



National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Guidance for the derivation of environmental risk limits

Part 2. Data collection, evaluation and selection

version 1.0

Colophon

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Contents

1	Introduction	5
1.1	Update of guidance	5
1.2	Scope and structure of this document	5
2	General guidance on data collection and quality assessment	7
2.1	Collection of data	7
2.2	Reliability and usefulness	7
3	Substance identity and use	11
3.1	Identification	11
3.2	Information on use	11
4	Physico-chemical properties, fate and behaviour	13
4.1	Data collection	13
4.2	Data evaluation and selection	14
4.2.1	Vapour pressure	16
4.2.2	Henry coefficient	18
4.2.3	Water solubility	19
4.2.4	Dissociation constant(s) – pK _a	19
4.2.5	Octanol/water partitioning coefficient K _{ow}	20
4.2.6	Partitioning coefficients for organic compounds and metals	23
4.2.7	Data on removal processes	28
5	Ecotoxicity data	31
5.1	Data collection	31
5.1.1	Data sources	31
5.1.2	Type of data considered	33
5.2	Data evaluation and selection: procedure and general aspects	34
5.2.1	Procedure	34
5.2.2	Acute and chronic ecotoxicity data used for ERL derivation	35
5.2.3	Relevant ecotoxicity endpoints	40
5.2.4	Toxicity values higher or lower than range of test concentration	41
5.2.5	Purity and identity of the test substance	42
5.2.6	Use of co-solvents, emulsifiers and dispersants, formulated products	42
5.2.7	Comparison of toxicity values with water solubility	43
5.2.8	pH, pK _a and ionisation of test compound	43
5.2.9	Ecotoxicity studies performed in other media	44
5.3	Selection and aggregation of laboratory ecotoxicity data	45
6	Evaluation and selection of bird and mammal toxicity data	47
6.1	Data collection and evaluation	47
6.1.1	General	47
6.1.2	Data tables for laboratory toxicity studies with birds and mammals	47
6.2	Selection of bird and mammal toxicity data	52
7	Human toxicological threshold limits	53

8	References	55
	List of abbreviations	61
	Appendix 1. Established guidelines for bird and mammal tests	65
	Appendix 2. Partition coefficients – glossary	67

1 Introduction

1.1 Update of guidance

The previous version of the guidance for derivation of environmental risk limits (ERLs) was published in 2007 and combined the existing European methodology [1,2] with national guidance for those aspects that were not addressed in the international guidance documents. Since then, the European legislation for new and existing substances became obsolete and new European guidance was introduced in 2008 for those compounds falling under REACH [3-8]. In addition, a technical guidance document for the derivation of water quality standards under the Water Framework Directive (WFD) was published in 2011 [9]. As a consequence, an update of the 2007 guidance was needed. It was decided to publish the updated guidance in the form of separate chapters that are accessible online.

1.2 Scope and structure of this document

The present document deals with the first steps of risk limit derivation: the collection and evaluation of data. This part of work is of crucial importance to ERL derivation. To make this section optimally useful to assessors, we reproduced sections from the WFD guidance [9] and the former INS (Integrale Normstelling Stoffen) guidance [10], rather than referring to these. Moreover, the accepted way of presenting the collected data for ERL derivation in the Netherlands is more elaborate than described in WFD guidance. This chapter gives general guidance on collection, evaluation and selection of data (Section 2) and on aspects that are relevant for several compartments: identity and use (Section 3), physico-chemical properties, fate and behaviour (Section 4), general guidance on ecotoxicity studies (Section 5), evaluation and selection of bird and mammal data (Section 6) and evaluation of human-toxicological data (Section 7).

Further details that are relevant for specific compartments can be found in the respective chapters on water (ERL Report 03), sediment (ERL Report 04), and air (ERL Report 06). Where appropriate, reference is given to the REACH guidance documents and the location in WFD guidance. Note that some sections of the WFD guidance were literal copies of the 2007 guidance, which are updated in the present document.

2 General guidance on data collection and quality assessment

2.1 Collection of data

For most physicochemical properties, database endpoints may be sufficient for ERL derivation since they are primarily needed to gain insight into the environmental behaviour of a compound. These compound properties are used as background information to enable interpretation of ecotoxicity tests. In cases where the data are more critical, such as input in model calculations like equilibrium partitioning (ERL Report 09) and the calculation of soil standards based on indirect exposure of humans, a critical review is needed.

The main environmental fate parameters needed are partitioning constants and information on physical, chemical and biological degradation, of which both database values and values collected from original sources are used. If an ERL for soil or sediment has to be derived by means of equilibrium partitioning, information on the sorption characteristics is of crucial importance and should be collected. More detail on collection methods for distribution constants is given in sections 4.2.5 and 4.2.6. Information on degradation of the substance considered is generally not used quantitatively in ERL derivation. However, this information is crucial to understand the behaviour of the substance in toxicity tests and in the environment. Data on e.g. hydrolysis, photolysis and biodegradation are collected and tabulated, but the underlying original sources are generally not evaluated, unless this becomes crucial for the derivation of the risk limit under consideration.

