types in specific European regions. With such assessments, countries could target management measures and thus decrease pesticide toxicity risk.

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Annex 1 Pesticide reference dataset on groundwater 2007–2017; Waterbase - Water Quality

Parameter	Distinct records	Distinct monitoring sites	Distinct countries	Distinct years
Atrazine	63941	14690	21	11
Simazine	63276	14542	21	11
Desethylatrazine	59184	12722	14	11
Diuron	46083	12430	18	11
Bentazone	45363	12288	16	11
1,2-dichloroethane	44518	11483	16	11
Desisopropylatrazine	43349	9809	12	11
Alachlor	42301	7660	17	11
Isoproturon	42038	9630	17	11
Linuron	36833	8505	13	11
Mecoprop	35365	9294	11	11
Trichloromethane	35080	10951	17	11
Chlorpyrifos	34378	8524	15	11
Prometryn	33441	7699	13	11
MCPA	32931	8871	14	11
Propazine	32495	8157	14	11
Carbon tetrachloride	32129	9809	15	11
Terbuthylazine	31053	6266	14	11
Gamma-HCH (Lindane)	30884	7815	16	11
Terbutryn	30774	8110	14	11
2,4-dichlorophenoxyacetic acid, 2-4 D	30500	7883	14	11
Chlorfenvinphos	29774	7636	15	11
Trifluralin	29540	7563	15	11
Aldrin	28331	7392	18	11
Dieldrin	27282	7498	18	11
Endrin	27154	7310	18	11
Metazachlor	26718	7367	11	11
Dichlorprop (2,4-DP)	26136	7914	8	11
Cyanazine	26031	6970	9	11
Ethofumesate	25846	7440	8	11
Dimethoate	25504	7347	12	11
Hexachlorobenzene	24891	6189	14	11
DDT, p,p'	24481	6927	16	11
p,p'-DDE	23885	6083	12	11
Metalaxyl	23873	7579	8	11
Chloridazon	23819	6793	11	11
Alpha-Endosulfan	23657	6323	14	11
Alpha-HCH	23487	6015	12	11

Parameter	Distinct records	Distinct monitoring sites	Distinct countries	Distinct years
Isodrin	23227	6248	14	11
DDT, o,p'	22682	5197	9	11
Dichlobenil	22136	6746	9	11
Pirimicarb	22054	6639	7	11
Pentachlorophenol	21677	5983	11	11
Dicamba	21362	6523	9	11
Parathion-methyl	21334	6328	9	11
Fenitrothion	21257	6737	9	11
Parathion	20649	6174	7	11
Chlorpyrifos-methyl	20495	6603	7	11
p,p'-DDD	20302	5327	12	11
Bromoxynil	20072	5766	5	11
Dichlorvos	19944	6362	8	11
Beta-HCH	19879	5623	13	11
MCPB	19650	6216	7	11
Metolachlor	19130	5374	9	11
Metribuzin	19110	5654	10	11
Fenpropimorph	19000	5639	5	11
Heptachlor	18720	6664	16	11
Metsulfuronmethyl	18679	5424	5	11
Clopyralid	18483	6078	7	11
Carbofuran	18206	6024	6	11
Hexazinone	18152	5188	5	11
Ioxynil	17316	5334	5	11
2,6-dichlorobenzamide	17054	5086	8	11
Pendimethalin	16645	5499	11	11
o,p'-DDE	16346	4945	8	11
2,4-DB	16315	4886	4	11
Beta-Endosulfan	16312	5443	10	11
Bromacil	15129	3994	9	11
Glyphosate	14954	4289	8	11
2,4,5-T	14800	5224	7	11
Desethylterbuthylazine	14660	4536	9	11
Methoxychlor	14508	5323	12	11
Aminomethylphosphonic acid (AMPA)	14177	3834	7	11
Metamitron	13895	3663	11	11
Heptachlor epoxide	13765	5012	13	11
Diazinon	13731	4813	12	11
Acetochlor	13443	3370	9	11
Deisopropyldeethylatrazine	13436	4082	3	11
Chlortoluron	12687	3579	10	11
Hydroxyatrazine	11697	3321	4	7
Propiconazole	11593	3586	9	11

Parameter	Distinct records	Distinct monitoring sites	Distinct countries	Distinct years
Propyzamide	11517	3831	6	5
Fenoprop	11329	3983	3	11
Lenacil	11077	2780	5	11
Hydroxyterbuthylazine	10742	2996	4	9
Desmetryn	10212	3262	3	5
Ametryn	10044	2421	7	11
Chlordane	9981	3879	6	11
Phosalone	9748	2769	5	10
Malathion	9686	3599	7	5
Delta-HCH	9445	3184	9	11
Epoxiconazole	9199	3055	5	6
Dimethachlor	9182	2461	3	5
Chlorsulfuron	8983	2208	2	6
Chlorobenzene	8830	4249	9	11
Imidacloprid	8687	2483	4	5
Carbendazim	8432	2374	4	5
Hydroxysimazine	8412	3065	3	8
Tri-allate	7886	2233	3	5
Methomyl	7805	2530	3	5
Carbetamide	7735	2599	3	5
Methiocarb	7499	2408	2	5
Sulfosulfuron	7458	2155	2	5
Epsilon-HCH	7344	1733	4	11
Terbumeton	7254	2058	3	8
Secbumeton	7150	1653	2	11
Diflufenican	7002	1886	3	5
Oxadiazon	6761	1757	2	5
Methamidophos	6694	2128	2	5
Aclonifen	6621	1915	3	5
3-hydroxycarbofuran	6556	2035	2	6
Cypermethrin	6494	2353	5	5
Quinoxyfen	6440	1860	3	5
Iodofenphos	6439	2491	2	5
Prometon	6333	1841	5	10
Dinoseb	6157	1521	3	11
Captan	5932	1776	2	5
Benfluralin	5867	1571	1	5
Bifenox	5864	1629	1	5
Permethrin-cis+trans	5836	1571	2	5
Propetamphos	5669	1907	3	5
Sebuthylazine	5604	1684	2	9
Thiamethoxam	5586	1942	3	5
Fluquinconazole	5480	1580	2	5

Parameter	Distinct records	Distinct monitoring sites	Distinct countries	Distinct years
Dicofol	5476	2054	4	5
Endosulfan	5445	2443	12	11
Desmedipham	5224	1571	2	11
Demeton-S-methyl	4972	1562	2	9
Fenazaquin	4934	1376	1	5
Hexachlorocyclohexane	4902	2524	4	8
Quintozene	4793	1473	1	5
Pyridate	4657	1626	2	10
Terbufos	4469	1544	2	5
Omethoate	4354	1509	5	7
Dichlorprop-P	3982	1461	1	5
Tebufenozide	3903	1255	1	5
Demeton-S-methylsulfon	3761	1626	2	5
Mecoprop-P (MCPP-P)	3632	1131	1	5
Trietazine	3529	1407	4	5
Ethanimidamide	3417	1188	2	5
Thiacloprid	3235	1178	2	5
Trichloroacetic acid	3227	984	3	7
Chlordecone (Kepone)	3031	1309	1	5
Chlorthiamid	3017	1140	1	5
1,4-dichlorobenzene	2752	1333	5	5
1,2-dibromoethane	2561	1490	6	11
Thiram	2410	820	1	5
Clothianidin	2363	905	2	4
Metalaxyl-M	2172	739	2	5
Mirex	1931	1030	5	10
Maleinhydrazid	1915	1039	1	5
Tetrasul	1406	459	1	4
Dalapon	1017	566	2	7
Toxaphene	697	434	1	4
Dinitro-o-cresol (DNOC)	651	651	2	2
Formaldehyde	135	70	2	4
Ziram	77	54	1	5
Bromomethane	73	73	2	2

Annex 2 Pesticide reference dataset on surface waters 2007–2017; Waterbase - Water Quality

Parameter	Distinct records	Distinct monitoring sites	Distinct countries	Distinct years
Atrazine	23027	6721	31	11
Simazine	22510	6456	28	11
Alachlor	21792	6397	29	11
Aldrin	21432	6411	27	11
Dieldrin	20999	6309	27	11
Endrin	20983	6300	27	11
DDT, p,p'	20626	6534	26	11
Chlorpyrifos	20299	5801	28	11
Trifluralin	20218	5995	28	11
1,2-dichloroethane	20032	6550	24	11
Hexachlorobenzene	19771	6161	26	11
Trichloromethane	19762	6405	23	11
Gamma-HCH (Lindane)	19620	4987	28	11
Diuron	19583	5398	27	11
Isodrin	19302	5739	24	11
Isoproturon	19171	5224	27	11
Carbon tetrachloride	19042	6194	22	11
Chlorfenvinphos	18982	5485	29	11
p,p'-DDE	18257	4920	22	11
DDT, o,p'	17716	5333	23	11
p,p'-DDD	17068	4709	23	11
Pentachlorophenol	17021	4923	23	11
Linuron	16058	3941	19	11
Alpha-Endosulfan	15083	3879	25	11
MCPA	13870	3421	20	11
Terbuthylazine	12984	4238	17	11
Alpha-HCH	12700	4053	23	11
Metolachlor	12062	3965	14	11
Beta-HCH	12036	3768	20	11
Heptachlor	11847	3743	21	11
Beta-Endosulfan	11215	3683	21	11
Mecoprop	10658	2950	15	11
Terbutryn	10566	3279	21	11
Dichlorvos	9773	2924	18	11
Desethylatrazine	9464	2706	13	11
Delta-HCH	9387	2935	17	11
Dimethoate	9344	2982	17	11
2,4-dichlorophenoxyacetic acid, 2-4 D	9330	2924	13	11

Parameter	Distinct records	Distinct monitoring sites	Distinct countries	Distinct years
Fenitrothion	9317	3371	15	11
Pendimethalin	9138	2833	9	11
Bentazone	9130	2786	15	11
Metazachlor	8823	2358	13	11
Parathion	8777	3331	10	11
Desethylterbuthylazine	8515	2662	9	11
Heptachlor epoxide	8479	2717	14	11
Parathion-methyl	8446	3112	11	11
Desisopropylatrazine	7828	2257	11	11
Metribuzin	7810	2515	11	11
Ethofumesate	7751	2351	9	11
Prometryn	7669	2379	12	11
Aclonifen	7630	2437	12	8
Dicofol	7600	2300	11	10
Acetochlor	7549	2047	4	11
Malathion	7479	3387	12	11
Propazine	7400	2703	13	11
Hexazinone	7366	2086	6	11
Metalaxyl	7304	2260	9	11
Chloridazon	7215	2393	10	11
Metamitron	7214	2154	11	11
Endosulfan	7084	3195	18	11
Dichlorprop (2,4-DP)	7083	2045	9	11
Bromacil	6986	1966	6	11
Cyanazine	6889	2008	11	11
Quinoxyfen	6782	2317	14	8
Chlortoluron	6567	2417	11	10
Dichlobenil	6512	2157	10	11
Carbofuran	6448	2095	8	11
Methoxychlor	6419	1910	11	11
2,4,5-T	6404	2111	7	11
Chlorpyrifos-methyl	6389	2157	11	11
Bromoxynil	6327	1866	5	11
Ametryn	6297	1988	9	11
Dicamba	6275	1940	10	11
Glyphosate	6257	2224	14	11
Chlorobenzene	6253	3314	12	11
Propiconazole	6226	2118	11	11
Fenpropimorph	6181	1711	8	11
Pirimicarb	5953	2180	10	11
Lenacil	5873	1749	4	11
Omethoate	5803	1935	9	11
Bifenox	5499	2044	10	7

Parameter	Distinct records	Distinct monitoring sites	Distinct countries	Distinct years
Cypermethrin	5326	1868	11	11
Hydroxyatrazine	5256	1595	2	11
Phosalone	5199	1763	4	11
Ioxynil	5122	1570	3	11
Terbumeton	5114	1493	2	10
Epoxiconazole	5069	1961	9	8
2,6-dichlorobenzamide	5056	1835	7	11
MCPB	4861	1472	9	11
Carbendazim	4769	1813	7	8
Secbumeton	4748	1305	4	11
Diazinon	4714	2328	13	11
Chlorsulfuron	4635	1363	3	11
Hydroxyterbuthylazine	4617	1544	2	9
Hexachlorocyclohexane	4583	2767	15	11
Demeton-S-methyl	4487	1450	6	11
1,4-dichlorobenzene	4478	2465	13	10
Clopyralid	4425	1634	9	11
Pyridate	4379	1614	3	11
Demeton-S-methylsulfon	4368	1358	4	11
Dimethachlor	4296	1460	5	8
Sebuthylazine	4132	1303	5	11
Epsilon-HCH	4039	1531	7	9
Prometon	3985	1354	5	11
Propyzamide	3884	2011	9	11
2,4-DB	3875	1390	5	11
Deisopropyldeethylatrazine	3811	1473	5	11
o,p'-DDE	3751	1844	14	11
Metsulfuronmethyl	3669	1285	8	8
Aminomethylphosphonic acid (AMPA)	3551	1792	9	11
Dinoseb	3507	1273	5	11
Carbetamide	3424	1430	3	5
1,2-dibromoethane	3276	1713	8	11
Hydroxysimazine	3257	1402	2	7
Desmetryn	3017	1190	5	11
Captan	2927	1538	5	10
Desmedipham	2808	1269	3	11
Chlordane	2760	1243	7	11
Propetamphos	2745	1149	2	5
Methamidophos	2605	1630	5	11
Terbufos	2456	1300	2	9
Benfluralin	2441	1273	2	7
Permethrin-cis+trans	2426	1347	7	10
Imidacloprid	2394	1465	24	8

Parameter	Distinct records	Distinct monitoring sites	Distinct countries	Distinct years
Oxadiazon	2350	1511	25	8
3-hydroxycarbofuran	2245	892	2	7
Trietazine	2130	1011	3	5
Tebufenozide	2051	1095	1	5
Quintozene	2037	1128	4	11
Methomyl	1974	1233	3	6
Dinitro-o-cresol (DNOC)	1919	1066	4	11
Chlordecone (Kepone)	1903	1060	2	11
Iodofenphos	1891	946	2	10
Fluquinconazole	1843	1140	3	7
Ethanimidamide	1709	1178	25	7
Fenazaquin	1461	861	1	5
Thiamethoxam	1449	908	26	7
Chlorthiamid	1428	864	1	5
Dichlorprop-P	1390	865	5	11
Tri-allate	1372	956	24	7
Bromoxynil octanoate	1327	859	1	5
Methiocarb	1272	894	26	8
Fenoprop	1220	786	4	11
Formaldehyde	1081	901	4	10
Mirex	1073	619	6	9
Dalapon	914	670	2	11
Thiram	863	535	2	9
Mecoprop-P (MCPP-P)	854	570	5	9
2-chloroethylphosphonic acid	814	623	2	6
Fenbutatin oxide	770	384	1	4
Maleinhydrazid	731	363	1	4
Diflufenican	719	283	6	7
Thiacloprid	669	466	26	7
Nitrophen	661	235	1	4
Metalaxyl-M	548	411	2	7
Clothianidin	536	401	25	6
Bromomethane	491	280	4	8
Ziram	269	201	1	4
Toxaphene	254	132	2	3
Isobenzane	148	127	4	8
trans-Nonachlor	75	35	2	11
Sulfosulfuron	24	8	1	4
Trichloroacetic acid	21	21	1	1
Flucythrinate	15	15	1	1
Bronopol	14	11	1	2
Tetrasul	12	12	1	1
Azinphos-ethyl	4	2	1	2

Parameter	Distinct records	Distinct monitoring sites	Distinct countries	Distinct years
Chlorothalonil	4	2	1	2
Deltamethrin	4	2	1	2
Fenthion	4	2	1	2
Formothion	4	2	1	2
Folpet	4	2	1	2
Iprodione	4	2	1	2
Kresoxim-methyl	4	2	1	2
Penconazole	4	2	1	2
Acrylonitrile	3	1	1	3
Hydrogen cyanide	2	2	1	1
Dimethomorph	1	1	1	1
Cyprodinil	1	1	1	1
Pyrimethanil	1	1	1	1

Annex 3 List of pesticides data availability based on Waterbase – Water Quality in the time period 2007 to 2017.