The collection of ecotoxicity data consists of multiple steps. The screening procedure is worked out in detail in section 5.1. First, data are gathered from secondary sources such as databases, handbooks, evaluation reports prepared in the context of authorisation (e.g. agricultural pesticides, biocides) or risk limit derivations prepared by other countries. The second step is to retrieve the studies underlying these secondary sources and to evaluate these. Thirdly, primary data are retrieved from the open literature. It is noted that with respect to ecotoxicity data, a full literature search is carried out in most cases. For human-toxicological data, data collection is only needed if an established human-toxicological threshold is absent or if re-evaluation of an old value is needed. The collection procedure for ecotoxicity data is described in more detail in section 5.1.

2.2 Reliability and usefulness

All data have to be evaluated with respect to reliability and to that end, the original data source (publication, study report) should be retrieved whenever possible. In principle, this also holds for studies that already have been accepted for use in another regulatory context. According to the WFD guidance, data that have already been subjected to data quality assurance and peer review and are published in risk assessment reports under other legal frameworks, may be used, based on summaries in those reports. It should be noted that these summaries

should be robust, i.e. contain enough information and detail to enable the assessor to judge whether the earlier study evaluation has adequately addressed reliability and usefulness with respect to use in ERL derivation. This should be done with care, since not all studies that have been accepted earlier meet the quality criteria that are applied nowadays. For instance, analytical verification of test concentrations was not common practice in the past and may be critical in case of fast dissipating or hydrophobic substances.

Reliability of a study pertains to the intrinsic, scientific quality of an individual study, and is determined by the set-up, performance and evaluation of the experiment, and the reporting [11-13]. A study may be properly reported, but considered less or not reliable because of an inadequate set-up (e.g. too few replicates) or performance (e.g. high control mortality). Sometimes, a study that was seemingly carried out in a scientifically sound way, cannot be properly evaluated because the description is so concise that the experimental set-up cannot be judged adequately (e.g. the study or its methods reported as a reference to another report), or if various items that are considered important for interpretation of the test results cannot be checked (e.g. temperature data are not given). Primary data sources and study summaries are evaluated with respect to their intrinsic reliability according to the methodology of Mensink et al. [12,13]. Reliability indices (Ri) are used to designate the reliability of a test or study, with Ri 1, 2, or 3 reflecting reliable, less reliable, and unreliable test results, respectively. A fourth category, Ri 4, is added for references which due to limited or inadequate reporting cannot be evaluated. The reliability codes assigned are summarised as follows (according to Klimisch et al. [11]):

1. reliable without restrictions: 'studies or data...generated according to generally valid and/or internationally accepted testing guidelines (preferably performed according to GLP) or in which the test parameters documented are based on a specific (national) testing guideline... or in which all parameters described are closely related/comparable to a guideline method.'
2. reliable with restrictions: 'studies or data... (mostly not performed according to GLP), in which the test parameters documented do not totally comply with the specific testing guideline, but are sufficient to accept the data or in which investigations are described which cannot be subsumed under a testing guideline, but which are nevertheless well documented and scientifically acceptable.'
3. not reliable: 'studies or data...in which there were interferences between the measuring system and the test substance or in which organisms/test systems were used which are not relevant in relation to the exposure (e.g., unphysiologic pathways of application) or which were carried out or generated according to a method which is not acceptable, the documentation of which is not sufficient for assessment and which is not convincing for an expert judgment.'

4. not assignable: 'studies or data...which do not give sufficient experimental details and which are only listed in short abstracts or secondary literature (books, reviews, etc.).'

Additional guidance on reliability assessment can be found in the endpoint specific guidance of REACH [4,5,8]. Reliability checklists for specific tests within the context of pesticide evaluation have been published by RIVM [12-15]. If a test result is not (properly) reported, but can be (re)calculated from the data presented by the author(s), the result is also used. Studies that show results in a graph of good quality that might be converted back into raw data are also evaluated. In general, when a test has fundamental shortcomings, it should be classified as not reliable (Ri 3). This applies e.g. to situations where the identity of the substance is improperly characterised or reported [13], ecotoxicity tests that are incubated too long (e.g. for algae) or too wet (for soil), or in which control mortality was higher than allowed according to the relevant guidelines. Studies performed and reported according to accepted international guidelines are generally reliable when the requirements of the protocols are met, although these studies should also be carefully evaluated. Hence, following an accepted protocol is not a prerequisite for being considered reliable (Ri 1 or 2), nor is the applicability of a formal quality assurance scheme, such as Good Laboratory Practice. The reported description of a study, should provide all information necessary to assess its quality. If more information from comparable studies and organisms is available, this can be involved to judge plausibility of the respective studies, but this is not a part of intrinsic reliability.