MS	Area (ha)	Area arable land (ha)	Data source	ratio arable land (%)	No. GW-sites	No. SW-sites	GW density/ ha	SW density /ha	No. GW-pollu-tants	No. SW-pollu-tants
AT	83858	13123	corine	15,6	2040	19	15,5	0,1	9	11
BA	51209	5940	eurostat	11,6	33	30	0,6	0,5	5	25
BE	32545	6672	corine	20,5	404	104	6,1	1,6	78	48
BG	110912	38222	corine	34,5	128	86	0,3	0,2	42	42
CH	41284	4002	eurostat	9,7	50	6	1,2	0,1	28	22
CY	9251	2272	corine	24,6	171	61	7,5	2,7	43	75
CZ	78866	28709	corine	36,4	736	404	2,6	1,4	86	129
DE	357022	135835	corine	38,0	1039	268	0,8	0,2	75	109
DK	43094	26852	corine	62,3	1607	32	6,0	0,1	35	8
EE	45100	6882	corine	15,3	153	34	2,2	0,5	14	87
GR	131957	18978	eurostat	14,4	0	260	0,0	1,4	0	45
ES	505992	98140	corine	19,4	594	1329	0,6	1,4	84	71
FI	338145	16768	corine	5,0	0	27	0,0	0,2	0	99
FR	551500	153839	corine	27,9	1963	1763	1,3	1,1	156	163
HR	56538	6104	corine	10,8	82	65	1,3	1,1	45	67
HU	93032	47092	corine	50,6	0	105	0,0	0,2	0	17
IE	70273	4603	eurostat	6,6	414	332	9,0	7,2	61	53
IS	103000	19	eurostat	0,0	8	1	41,9	5,2	2	41
IT	301318	79515	corine	26,4		1739	0,0	2,2	0	114
LT	65300	21015	eurostat	32,2	44	63	0,2	0,3	29	43
LU	2586	443	corine	17,1		4	0,0	0,9	0	58
LV	64600	12054	corine	18,7	117	23	1,0	0,2	7	34
MK	25713	4167	eurostat	16,2		5	0,0	0,1	0	1
MT	316	7	corine	2,1		6	0,0	89,1	0	20
NL	41528	7327	corine	17,6		125	0,0	1,7	0	101
NO	385155	8072	eurostat	2,1		12	0,0	0,1	0	1
PL	312685	133403	corine	42,7	449	1310	0,3	1,0	21	34
PT	91982	6849	corine	7,4	206	59	3,0	0,9	16	25
RO	238391	86008	corine	36,1	148	74	0,2	0,1	15	28
RS	77474	25950	eurostat	33,5	138	189	0,5	0,7	37	37
SE	449964	30040	corine	6,7	101	24	0,3	0,1	2	66
SI	20256	1744	eurostat	8,6	55	33	3,2	1,9	35	45
SK	49033	15861	corine	32,3	533	79	3,4	0,5	53	61
UK	242900	60890	eurostat	25,1	4158	1030	6,8	1,7	102	109

Data source: Corine land cover: https://land.copernicus.eu/eagle/files/eagle-related-projects/pt_clc-conversion-to-fao-lccs3_dec2010); Eurostat: https://ec.europa.eu/eurostat/web/products-datasets/-/tag00025

Annex 4 Overview of databases according to pesticides from EU countries

Country	Link to database
Austria	https://psmregister.baes.gv.at/psmregister/faces/main?_afrLoop=695602457331339&_afrWindowMode=0&_adf.ctrl-state=rqaph0bok_14
Croatia	https://fis.mps.hr/TrazilicaSZB/Default.aspx?lan=en-Us
Denmark	https://middeldatabasen.dk/positiveList.asp
Estonia	https://portaal.agri.ee/avalik/#/taimekaitse/taimekaitsevahendid-otsing/en
France	https://ephy.anses.fr/resultats_recherche/substance
France	http://www.agritox.anses.fr/php/donnees-essentielles.php
Georgia	List of pesticides registered in Georgia
Germany	https://apps2.bvl.bund.de/psm/jsp/index.jsp?modul=form
Greece	http://wwww.minagric.gr/syspest/syspest_bycat_byActive_eng.aspx
Hungary	https://novenyvedoszer.nebih.gov.hu/Engedelykereso/kereso
Ireland	http://www.pcs.agriculture.gov.ie/products/
Italy	http://www.fitosanitari.salute.gov.it/fitosanitariwsWeb_new/FitosanitariServlet
Lithuania	http://195.182.68.150:8080/vaat/aap/aap/aap_list.jsf
Luxembourg	https://saturn.etat.lu/tapes/tapes_de_mnu_pdt.htm
Moldova	http://www.pesticide.md/registrul-de-stat/
Netherlands	https://pesticidesdatabase.ctgb.nl/nl/authorisations
Norway	https://www.mattilsynet.no/plantevernmidler/godk.asp?sortering=preparat&preparat=Alle&sprak=In+English
Poland	https://www.gov.pl/attachment/e79ce4f1-af75-495b-bad8-3834b0bcb25f
Slovakia	http://pripravky.uksup.sk/pripravok/search
Slovenia	http://spletni2.furs.gov.si/FFS/REGSR/EN/index.htm
Sweden	http://webapps.kemi.se/BkmRegistret/Kemi.Spider.Web.External/Produkt#8bcf2b59-bd6f-4128-a945-b69e22cd7b04
Switzerland	https://www.psm.admin.ch/fr/produkte/bs/A
Turkey	https://bku.tarim.gov.tr/Kullanim/TavsiyeArama
Ukraine	https://agroscience.com.ua/views/perelik-pest-all
United Kingdom	https://secure.pesticides.gov.uk/pestreg/ProdSearch.asp

Source: https://www.eppo.int/ACTIVITIES/plant_protection_products/registered_products

Annex 5 Overview of pesticides available under Waterbase – Water Quality – characteristics and grouping

Label	CAS	Usage	Chemical group	Parent (P) or Transformation Product (TP)	Mode of Action (MoA)	Mode of Action – specific	PPP-approval; Yes; No
1,2-dibromoethane	106-93-4	Insecticide	Unclassified	P	Neurotoxic	CNS toxicity	N
1,2-dichloroethane	107-06-2	Insecticide	Chlorinated hydrocarbon	P	Unknown		N
1,3-dichloropropene	542-75-6	Pesticide	Halogenated hydrocarbon	P	Unknown		N
1,4-dichlorobenzene	106-46-7	Pesticide / Desinfectant		P	not found in database		N
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)	93-76-5	Herbicide		P	Plant Growth Regulator	Ethylene generator	Y
2,4-DB	94-82-6	Herbicide	Aryloxyalkanoic acid	P	Synthetic Auxin (Plant growth regulator)		Y
2,4-dichlorophenoxyacetic acid, 2-4 D	94-75-7	Herbicide		P	Synthetic Auxin (Plant growth regulator)		Y
2,6-dichlorobenzamide	2008-58-4	Herbicide	Chlorophenoxy acid	P	Synthetic Auxin (Plant growth regulator)		N
2-chloroethylphosphonic acid (Ethephon)	16672-87-0	Herbicide	Substituted benzene	TP	Unknown	Not applicable	
3-hydroxycarbofuran	16655-82-6	Metabolite	Unclassified	TP	Unknown		
Acetochlor	34256-82-1	Herbicide	Chloroacetamide	P	Mitosis, Cell cycle, cell wall synthesis	Inhibition of VLCFA (inhibition of cell division)	N
Aclonifen	74070-46-5	Herbicide	Diphenyl ether	P	Carotenoid biosynthesis inhibition		Y
Acrylonitrile	107-13-1	Insecticide	Unclassified	P	Respiratory action		N
Alachlor	15972-60-8	Herbicide	Chloroacetamide	P	Mitosis, Cell cycle, cell wall synthesis	Inhibition of VLCFA (inhibition of cell division)	N
Aldrin	309-00-2	Insecticide	Organochlorine	P	Neurotoxic	GABA antagonist	N
Alpha-Endosulfan	959-98-8	Insecticide	Organochlorine	P	Neurotoxic	GABA antagonist	
Alpha-HCH	319-84-6	Insecticide	Organochlorine	P	not applicable	Not applicable	

Label	CAS	Usage	Chemical group	Parent (P) or Transformation Product (TP)	Mode of Action (MoA)	Mode of Action – specific	PPP-approval; Yes; No
Ametryn	834-12-8	Herbicide	Triazine	P	Photosynthesis inhibition	Photosystem II	N
Aminomethylphosphonic acid (AMPA)	1066-51-9	Metabolite		TP	unknown		
Atrazine	1912-24-9	Herbicide	Triazine	P	Photosynthesis inhibition	Photosystem II	N
Azinphos-ethyl	2642-71-9	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Benfluralin	1861-40-1	Herbicide	Dinitroaniline	P	Mitosis, Cell cycle, cell wall synthesis	Microtubule assembly inhibition	Y
Bentazone	25057-89-0	Herbicide	Benzothiazinone	P	Photosynthesis inhibition	Photosystem II	Y
Beta-Endosulfan	33213-65-9	Insecticide	Organochlorine	P	Neurotoxic	GABA antagonist	
Beta-HCH	319-85-7	Insecticide		P	Neurotoxic		
Bifenox	42576-02-3	Herbicide	Diphenyl ether	P	Photosynthesis inhibition	Protoporphyrinogen oxidase (PPO) inhibition	Y
Bromacil	314-40-9	Herbicide	Uracil	P	Photosynthesis inhibition	Photosystem II	N
Bromomethane	74-83-9	Insecticide	Inorganic compound	P	Respiratory action	Respiratory action	N
Bromoxynil	1689-84-5	Herbicide	Hydroxybenzonitrile	P & TP	Photosynthesis inhibition	Photosystem II	Y
Bromoxynil octanoate	1689-99-2	Herbicide	Hydroxybenzonitrile	P	Photosynthesis inhibition		Y
Bronopol	52-51-7	Fungicide		P	Cell membrane disruption	Inhibition of dehydrogenase activity causes membrane damage	N
Captan	133-06-2	Fungicide	Thiophthalimide	P	Multi-site activity	Non-systemic with protective And curative action. Multi-site activity	Y
Carbendazim	10605-21-7	Fungicide / Metabolite	Benzimidazoles	P & TP	Mitosis, Cell cycle, cell wall synthesis	Beta-tubulin assembly inhibition	N
Carbetamide	16118-49-3	Herbicide	Amide	P	Neurotoxic	AChE inhibition	Y
Carbofuran	1563-66-2	Insecticide	N-Methyl Carbamate	P	Neurotoxic	AChE inhibition	N
Carbon tetrachloride	56-23-5	Insecticide	Organochlorine	P	Neurotoxic		N
Chlordane	57-74-9	Insecticide	Organochlorine	P	Neurotoxic	GABA antagonist	N

Label	CAS	Usage	Chemical group	Parent (P) or Transformation Product (TP)	Mode of Action (MoA)	Mode of Action – specific	PPP-approval; Yes; No
Chlordecone (Kepone)	143-50-0	Insecticide	Organochlorine	P	Neurotoxic	GABA antagonist	N
Chlorfenvinphos	470-90-6	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Chloridazon	1698-60-8	Herbicide	Pyridazinone	P	Photosynthesis inhibition	Photosystem II	N
Chlorobenzene	108-90-7	Industrial chemical/Synthese product	Organochlorine	not applicable	unknown		N
Chlorothalonil	1897-45-6	Fungicide	Chloronitrile	P	Multi-site activity	Spore germination, zoospore motility	Y
Chlorpyrifos	2921-88-2	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	Y
Chlorpyrifos-methyl	5598-13-0	Insecticide	organophosphate	TP	Neurotoxic	AChE inhibition	Y
Chlorsulfuron	64902-72-3	Herbicide	Sulfonylurea	P	Mitosis, Cell cycle, cell wall synthesis		Y
Chlorthiamid	1918-13-4	Herbicide	Benzonitrile	P	Mitosis, Cell cycle, cell wall synthesis		N
Chlortoluron	15545-48-9	Herbicide	Phenylurea	P	Photosynthesis inhibition	Photosystem II	Y
Clopyralid	1702-17-6	Herbicide	Pyridinecarboxylic acid	P	Synthetic Auxin (Plant growth regulator)		Y
Clothianidin	210880-92-5	Insecticide	Neonicotinoid	P & TP	Neurotoxic	nAChR receptor agonist	N
Cyanazine	21725-46-2	Herbicide	Triazine	P	Photosynthesis inhibition	Photosystem II	N
Cypermethrin	52315-07-8	Insecticide	Pyrethroid	P	Ion channel blocker/modulator	Sodium channel modulation	Y
Cyprodinil	121552-61-2	Fungicide	Pyrimidine	P	Protein biosynthesis inhibition	methionine biosynthesis (proposed)	Y
Dalapon	75-99-0	Herbicide	Organochlorine	P	Plant Growth Regulator		
DDT, o,p'	789-02-6	Insecticide	Organochlorine	P	Neurotoxic	GABA antagonist	
DDT, p,p'	50-29-3	Insecticide	Organochlorine	P	Neurotoxic	GABA antagonist	N
Deisopropyldeethylatrazine	3397-62-4	Herbicide		TP			
Delta-HCH	319-86-8	Insecticide	Organochlorine	TP/ isomer			
Deltamethrin	52918-63-5	Insecticide	Pyrethroid	P & TP	Neurotoxic	Sodium channel modulation	Y
Demeton-S-methyl	919-86-8	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N