Good quality tests may be considered not useful or not relevant for ERL derivation. This is the case when a parameter is derived under conditions that are not considered relevant for the field situation, for instance when a DT50 for hydrolysis relates to a pH of 10 and 50°C. Tests that are not relevant for the purpose of ERL derivation may still contain information that is useful as circumstantial evidence. An example is an ecotoxicity experiment that is carried out in a medium that is not the natural habitat of the tested species. Results of a terrestrial plant test that is carried out in water, cannot be used as a basis for ERL derivation. These tests may still be valid and reported with Ri 1 or 2, but it should be clearly indicated that the endpoint is not considered relevant for ERL derivation. However, such a test may provide information that is useful, e.g. to show that macrophytes are likely not sensitive. Other examples of studies that contain useful ecotoxicity information but cannot be used directly for derivation of ERLs, are a NOEC value from a short term test, or a value higher than the highest tested concentration or lower than lowest tested concentration. The judgement of relevance is thus highly dependent on the context of ERL derivation, and specific guidance is given in the respective chapters (see sections 5.2.4 and 5.2.9).

3 Substance identity and use

3.1 Identification

For a proper identification of the chemical under consideration, information is presented on names, registry numbers and formulas of the compound. The required information is presented in a table format which is also included in the ERL report (Table 1).

Table 1 Identification of substance [name]. Example of the table format used for the identification of the substance under evaluation.

Parameter	Value
Chemical name	indicate if this is IUPAC or CAS name or otherwise
Common/trivial/other name	trade names, product names
CAS number	
EC number	
Molecular formula	C _x H _y O _z
Molecular mass	
Structural formula	
SMILES code	

The information may be collected from various sources, but the OECD QSAR Toolbox [16] is used as the primary data source. The OECD QSAR Toolbox includes a number of data sources, among which the US EPA Ecotox database, public data from the REACH dossiers [17] and information from EPI Suite™ [18]. The molecular formula (C_xH_yO_z, etc.) is not yet included in the QSAR Toolbox, and should be obtained separately from EPI Suite™ [18]. If a structural formula cannot be obtained from the OECD QSAR Toolbox, general handbooks like Mackay et al. [19] can be consulted. For pesticides and biocides, reference is made to the assessment reports prepared in the context of European active substance approval, available via EFSA and ECHA, respectively. The SMILES code is also generated by the QSAR Toolbox or EPI Suite if the substance is present in the database. If the compound of interest is not available, the SMILES code can be generated using chemical drawing software, e.g. ChemSketch [20].

➔ Location in WFD guidance: Appendix 1.2, p. 128.

3.2 Information on use

Next to information on identity, it is advised to collect information on the use of the compound and the main emission sources, e.g. industrial categories or agricultural application. Information on the function (herbicide, fungicide, insecticide, disinfectant, biocide, antifouling, veterinary pharmaceutical, antibiotic, human pharmaceutical, anti-cancer drug, cardiovascular drug, flame retardant, etc.) and mode of action should also be presented. This information may be added to the table, or presented in a separate section when given in more detail. Various sources are used, starting with the risk assessment reports that are made publicly available in the respective frameworks, such as EU

RARs or the REACH dossier data the REACH dossier data (dossiers are accessible via <https://echa.europa.eu/information-on-chemicals>, see section on Manufacture, Use and Exposure information). For plant protection products or biocides, the respective assessment reports (DARs and CARs) should be consulted. For human pharmaceuticals the European Public Assessment Reports published by EMA are a relevant source (<https://www.ema.europa.eu/en/medicines>). Apart from these sources, handbooks like e.g. Pesticide Manual can be consulted.

4 Physico-chemical properties, fate and behaviour

4.1 Data collection

The following physical and chemical parameters and data on behaviour should at least be collected for the molecule of interest:

- melting point: T_m , ($^{\circ}\text{C}$);
- boiling point: T_b , ($^{\circ}\text{C}$);
- vapour pressure: P_v (Pa), experimentally determined values for melting point and boiling point can be useful for estimation of the vapour pressure;
- Henry's law constant: H ($\text{Pa}\cdot\text{m}^3/\text{mol}$).
- water solubility: S_w (mg/L), an experimentally determined value for melting point can be useful for the estimation of the solubility from $\log K_{ow}$;
- dissociation constant: $\text{p}K_a$ (-);
- *n*-octanol/water partition coefficient: K_{ow} (-);
- soil/sediment water partition coefficient: K_{pr} (L/kg_{dw}).
 - For organic substances, the partition coefficient normalised to organic carbon is preferred: K_{oc} (L/kg_{oc}).
 - For metals, field based partition coefficients (K_p) are preferred.
- additional information on environmental fate, such as dissipation half-life times in water, soil and sediment due to e.g. hydrolysis, photolysis and/or biodegradation.

→ Location in WFD guidance: Appendix A1.2

→ REACH guidance document R7.a [8]

As noted in section 2.1, database endpoints on physico-chemical parameters are generally considered sufficient as background information for the interpretation of ecotoxicity tests. Properties that are associated with potential high disappearance from the test solutions (e.g. high vapor pressure, low solubility, high K_{ow} , fast hydrolysis) give an indication that special care should be taken to maintain test concentrations during the experiment and/or that test endpoints should be based on measured concentrations only. For the derivation of ERLs for soil or sediment, an additional evaluation of sorption characteristics may be needed in case an ERL has to be derived by means of equilibrium partitioning.

For plant protection products and biocides, the assessment reports prepared in the context of European substance approval procedures are used as the primary source of information (see section 5.1). $\log K_{ow}$ should additionally be obtained using the BioLoom software (former ClogP) [21]. Additional information may be obtained from the OECD QSAR Toolbox [16] and general handbooks such as the Pesticide Manual [22].

For other compounds, $\log K_{ow}$ is also derived from BioLoom [21], while for the other physico-chemical data, the OECD QSAR Toolbox [16] is used as the starting point. Most recommended values from the MacKay-handbook [19] are included in the SRC database that is part of EPI Suite™ [18] and the OECD QSAR Toolbox [16]. The program does

not search online, and thus gives a momentary view of the data sources at the time of release of the present version. For the data on physico-chemical properties, this is not considered as a serious drawback, since major changes in parameters are rare and hence databases for these properties are generally not frequently updated. However, if the OECD QSAR Toolbox does not give (enough) results, the REACH dossiers [17] and other sources should be consulted. Care should be taken to verify whether the latter data sources do contain data that have been evaluated REACH dossiers may contain data that have been evaluated previously in the context of other regulatory frameworks, but reliability indices are designated by the registrant.

4.2 Data evaluation and selection

In case primary data sources such as peer-reviewed literature are collected, these studies are evaluated according to the reliability criteria in section 2.2. The studies are summarised in a data table which is included in an Annex to the ERL derivation report. An example of such a summary table is given below for a sorption study (Table 2). In most cases, the evaluation consists of a general assessment of database results, e.g. the suitability of the reported methods is evaluated in relationship to the properties of the compound, depending on the available data on the evaluated properties. Lipophilicity is inversely related with water solubility. Hence, if for a compound the reported $\log K_{ow}$ and water solubility are both relatively high or both relatively low, the reliability of the data on these properties should be further investigated, e.g. by attempting to retrieve more data or QSAR estimates of both parameters.

Table 2 Example of a data table for batch equilibrium soil adsorption studies.

Legend to column headings	
Purity	refers to purity of active substance or content of active substance in formulation; ag = analytical grade; tg = technical grade
om	organic matter content
soil:sol ratio	soil solution:ratio
Ads.	Adsorption
Des.	Desorption
T	Temperature
Analysis	indicate if water and/or soil are analysed
K	type of partitioning coefficient, e.g. Kd (single concentration estimate) or Kf (partition coefficient based on Freundlich isotherm)
$1/n$	Freundlich exponent
Ri	Reliability index according to [11]. Valid studies (Ri 2 or higher) are considered for ERL derivation

Soil type	Test compound	Purity [%]	Soil om [%]	Soil pH	pH type	soil:sol ratio	Ads. time	Des. time	T [°C]	Analysis	K	Value [L/kg]	1/n	Ri	Note	Ref.
sand	active	tg	0.8	5.5	0.01 M CaCl ₂	1:10	24 h	48 h	20	water only	Kf	12	0.9	3	1	[a]
loamy sand	active	ag	2	6.3	H ₂ O	1:5	24 h	48 h	19	water, soil	Kf	104	0.8	2	2	[b]]

Notes

- 1 Study according to OECD 106, five concentrations, stability and mass balance checked; soil:water ratio too low for adequate determination of $K_{s/1}$
- 2 Study according to OECD 106, six concentrations, degradation observed, but Kf based on measured concentrations in water and soil

The relevant and reliable data are summarised in an overview table according to the format below (Table 3). If for a given parameter more than one result is available, these are all listed and it is indicated what is the representative value to be used for derivation of ERLs. In the next sections, some parameters are discussed in more detail. Specific guidance is given on the evaluation of experimental data and on estimation methods in case of absence of data, and advice is given on the selection of the appropriate endpoints.

Table 3 Overview and default table structure for reporting physico-chemical and fate parameters.

Properties	Value	Unit	Reference
Melting point		°C	
Boiling point		°C	
Vapour pressure		Pa	
Henry's law constant		Pa.m ³ /mol	
Water solubility		mg/L	
pK _a (specify reaction ^a 1 to which pK _a applies)			
log K _{ow}			
log K _{oc}			
log K _p			
log K _{p, susp}			
Dissipation half-life (DT50) or degradation half-life ^b (DegT50) for hydrolysis/photolysis/biodegradation in water and/or sediment		hours, days	

a: pK_a values are not informative unless the dissociation reaction to which the value applies is presented. E.g. pK_a for RN⁺H → RN + H⁺

b: DT50 is used for hydrolysis, photolysis and non-microbial removal in biodegradation studies. DegT50 is used when the half-life value is known to represent biodegradation.

4.2.1

Vapour pressure

The experimental determination of the vapour pressure of a compound is described in OECD guideline 104 [23]. In this guideline several methods are discussed, each with its own range of applicability. The following table presents information from the guideline, which specifies what method is suitable for which compound.

Table 4 Domain of applicability of different methods for the determination of vapour pressure [23].