Label	CAS	Usage	Chemical group	Parent (P) or Transformation Product (TP)	Mode of Action (MoA)	Mode of Action – specific	PPP-approval; Yes; No
Demeton-S-methylsulfon	17040-19-6	Insecticide	organophosphate	P & TP	Neurotoxic	AChE inhibition	N
Desethylatrazine	6190-65-4	Metabolite (Herbicide)	Triazine	TP			
Desethylterbuthylazine	30125-63-4	Metabolite (Herbicide)	Triazine	TP			
Desisopropylatrazine	1007-28-9	Herbicide	Triazine	TP			
Desmedipham	13684-56-5	Herbicide	Carbamate	P	Photosynthesis inhibition		Y
Desmetryn	1014-69-3	Herbicide	Triazine	P	Photosynthesis inhibition		N
Diazinon	333-41-5	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Dicamba	1918-00-9	Herbicide	Benzoic acid	P	Synthetic Auxin (Plant growth regulator)		Y
Dichlobenil	1194-65-6	Herbicide	Benzonitrile	P	Mitosis, Cell cycle, cell wall synthesis	Cell wall biosynthesis	N
Dichlorprop (2,4-DP)	120-36-5	Herbicide	Chlorophenoxy Acid or Ester	P	Synthetic Auxin (Plant growth regulator)		N
Dichlorprop-P	15165-67-0	Herbicide	Aryloxyalkanoic acid	P	Synthetic Auxin (Plant growth regulator)		Y
Dichlorvos	62-73-7	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Dicofol	115-32-2	Insecticide	Organochlorine	P	Neurotoxic		N
Dieldrin	60-57-1	Insecticide	Organochlorine	P & TP	Neurotoxic	GABA antagonist	N
Diflufenican	83164-33-4	Herbicide	Carboxamide	P	Carotenoid biosynthesis inhibition		Y
Dimethachlor	50563-36-5	Herbicide	Chloroacetamide	P	Mitosis, Cell cycle, cell wall synthesis		Y
Dimethoate	60-51-5	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	Y
Dimethomorph	110488-70-5	Fungicide	Morpholine	P	Lipid metabolism	Fatty acid biosynthesis inhibition	Y
Dinitro-o-cresol (DNOC)	534-52-1	Insecticide		P			N
Dinoseb	88-85-7	Herbicide	Dinitrophenol derivative	P	Respiratory action	membrane disruption	N
Diuron	330-54-1	Herbicide	Phenylurea	P	Photosynthesis inhibition	Photosystem II	Y
Endosulfan	115-29-7	Insecticide	Organochlorine	P			N

Label	CAS	Usage	Chemical group	Parent (P) or Transformation Product (TP)	Mode of Action (MoA)	Mode of Action – specific	PPP-approval; Yes; No
Endrin	72-20-8	Insecticide	Organochlorine	P	Neurotoxic	Chloride channel blocking	N
Epoxiconazole	133855-98-8	Fungicide	Triazole		Sterol biosynthesis inhibition		Y
Epsilon-HCH	6108-10-7	Insecticide		TP/ isomer			
Ethanimidamide (Acetamipride)	135410-20-7	Insecticide	Neonicotinoid		Neurotoxic	Acetylcholine receptor (nAChR) agonist	Y
Ethion	563-12-2	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Ethofumesate	26225-79-6	Herbicide	Benzofuran	P	Lipid metabolism	Fatty acid biosynthesis inhibition	Y
Fenazaquin	120928-09-8	Insecticide	Quinazoline	P	Respiratory action		Y
Fenbutatin oxide	13356-08-6	Insecticide	Organometal		Respiratory action		N
Fenitrothion	122-14-5	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Fenoprop	93-72-1	Herbicide		P	Synthetic Auxin (Plant growth regulator)	Synthetic auxin affecting nucleic acid biosynthesis and cell elongation	N
Fenpropimorph	67564-91-4	Fungicide	Morpholine		Cell membrane disruption		Y
Fenthion	55-38-9	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Flucythrinate	70124-77-5	Insecticide	Pyrethroid	P	Neurotoxic	Ion channel blocker/modulator	N
Fluquinconazole	136426-54-5	Fungicide	Triazole	P	Sterol biosynthesis inhibition		Y
Folpet	133-07-3	Fungicide	Phthalimide	P	Mitosis, Cell cycle, cell wall synthesis		Y
Formaldehyde	50-00-0	Pesticide	Unclassified	P & TP	Protein denaturation		N
Formothion	2540-82-1	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Gamma-HCH (Lindane)	58-89-9	Insecticide	Organochlorine	P	Ion channel blocker/modulator	GABA antagonist	N
Glyphosate	1071-83-6	Herbicide	Phosphonoglycine	P	Protein biosynthesis inhibitor	EPSP synthase inhibition	Y
Heptachlor	76-44-8	Insecticide	Organochlorine	P	Ion channel blocker/modulator		N
Heptachlor epoxide	1024-57-3	Metabolite (Insecticide)	Organochlorine	TP			
Hexachlorobenzene	118-74-1	Fungicide		P & TP	Fungal spore inhibitor		N

Label	CAS	Usage	Chemical group	Parent (P) or Transformation Product (TP)	Mode of Action (MoA)	Mode of Action – specific	PPP-approval; Yes; No
Hexachlorocyclohexane	608-73-1	Insecticide	Organochlorine	P	Ion channel blocker/modulator	GABA antagonist	N
Hexazinone	51235-04-2	Herbicide	Triazinone	P	Photosynthesis inhibition	Photosystem II	N
Hydrogen cyanide	74-90-8	Pesticide	Unclassified	P			N
Hydroxyatrazine	2163-68-0	Herbicide		TP			
Hydroxysimazine	2599-11-3	Herbicide		TP			
Hydroxyterbuthylazine	66753-07-9	Herbicide		TP (from terbuthylazine)			
Imidacloprid	138261-41-3	Insecticide	Neonicotinoid	P	Neurotoxic	nAChR receptor agonist	Y
Iodofenphos	18181-70-9	Insecticide	organophosphate	P			N
Ioxynil	1689-83-4	Herbicide	Hydroxybenzonitrile	P & TP	Photosynthesis inhibition	Photosystem II	N
Iprodione	36734-19-7	Fungicide	Dicarboximide	P	Signal transduction	Signal transduction inhibitor	N
Isobenzane	297-78-9	Insecticide	Organochlorine	P	Ion channel blocker/modulator	GABA antagonist	N
Isodrin	465-73-6	Insecticide	Organochlorine	P			N
Isoproturon	34123-59-6	Herbicide		P	Photosynthesis inhibition	Photosystem II	N
Kresoxim-methyl	143390-89-0	Fungicide	Strobilurin /Strobin	P	Respiratory action	QoL fungicide	Y
Lenacil	2164-08-1	Herbicide	Uracil	P	Photosynthesis inhibition	Photosystem II	Y
Linuron	330-55-2	Herbicide	Urea	P	Photosynthesis inhibition	Photosystem II	N
Malathion	121-75-5	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	Y
Maleinhydrazid	123-33-1	Herbicide	Pyridazine	P			Y
MCPA	94-74-6	Herbicide		P			Y
MCPB	94-81-5	Herbicide		P			Y
Mecoprop	7085-19-0	Herbicide	Aryloxyalkanoic acid	P			N
Mecoprop-P (MCPP-P)	16484-77-8	Herbicide	Aryloxyalkanoic acid	P	Synthetic Auxin (Plant growth regulator)		Y
Metalaxyl	57837-19-1	Fungicide	Phenylamide	P	Synthetic Auxin (Plant growth regulator)		Y

Label	CAS	Usage	Chemical group	Parent (P) or Transformation Product (TP)	Mode of Action (MoA)	Mode of Action – specific	PPP-approval; Yes; No
Metalaxyl-M	70630-17-0	Fungicide	Phenylamide	P	Synthetic Auxin (Plant growth regulator)		Y
Metamitron	41394-05-2	Herbicide	Triazinone	P	Photosynthesis inhibition	Photosystem II	Y
Metazachlor	67129-08-2	Herbicide	Chloroacetamide	P	Mitosis, Cell cycle, cell wall synthesis	Ergosterol inhibitor	Y
Methamidophos	10265-92-6	Insecticide	organophosphate	P & TP	Neurotoxic	AChE inhibition	N
Methidathion	950-37-8	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Methiocarb	2032-65-7	Insecticide	Carbamate	P	Neurotoxic	AChE inhibition	Y
Methomyl	16752-77-5	Insecticide	Carbamate	P	Neurotoxic	AChE inhibition	Y
Methoxychlor	72-43-5	Insecticide	Organochlorine	P	Neurotoxic	AChE inhibition	N
Metolachlor	51218-45-2	Herbicide	Chloroacetamide	P	Neurotoxic	AChE inhibition	N
Metribuzin	21087-64-9	Herbicide	Triazinone	P	Photosynthesis inhibition	Photosystem II	Y
Metsulfuronmethyl	74223-64-6	Herbicide	Triazinone	P	Mitosis, Cell cycle	Gibberellin pathway	Y
Mirex	2385-85-5	Insecticide	Organochlorine	P	Photosynthesis inhibition	Photosystem II	
Molinate	2212-67-1	Herbicide	ThioCarbamate	P	Mitosis, Cell Cycle		N
Nitrophen	1836-75-5	Herbicide	Diphenyl ether	P			N
o,p'-DDE	3424-82-6	Pesticide	Organochlorine	P & TP	Lipid metabolism		
Omethoate	1113-02-6	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Oxadiazon	19666-30-9	Herbicide	Oxidiazole	P			N
p,p'-DDD	72-54-8	Insecticide	Organochlorine	P & TP	Neurotoxic	AChE inhibition	N
p,p'-DDE	72-55-9	Insecticide	Organochlorine	P & TP			
Parathion	56-38-2	Insecticide	organophosphate	P			N
Parathion-methyl	298-00-0	Insecticide	organophosphate	TP			N
Penconazole	66246-88-6	Fungicide	triazole	P		Ergosterol inhibitor	Y
Pendimethalin	40487-42-1	Herbicide	Dinitroaniline	P	Mitosis, Cell cycle, cell wall synthesis	Inhibition of mitosis and cell division. Microtubule assembly inhibition.	Y
Pentachlorophenol	87-86-5	Pesticide	Organochlorine	P	Sterol biosynthesis inhibition		N

Label	CAS	Usage	Chemical group	Parent (P) or Transformation Product (TP)	Mode of Action (MoA)	Mode of Action – specific	PPP-approval; Yes; No
Permethrin-cis+trans	52645-53-1	Insecticide	Pyrethroid	P	Mitosis, Cell cycle	Microtubule assembly inhibition	N
Phosalone	2310-17-0	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Pirimicarb	23103-98-2	Insecticide	Carbamate	P	Neurotoxic	AChE inhibition	Y
Procymidone	32809-16-8	Fungicide	Dicarboximide	P		Signal transduction inhibitor/modulator	N
Prometon	1610-18-0	Herbicide	Methoxytriazine	P	Photosynthesis inhibition	Photosystem II	
Prometryn	7287-19-6	Herbicide	Triazine	P			N
Propazine	139-40-2	Herbicide	Triazine	P			N
Propetamphos	31218-83-4	Insecticide	organophosphate	P	Photosynthesis inhibition	Photosystem II	N
Propiconazole	60207-90-1	Fungicide	triazole	P	Sterol biosynthesis inhibition	Ergosterol inhibitor	N
Propyzamide	23950-58-5	Herbicide	Benzamide	P	Mitosis, Cell cycle, cell wall synthesis		Y
Pyridate	55512-33-9	Herbicide	Phenylpyridazine	P	Photosynthesis inhibition	Photosystem II	Y
Pyrimethanil	53112-28-0	Fungicide	Anilinopyrimidine	P	Mitosis, Cell cycle, cell wall synthesis	Microtubule assembly inhibition	Y
Quinoxyfen	124495-18-7	Fungicide	Quinoline	P	Photosynthesis inhibition	Photosystem II	N
Quintozene	82-68-8	Fungicide	Chlorophenyl	P	Lipid metabolism	Lipid peroxidation inhibitor	N
Sebuthylazine	7286-69-3	Herbicide	Triazine	P	Signal transduction	G-Proteins	N
Secbumeton	26259-45-0	Herbicide	Methoxytriazine	P			N
Simazine	122-34-9	Herbicide	Triazine	P			N
Sulfosulfuron	141776-32-1	Herbicide	Sulfonylurea	P			Y
Tebuconazole	107534-96-3	Fungicide	Triazole	P	Sterol biosynthesis inhibition		Y
Tebufenozide	112410-23-8	Insecticide	Diacylhydrazine	P	Protein biosynthesis inhibition	Acetolactate synthase (ALS) inhibition	Y
Terbufos	13071-79-9	Insecticide	organophosphate	P	Neurotoxic	AChE inhibition	N
Terbumeton	33693-04-8	Herbicide	Triazine	P	Photosynthesis inhibition	Photosystem II	N
Terbuthylazine	5915-41-3	Herbicide	Triazine	P	Photosynthesis inhibition	Photosystem II	Y
Terbutryn	886-50-0	Herbicide	Triazine	P	Photosynthesis inhibition	Photosystem II	N

Label	CAS	Usage	Chemical group	Parent (P) or Transformation Product (TP)	Mode of Action (MoA)	Mode of Action – specific	PPP-approval; Yes; No
Tetrasul	2227-13-6	Insecticide	bridged diphenyl	P	Photosynthesis inhibition	Photosystem II	N
Thiacloprid	111988-49-9	Insecticide	Neonicotinoid	P	Neurotoxic	nAChR receptor agonist	Y
Thiamethoxam	153719-23-4	Insecticide	Neonicotinoid	P	Neurotoxic	nAChR receptor agonist	Y
Thiram	137-26-8	Fungicide	Carbamate	P & TP			Y
Toxaphene	8001-35-2	Insecticide	Chlorinated hydrocarbon	P	Neurotoxic		N
trans-Nonachlor	39765-80-5	Insecticide	Organochlorine	P			
Tri-allate	2303-17-5	Herbicide	ThioCarbamate	P			Y
Trichloroacetic acid	76-03-9	Metabolite	Haloacetic acid	TP			N
Trietazine	1912-26-1	Herbicide	Triazine	P	Photosynthesis inhibition	Photosystem II	N
Trifluralin	1582-09-8	Herbicide	Dinitroaniline	P	Mitosis, Cell cycle, cell wall synthesis	Microtubule assembly inhibition	N
Ziram	137-30-4	Fungicide	Carbamate	P	Multi-site activity		Y

Annex 6 Overview of pesticides available under Waterbase – Water Quality – thresholds

Label	CAS	approved till	AA-EQS [µg/l]	MAC-EQS [µg/l]	List (PS, WL)	AA-EQS regulated in MS (No)	Lowest AA-EQS regulated in MS [µg/l]	MS with lowest AA-EQS	MAC-EQS regulated in MS (No)	Lowest MAC-EQS regulated in MS [µg/l]	MS with lowest MAC-EQS
1,2-dibromoethane	106-93-4		2.0	500		1	2	DE	1	500	BE
1,2-dichloroethane	107-06-2										
1,3-dichloropropene	542-75-6		2.0			2	2	BE			
1,4-dichlorobenzene	106-46-7	31.12.2004	1.0	70		7	1	BE	1	70	BE
2,4,5-T (2,4,5- Trichloro-phenoxyacetic acid)	93-76-5	31.12.2003				3	0.1	DE	1	20	BE
2,4-DB	94-82-6	31.10.2032									
2,4-dichlorophenoxyacetic acid, 2-4 D	94-75-7	31.12.2030	0.1			8	0.1	CZ, DE	2	1	DE
2,6-dichlorobenzamide	2008-58-4		0.1			2	0.1	IT			
2-chloroethylphosphonic acid (Ethephon)	16672-87-0	31.07.2020									
3-hydroxycarbofuran	16655-82-6										
Acetochlor	34256-82-1					1	0.1	IT			
Aclonifen	74070-46-5	31.07.2022	0.12	0.12	PS						
Acrylonitrile	107-13-1										
Alachlor	15972-60-8	18.06.2007	0.3	0.7	PS						
Aldrin	309-00-2	29.04.2004	0.1		PS						
Alpha-Endosulfan	959-98-8		0.005	0.005		2	0.005	ES	1	0.005	ES
Alpha-HCH	319-84-6		0.1			1	0.1	IT			
Ametryn	834-12-8	31.12.2003	0.1			3	0.1	BG, IT			
Aminomethylphosphonic acid (AMPA)	1066-51-9		0.1			2	0.1	IT			
Arsenic and its compounds	7440-38-2					21					