Method	Suitable for liquids	Suitable for solids	Recommended range
Dynamic method	low melting	Yes	10 ³ -10 ⁵ Pa
Static method	yes	Yes	10-10 ⁵ Pa
Isotenoscope	yes	Yes	10 ² -10 ⁵ Pa
Effusion method	yes	Yes	10 ⁻³ -1 Pa
Gas saturation method	yes	Yes	10 ⁻⁵ -10 ³ Pa
Spinning rotor method	yes	Yes	10 ⁻⁴ -0.5 Pa

1.

In the dynamic method (Cottrell's method), the boiling point of a compound is determined at various pressures between about 10^3 and 10^5 Pa. In the static method, the vapour pressure is determined at one specified temperature by means of a manometer (e.g. 25°C). The isoteniscope method is based on the same principle as the static method, and although it was developed to measure the vapour pressure of certain liquid hydrocarbons it is appropriate for solids as well. The method is usually not suitable for multicomponent systems. In the effusion method the weight loss of the compound is measured. This can be done directly by measuring the mass of the remaining substance or by analysing the volatilised amount by gas chromatography (GC). In the updated OECD guideline 104 [23], isothermal gravimetry is added for the effusion method. The weight loss is then determined at different temperatures and an extrapolation to 20 or 25°C can be made. The range of vapour pressures that can be determined with this method is 10^{-10} to 1 Pa. The gas saturation method makes use of a column containing a carrier material supporting the substance, through which an inert gas is passed. The concentration of the substance in this carrier gas is then determined, usually by GC. The last method is the spinning rotor method, where the retardation of a spinning ball due to the friction with the gas phase is measured.

In general, the methods that make use of an analysis of the substance, for example by gas chromatography, are less prone to errors due to impurities than the other methods. The OECD guideline does not mention this explicitly. However, degassing of more volatile compounds prior to the determination of the vapour pressure also enhances the reliability of the determination. The retention time in gas chromatography can be used to estimate the vapour pressure of a compound. Although this is not a direct determination of the vapour pressure, it generally gives rather accurate results and is applicable to substances with a very low vapour pressure. In addition to this, the vapour pressure can be estimated by the programme MPBPwin, which is incorporated in EPI Suite™ [18]. The programme makes use of three estimation methods, which are the Antoine method, the modified Grain method and the Mackay method. All three methods use the boiling point and melting point of the compound for their estimation of the vapour pressure. Both boiling and melting point can be estimated by the programme, but experimental values can also be entered if known. For solids, the result of the modified Grain method is presented as the preferred value, while for liquids this is the mean of the Antoine method and the modified Grain method.

In the data table, experimental and estimated values are both reported. If results from different methods deviate significantly from each other, only the methods with a direct analysis of the compound should be used, such as the gas saturation method. Complementary to this, the data from GC retention times may be used if there are not enough reliable data. If no experimental data are available, the estimate from EPI Suite™ as included in the OECD QSAR Toolbox can be used [18].

4.2.2 *Henry coefficient*

No general accepted guideline exists for the determination of the Henry coefficient. However, several methods exist to determine the Henry coefficient experimentally.

In the batch stripping method, gas is bubbled at a known rate through a solution of the compound in water. The Henry coefficient is calculated from the decrease in the aqueous concentration, using the mass balance. The concentration in air is generally not measured. This method works well for fairly volatile compounds with Henry coefficients higher than 2.5 and occasionally down to 0.25 Pa.m³/mol [24]. One common method, very similar to the batch stripping method, is the gas stripping method in which a gas is bubbled through the aqueous solution and both the aqueous concentration and the gas concentration are determined. The technique was applied to chlorobenzenes, polyaromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), in a range from 0.018 to 276 Pa.m³/mol [25].

A method for highly volatile compounds (i.e. higher than 120 Pa.m³/mol) is the Equilibrium Partitioning In Closed Systems (EPICS) method. With this method a known volume of solute in water solution is equilibrated with air in sealed vessels. The headspace air concentrations are measured. The method has a high precision [24]. A number of other headspace analysis techniques that are used, are slightly different from the EPICS method, in some techniques not only the headspace but both phases are analysed [24].

A method for less volatile compounds is the wetted-wall method. In this method the solute is equilibrated between a thin flowing film of water and a concurrent air flow in a vertical column. Both phases are measured. The method has been applied to pesticides and other less volatile compounds, but no recommended range is given [24]. In the cited handbook, values for PCBs, PAHs, and two pesticides are tabulated using this method. Values for PCBs and PAHs range from 0.91 to 74.3 Pa.m³/mol. One of the pesticides (alachlor) has a much lower Henry coefficient of 8.43×10^{-4} Pa.m³/mol. This is in agreement with the method being suitable for less volatile compounds.

The Henry coefficient is sometimes related to retention times [24]. However, results obtained using this method should be considered as an estimate. Another estimation that is often used for the Henry coefficient is the quotient of vapour pressure and solubility. This method works quite well for substances that have a solubility of less than 1% in water. The Henry coefficient can also be calculated by a bond contribution method as included in EPI Suite™ [18]. These estimated values should be included in the physico-chemical data table.

The validity of values for the Henry coefficient should be considered on a case-by-case basis. When no reliable experimental values are available, the Henry coefficient can be estimated from the quotient of the vapour pressure and the water solubility, provided that reliable values are available for both parameters. If this is not the case, the estimate from EPI Suite, as included in the OECD QSAR Toolbox can be used [16,18].

➔ Location in WFD guidance: Appendix A1.2.3, p. 130-132.

4.2.3 *Water solubility*

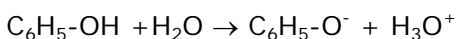
Two methods for the experimental determination of water solubility are described in OECD guideline 105 [26]. These methods are the flask method (shake-flask) and the column elution method (generator column). The flask method can be used for compounds with a solubility higher than 10 mg/L. Below that value, colloid formation will overestimate the true aqueous solubility and in that case the column elution method should be used, which prevents this phenomenon. Apart from the methods proposed in the OECD guideline, the water solubility of poorly soluble liquid compounds can be accurately determined by means of the slow-stirring method. The reliability of the slow-stirring method applied to liquid substances can be considered equivalent to that of the column elution method. Only few examples are available of the use of this method for the determination of solubility, mostly for hydrocarbons and phthalate esters [27-29]. This method is often used to prepare saturated solutions of hydrocarbon mixtures (oil products) in water (water accommodated fractions or WAF), by which information on the solubility of a mixture is given [30].

Estimates of the water solubility can be made by two different programmes included in EPI Suite [18]. These programmes are WSKOWwin, which estimates the solubility from $\log K_{ow}$, and WATERnt, which is a fragment method for water solubility independent of $\log K_{ow}$. Experimental values for $\log K_{ow}$ and melting point can be entered in WSKOWwin if available. Otherwise WSKOWwin will use the default values (experimental or calculated) from EPI Suite for these parameters. These estimated values should be reported as well in the data tables. The selected value for water solubility may be calculated from the geometric mean of all valid values for the water solubility. Values below 10 mg/L determined with the shake-flask method should be considered as unreliable. For these poorly soluble compounds, the geometric mean of the generator column and slow-stirring method is used as selected value.

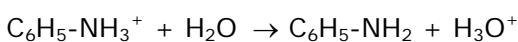
4.2.4 *Dissociation constant(s) – pK_a*

It should be reported whether the substance under investigation contains groups that dissociate upon dissolution in water. When it is known that a substance is neutral at environmentally pH values (pH range 5 – 10), this is worthwhile information, especially for more complex molecules. For substances that contain dissociating groups, the pK_a values should be collected and preferably a short description is given on how the molecule is charged as a function of pH. Experimentally determined pK_a values are preferable, but values from handbooks, databases or computation software are tabulated as well. For the latter, e.g. Marvin Sketch [31] could be used.

For both acidic (proton donating) groups and basic (proton accepting) groups, the pK_a value should be reported. In both cases, this is the equilibrium constant for the proton releasing reaction. For bases this is the equilibrium constant for the proton releasing reaction of the conjugated acid. For example:



is the reaction for the dissociation of the weakly acidic phenolic group of phenol. The pK_a of this reaction is 10.0. This means that at pH 12 the molecule will be in its ionised form (1-) for ~99% and at pH 8 the molecule will be in its neutral form for ~99%. Below pH 8 the neutral fraction will only increase further.



is the reaction for the acidic dissociation of the conjugated acid of aniline. The pK_a of this reaction is 4.6. Note that the pK_b of aniline is 9.6. A pK_a of 4.6 means that at pH 2.6 the molecule is present in its ionised form (1+) for ~99% and at pH 6.6 the molecule is present in its neutral form for ~99%. The neutral form will be even more dominant at increasing pH values.

If there are several dissociating groups in the molecule, clarify which pK_a is valid for which group and reaction. The most acidic pK_a value is given an index of 1: pK_{a1} , the second one an index of 2 (pK_{a2}), etc.

4.2.5 Octanol/water partitioning coefficient K_{ow}

Several methods are available for the experimental determination of $\log K_{ow}$. Three methods are described in OECD guidelines and a fourth method is described in a draft guideline. The first method is the shake-flask method: OECD guideline 107 [32]. This method is applicable to compounds with $\log K_{ow}$ values in the range between -2 and 4 (occasionally up to 5), but is impossible to use with surface-active materials. For these materials, a calculated value (using BioLoom [21]) or an estimate based on individual *n*-octanol solubility and water solubility should be provided, preferably in mutually saturated *n*-octanol and water [33-35].

The second method is the HPLC method. Values of $\log K_{ow}$ in the range between 0 and 6 can be estimated using high performance liquid chromatography: OECD guideline 117 [36]. The HPLC method is not applicable to strong acids and bases, metal complexes, surface-active materials or substances which react with the eluent. The HPLC method is less sensitive to the presence of impurities in the test compound than is the shake-flask method. Nevertheless, in some cases impurities can make the interpretation of the results difficult because peak assignment becomes uncertain. For mixtures which give an unresolved band, upper and lower limits of $\log K_{ow}$ should be stated.