Label	CAS	approved till	AA-EQS [µg/l]	MAC-EQS [µg/l]	List (PS, WL)	AA-EQS regulated in MS (No)	Lowest AA-EQS regulated in MS [µg/l]	MS with lowest AA-EQS	MAC-EQS regulated in MS (No)	Lowest MAC-EQS regulated in MS [µg/l]	MS with lowest MAC-EQS
Atrazine	1912-24-9	31.12.2007	0.6	2	PS						
Azinphos-ethyl	2642-71-9					1	0.01	DE			
Benfluralin	1861-40-1	29.02.2020	0.1			1	0.1	IT			
Bentazone	25057-89-0	31.05.2025	0.1	100		10	0.1	DE, LU	4	100	PT
Beta-Endosulfan	33213-65-9										
Beta-HCH	319-85-7										
Bifenox	42576-02-3	31.12.2019	0.012	0.04	PS						
Bromacil	314-40-9					1	0.6	DE			
Bromomethane	74-83-9										
Bromoxynil	1689-84-5	31.07.2020	0.5			1	0.5	DE			
Bromoxynil octanoate	1689-99-2	31.07.2020									
Bronopol	52-51-7		0.7			2	0.7	SE			
Captan	133-06-2	31.07.2020	0.1	0.34		2	0.1	IT	1	0.34	NL
Carbendazim	10605-21-7	30.11.2014	0.15	0.6		3	0.15	UK	2	0.6	NL
Carbetamide	16118-49-3	31.05.2021									
Carbofuran	1563-66-2		0.1			1	0.1	IT			
Carbon tetrachloride	56-23-5										
Chlordane	57-74-9	29.04.2004	0.002		POP	4	0.002	AT, BE, LU			
Chlordecone (Kepone)	143-50-0		0.1			1	0.1	FR			
Chlorfenvinphos	470-90-6	31.12.2003	0.1	0.3	PS						
Chloridazon	1698-60-8	31.12.2018	0.1	20		5	0.1	DE, IT	2	20	BE
Chlorothalonil	1897-45-6	20.05.2019									
Chlorpyrifos	2921-88-2	31.01.2020	0.03	0.1	PS						
Chlorpyrifos-methyl	5598-13-0	31.01.2020	0.03			2	0.03	ES			
Chlorsulfuron	64902-72-3	31.12.2019									

Label	CAS	approved till	AA-EQS [µg/l]	MAC-EQS [µg/l]	List (PS, WL)	AA-EQS regulated in MS (No)	Lowest AA-EQS regulated in MS [µg/l]	MS with lowest AA-EQS	MAC-EQS regulated in MS (No)	Lowest MAC-EQS regulated in MS [µg/l]	MS with lowest MAC-EQS
Chlorthiamid	1918-13-4										
Chlortoluron	15545-48-9	31.10.2019	0.4	0.8		7	0.4	NL	2	0.8	SI
Clopyralid	1702-17-6	30.04.2020	70	300		1	70	SK	1	300	SK
Clothianidin	210880-92-5	31.01.2019	0.0083		WL-1,2						
Cyanazine	21725-46-2		0.1			1	0.1	IT			
Cypermethrin	52315-07-8	31.10.2019	0.00008	0.0006	PS						
Cyprodinil	121552-61-2	30.04.2020									
Dalapon	75-99-0										
DDT, o,p'	789-02-6	29.04.2004	0.025		PS						
DDT, p,p'	50-29-3	29.04.2004	0.01		PS						
Deisopropyldeethylatrazine	3397-62-4										
Delta-HCH	319-86-8										
Deltamethrin	52918-63-5	31.10.2019									
Demeton-S-methyl	919-86-8		0.1			1	0.1	DE			
Demeton-S-methylsulfon	17040-19-6		0.1			1	0.1	DE			
Desethylatrazine	6190-65-4		0.1			4	0,1	IT			
Desethylterbuthylazine	30125-63-4		0.1	0.1		3	0,1	IT. PT	1	0,1	PT
Desisopropylatrazine	1007-28-9										
Desmedipham	13684-56-5	31.07.2020	1	15		1	1	SK	1	15	SK
Desmetryn	1014-69-3										
Diazinon	333-41-5		0.1			1	0.1	IT			
Dicamba	1918-00-9	31.12.2019	0.1				0.1	IT			
Dichlobenil	1194-65-6										
Dichlorprop (2,4-DP)	120-36-5	31.12.2003	0.1	200		3	0.1	CZ, DE	1	200	BE
Dichlorprop-P	15165-67-0	30.04.2020	1.0	7.6		2	1	NL	1	7.6	NL

Label	CAS	approved till	AA-EQS [µg/l]	MAC-EQS [µg/l]	List (PS, WL)	AA-EQS regulated in MS (No)	Lowest AA-EQS regulated in MS [µg/l]	MS with lowest AA-EQS	MAC-EQS regulated in MS (No)	Lowest MAC-EQS regulated in MS [µg/l]	MS with lowest MAC-EQS
Dichlorvos	62-73-7	06.12.2008	0.0006	0.0007	PS						
Dicofol	115-32-2	30.03.2010	0.0013		PS						
Dieldrin	60-57-1	29.04.2004	0.1		PS						
Diflufenican	83164-33-4	31.12.2019	0.009			2	0.009	DE			
Dimethachlor	50563-36-5	31.12.2021	0.09			1	0.09	Cz			
Dimethoate	60-51-5	31.07.2020	0.02	0.2		7	0.02	BE	3	0.2	BE
Dimethomorph	110488-70-5	31.07.2020									
Dinitro-o-cresol (DNOC)	534-52-1										
Dinoseb	88-85-7										
Diuron	330-54-1	30.09.2020	0.2	1.8	PS						
Endosulfan	115-29-7	02.06.2007	0.005	0.01	PS						
Endrin	72-20-8	29.04.2004	0.1		PS						
Epoxiconazole	133855-98-8	30.04.2020	0.1			2	0.1	IT			
Epsilon-HCH	6108-10-7										
Ethanimidamide (Acetamipride)	135410-20-7	28.02.2033	0.1			1	0.1	IT			
Ethion	563-12-2										
Ethofumesate	26225-79-6	31.10.2031	0.1	50		2	0.1	IT	1	50	SK
Fenazaquin	120928-09-8	31.05.2023									
Fenbutatin oxide	13356-08-6										
Fenitrothion	122-14-5	25.11.2008	0.0009	0.002		6	0.0009	BE	1	0.002	BE
Fenoprop	93-72-1										
Fenpropimorph	67564-91-4	30.04.2019	0.02	20		1	0.02	DE	1	20	DE
Fenthion	55-38-9		0.004			1	0.004				
Flucythrinate	70124-77-5										
Fluquinconazole	136426-54-5	31.12.2021									