The slow-stirring method is the third method. It determines the distribution of a compound between *n*-octanol and water directly, with a range of applicability extending beyond that of the shake-flask method: OECD guideline 123 [37]. With this method, $\log K_{ow}$ values up to 8.2 can be accurately determined, making it suitable for highly hydrophobic

compounds. This method prevents the formation of micro droplets of *n*-octanol in the aqueous phase, which results in an overestimation of the water concentration and, consequently, an underestimation of the log K_{ow} value. For the same reason, the shake-flask method can only be used up to log K_{ow} values of around 4 and definitely not higher than 5.

Another method, not mentioned in OECD guidelines, is the generator-column technique. Although this technique is most frequently used for the determination of water solubility, it is occasionally used for the determination of log K_{ow} . Because the supporting material silica, saturated with *n*-octanol containing the compound, is held in a column, the formation of micro droplets is excluded. For this reason, the results from this technique can be considered equivalent to results obtained with the slow stirring method. In general, good correlation exists between the slow stirring method and the generator column technique, within the experimental error of both methods. However, only a limited number of studies is available that use this technique, primarily for chlorinated biphenyls and dibenzodioxins (e.g. [38-45]).

Before deciding on what procedure to use, a preliminary estimate of log K_{ow} should be obtained from calculations (see the annex to Guideline 117), or where appropriate from the ratio of the solubilities of the test substance in the pure solvents. Still, the HPLC method should be regarded as an estimation method for log K_{ow} , because it does not directly measure the distribution of a compound between octanol and water.

Besides experimental determination, log K_{ow} values can also be calculated with a QSAR programme. The log K_{ow} values calculated with ClogP (BioByte, 2004) and EPI Suite™ [18] should always be presented for comparison. Both programmes are based on a fragment contribution method. The log K_{ow} value that is selected for use in the ERL derivation is preferably the selected experimental value (MlogP) presented by BioLoom [21]. This value is assigned the highest quality in the underlying MedChem database. Only if this database does not give a selected value or when careful considerations lead to a different selection, the selected log K_{ow} value may be the average value of all reliable log K_{ow} values determined by the shake flask, slow stirring or generator column method. Since log K_{ow} values estimated using the HPLC method are indirect estimates of octanol/water partitioning and are therefore not regarded as most reliable, they should not be used when more reliable data are available. When no or only unreliable experimental data on log K_{ow} are available, the ClogP value of BioLoom [21] is preferred.

4.2.5.1 Ionisable substances

Determination of the partition coefficient of ionisable organic compounds requires extra attention. Based on the collected pK_a values (section 4.2.4) it can be inferred at what pH values the molecule is charged and where it is neutral. Take care that some substances are always charged in solution and that substances may be zwitterions, i.e. they may be charged at several places in the molecule, but their net charge may be zero at given pH values.

A partitioning coefficient of an ionisable molecule at a pH where the molecule is not fully neutral is called a D_{ow} rather than K_{ow} . The K_{ow} is defined as the *n*-octanol:water partitioning coefficient for the fully neutral species. As said, for some molecules this may be a theoretical value as these substances never become neutral in aqueous solution. QSAR determined values of K_{ow} for ionisable substances in principle pertain to the fully neutral form of the molecule, if this form exists. Some QSAR software also enables to calculate either D_{ow} values or lipophilicity-pH profiles, e.g. Marvin Sketch [31]. This is a useful tool if the lipophilicity-pH profile of the compound is complex.

For simple molecules, with few dissociating groups, K_{ow} may be determined by performing the determination of K_{ow} at a pH value where the molecule is fully neutral. A practical approximation of 'fully neutral' is a fraction of at least 99% of non ionisable species in solution, which is reached at ≥ 2 pH units above or below the pK_a value, for molecules with one dissociating group. The outcomes of studies performed in this way may be accepted to reflect the K_{ow} . If the study has been conducted at pH values where the molecule is not fully neutral, the outcome should always be reported as D_{ow} , together with the pH of determination.

D_{ow} determinations of acids and bases with one dissociating group can be easily recalculated to a K_{ow} or to a 'ion corrected D_{ow} '. This calculation is based on the Henderson-Hasselbalch equation and can be found in textbooks. We cite from Schüürmann et al. [46]. For the dissociation of an acid ($AH \rightarrow A^- + H^+$) the fraction of non dissociated acid is:

$$f_{u, \text{ acid}} = \frac{1}{1+10^{pH-pK_a}} \quad (1)$$

Further:

$$D_{ow} = f_u \cdot K_{ow}, \quad (2)$$

and equations 1 and 2 combine to:

$$K_{ow} = D_{ow} \cdot (1 + 10^{(pH - pK_a)}) \quad (3)$$

And for the dissociation of a base ($BH^+ \rightarrow B + H^+$):

$$K_{ow} = D_{ow} \cdot (1 + 10^{(pK_a - pH)}) \quad (4)$$

If it is possible to derive a value for K_{ow} as an ion corrected value of the D_{ow} available, this value should be presented in the section on physico-chemical properties, with the note that it concerns a ion corrected $\log D_{ow}$.