Label	CAS	approved till	AA-EQS [µg/l]	MAC-EQS [µg/l]	List (PS, WL)	AA-EQS regulated in MS (No)	Lowest AA-EQS regulated in MS [µg/l]	MS with lowest AA-EQS	MAC-EQS regulated in MS (No)	Lowest MAC-EQS regulated in MS [µg/l]	MS with lowest MAC-EQS
Folpet	133-07-3	31.07.2020									
Formaldehyde	50-00-0	31.12.2003	5.0	50		3	5	SK	2	50	SK
Formothion	2540-82-1										
Gamma-HCH (Lindane)	58-89-9	20.12.2002	0.01		PS	2	0.01	CZ			
Glyphosate	1071-83-6	15.12.2022	0.1	197		6	0.1	IT	1	197	SI
Heptachlor	76-44-8	29.04.2004	0.0000007	0.0003	PS						
Heptachlor epoxide	1024-57-3	29.04.2004	0.0002	0.3		3	0.0002	ES	1	0.3	ES
Hexachlorobenzene	118-74-1	29.04.2004		0.05	PS						
Hexachlorocyclohexane	608-73-1	29.04.2004	0.02	0.04	PS						
Hexazinone	51235-04-2		0.048			2	0.048	CZ			
Hydrogen cyanide	74-90-8					2	1	BG			
Hydroxyatrazine	2163-68-0										
Hydroxysimazine	2599-11-3										
Hydroxyterbuthylazine	66753-07-9										
Imidacloprid	138261-41-3	31.07.2022	0.0083	0.1	WL-1,2						
Iodofenphos	18181-70-9										
Ioxynil	1689-83-4										
Iprodione	36734-19-7	04.12.2017									
Isobenzane	297-78-9										
Isodrin	465-73-6		0.1		PS						
Isoproturon	34123-59-6	30.09.2017	0.3	1	PS						
Kresoxim-methyl	143390-89-0	31.12.2024									
Lenacil	2164-08-1	31.12.2019	0.1			1	0.1	IT			
Linuron	330-55-2	03.03.2017	0.1	0.29		8	0.1	DE	2	0.29	NL
Malathion	121-75-5	30.04.2022	0.0008	0.003		5	0.0008	BE	1	0.003	BE

Label	CAS	approved till	AA-EQS [µg/l]	MAC-EQS [µg/l]	List (PS, WL)	AA-EQS regulated in MS (No)	Lowest AA-EQS regulated in MS [µg/l]	MS with lowest AA-EQS	MAC-EQS regulated in MS (No)	Lowest MAC-EQS regulated in MS [µg/l]	MS with lowest MAC-EQS
Maleinhydrazid	123-33-1	31.10.2032									
MCPA	94-74-6	31.10.2019	0.1	13		9	0.1	CZ, DE, FR	3	13	BE
MCPB	94-81-5	31.10.2019	0.1			1	0.1	CZ			
Mecoprop	7085-19-0	31.01.2017	0.1	40		6	0.1	CZ, DE, IT	2	40	BE
Mecoprop-P (MCPP-P)	16484-77-8	31.01.2020	0.1			2	0.1	CZ			
Metalaxyl	57837-19-1	30.06.2023	0.1			1	0.1	IT			
Metalaxyl-M	70630-17-0	30.06.2020	0.1			1	0.1	IT			
Metamitron	41394-05-2	31.08.2022	0.1			2	0.1	IT			
Metazachlor	67129-08-2	31.07.2021	0.08	0.48		5	0.08	NL	1	0.48	NL
Methamidophos	10265-92-6	30.06.2008	0.1			2	0.1	DE			
Methidathion	950-37-8										
Methiocarb	2032-65-7	31.07.2020	0.002		WL-1,2						
Methomyl	16752-77-5	31.08.2019									
Methoxychlor	72-43-5		0.005			1	0.005	BG			
Metolachlor	51218-45-2	31.12.2003	0.1	0.3		6	0.1	IT, LU	3	0.3	SI
Metribuzin	21087-64-9	31.07.2020	0.08			3	0.08	SE			
Metsulfuronmethyl	74223-64-6	31.03.2023	0.01	0.03		2	0.01	NL	1	0.03	NL
Mirex	2385-85-5				POP						
Molinate	2212-67-1										
Nitrophen	1836-75-5										
o,p'-DDE	3424-82-6										
Omethoate	1113-02-6	31.12.2003	0.0008	0.22		9	0.0008	BE	3	0.22	BE
Oxadiazon	19666-30-9	31.12.2018	0.088		WL-1						
p,p'-DDD	72-54-8		0.00625			1	0.00625	ES			

Label	CAS	approved till	AA-EQS [µg/l]	MAC-EQS [µg/l]	List (PS, WL)	AA-EQS regulated in MS (No)	Lowest AA-EQS regulated in MS [µg/l]	MS with lowest AA-EQS	MAC-EQS regulated in MS (No)	Lowest MAC-EQS regulated in MS [µg/l]	MS with lowest MAC-EQS
p,p'-DDE	72-55-9		0.00625			1	0.00625	ES			
Parathion	56-38-2	09.07.2003	0.0002	0.004		7	0.0002	BE, LU	1	0.004	BE
Parathion-methyl	298-00-0	10.03.2005	0.005			6	0.005	CZ			
Penconazole	66246-88-6	31.12.2021									
Pendimethalin	40487-42-1	31.08.2024	0.1	0.3		5	0.1	IT	2	0.3	SI
Pentachlorophenol	87-86-5	20.11.2002	0.4	1	PS						
Permethrin-cis+trans	52645-53-1		0.001			1	0.001	UK			
Phosalone	2310-17-0		0.1			2	0.1	AT, IT			
Pirimicarb	23103-98-2	30.04.2020	0.09	1.8		4	0.09	NL, SE, DE	1	1.8	NL
Procymidone	32809-16-8	30.06.2008									
Prometon	1610-18-0					1	1	BG			
Prometryn	7287-19-6	31.12.2003	0.1			3	0.1	IT			
Propazine	139-40-2		0.1			2	0.1	IT			
Propetamphos	31218-83-4										
Propiconazole	60207-90-1	31.01.2019	0.1			6	0.1	IT			
Propyzamide	23950-58-5	30.06.2025	0.1			1	0.1	IT			
Pyridate	55512-33-9	31.12.2030									
Pyrimethanil	53112-28-0	30.04.2020									
Quinoxyfen	124495-18-7	30.04.2019	0.15	2.7	PS						
Quintozene	82-68-8		0.1			2	0.1	IT			
Sebuthylazine	7286-69-3		0.01			1	0.01	AT			
Secbumeton	26259-45-0										
Simazine	122-34-9	10.09.2005	1.0	4	PS						
Sulfosulfuron	141776-32-1	31.12.2030	0.05			1	0.05	SE			
Tebuconazole	107534-96-3	31.08.2020									

Label	CAS	approved till	AA-EQS [µg/l]	MAC-EQS [µg/l]	List (PS, WL)	AA-EQS regulated in MS (No)	Lowest AA-EQS regulated in MS [µg/l]	MS with lowest AA-EQS	MAC-EQS regulated in MS (No)	Lowest MAC-EQS regulated in MS [µg/l]	MS with lowest MAC-EQS
Tebufenozide	112410-23-8	31.05.2024	0.1			1	0.1	IT			
Terbufos	13071-79-9										
Terbumeton	33693-04-8		0.1			1	0.1	IT			
Terbuthylazine	5915-41-3	31.12.2024	0.2	0.5		6	0.2	NL	4	0.5	SI
Terbutryn	886-50-0	20.11.2002	0.065	0.34	PS						
Tetrasul	2227-13-6										
Thiacloprid	111988-49-9	30.04.2020	0.0083		WL-1,2						
Thiamethoxam	153719-23-4	30.04.2019	0.0083		WL-1,2						
Thiram	137-26-8	30.04.2019									
Toxaphene	8001-35-2										
trans-Nonachlor	39765-80-5										
Tri-allate	2303-17-5	31.12.2021	0.67		WL-1						
Trichloroacetic acid	76-03-9										
Trietazine	1912-26-1										
Trifluralin	1582-09-8	25.06.2010	0.03		PS						
Ziram	137-30-4	30.04.2020									

Notes: Lists: PS = Priority Substances; WL = Whatch List (1: according to Commission Implementing Decision (EU) 2015/495; 2. according to Commission Implementing Decision (EU) 2018/840)