A revised draft OECD guideline was published [47] describing a potentiometric method to determine the pH-lipophilicity profile of a substance. This method is also described in the scientific literature, e.g. in Avdeef [48] and Takács-Novák and Avdeef [49]. The method is also applicable to multiprotic substances, i.e. substances with more than one proton donating group. Results for $\log K_{ow}$ obtained using this method may be valid, provided that the method used is well reported and can be evaluated.

In the interpretation of the tabulated results, K_{ow} should be used as main descriptor of the potential for bioaccumulation. For substances that are not neutral within the environmentally relevant pH range (5-9) and consequently have D_{ow} values in that range that are lower than their K_{ow} , these D_{ow} values should not be automatically be used to conclude that 'no bioaccumulation potential' exists, if the value is below the appropriate trigger value. The bioaccumulation potential of the ionised part of the molecule is generally expected to be lower than that of the neutral species, but the extent to which this is true is generally not known.

4.2.6 *Partitioning coefficients for organic compounds and metals*

4.2.6.1 Organic compounds - organic carbon normalised partitioning coefficients

The organic carbon normalised partition coefficient (K_{oc}) is calculated or directly retrieved from literature. The soil or sediment type that is used to determine the partition coefficients (e.g. sediment, loamy sand, suspended matter) is reported in the table. The organic carbon content is also reported. The method to determine the K_{oc} most accurately is OECD guideline 106 [50]. All K_{oc} values that are determined with a method similar to this guideline method can be regarded to be reliable and are preferably used, if well performed and described. The REACH guidance [8] also allows K_{oc} values to be derived using the HPLC method according to OECD guideline 121 [51]. The HPLC method is no direct determination of the K_{oc} but an estimate based on another property (retention in HPLC). Other options are soil column studies according to OECD guideline 312 [52], or field studies or simulation studies. Expert judgement is required for evaluation and interpretation of the results of these latter studies [53]. If reliable, the results can be used but will most often be considered as additional information.

K_{oc} may also be estimated. More information can be found in the REACH guidance [8]. If no experimental values are available, the estimated values from the OECD QSAR Toolbox should be reported, which are based on the EPI suite estimation routine KOCwin, which employs a calculation method based on molecular connectivity indices (MCI). In addition, the QSAR models presented in the former Technical Guidance Document (TGD) [54] should be used. These models originate from Sabjlić et al. [55] and are based on the relationship between K_{ow} and K_{oc} . Table 5 gives the QSAR models, the domain and statistics of the models. In principle, the appropriate QSAR should be chosen based on this table. For many compounds with polar groups attached, a separate QSAR is available for that particular chemical class. In general, these QSARs do not deviate very much from the QSARs for larger subsets of chemical classes. However, if there is doubt about which QSAR to use, for example, due to the presence of more than one functional group, it is often most convenient to use the more general QSARs, in particular the QSAR for non-hydrophobic chemicals. This QSAR, together with the QSAR for predominantly hydrophobic compounds provides a reasonable estimate of the K_{oc} for most compounds.

For the selection of the K_{oc} value, experimentally determined values according to standardised tests (e.g. OECD guideline 106; [50]) or from other studies published in scientific literature are preferred. K_{oc} values

determined by the HPLC method (OECD guideline 121; [51]) should be considered as estimates of the real K_{oc} values and consequently, these values are not used as experimental values. The geometric mean of the valid experimental K_{oc} values is calculated. K_{oc} values estimated with EPI Suite™ [18] and other estimates (Table 5) should always be presented for comparison. In case experimental K_{oc} values vary widely and no value for K_{oc} can be considered as the most reliable value, consider to calculate the geometric mean of all valid K_{oc} values, including both EPI suite KOCwin estimates and the appropriate QSAR estimate based on $\log K_{ow}$ according to Table 5. This geometric mean K_{oc} can then be used as the selected value in ERL derivations [56].

Table 5 QSARs for soil and sediment sorption for different chemical classes with domains and statistics according to [54,55].

Model	X-variable domain log K _{ow} in log units	Chemical domain	Substituents	Equation	Statistics
Hydrophobics	1 - 7.5	chemicals containing C, H, F, Cl, Br, and I atoms		$\log K_{oc} = 0.81 \log K_{ow} + 0.10$	n=81, r ² =0.89, s.e.=0.45
Nonhydrophobics	(-2.0) - 8.0	All chemicals that are not classified as hydrophobics		$\log K_{oc} = 0.52 \log K_{ow} + 1.02$	n=390, r ² =0.63, s.e.=0.56 ^a
Phenols	1.0 - 5.0	Phenols Anilines Benzonitriles Nitrobenzenes	Cl, Br, CH ₃ , OH, NO ₂ , CH ₃ O Cl, Br, CH ₃ , CF ₃ , CH ₃ O, N-Me Chlorinated Cl, Br, NH ₂	$\log K_{oc} = 0.63 \log K_{ow} + 0.90$	n=54, r ² =0.75, s.e.=0.40
Agricultural	(-1.0) - 8.0	not covered by a specific other group		$\log K_{oc} = 0.47 \log K_{ow} + 1.09$	n=216, r ² =0.68, s.e.=0.43
Alcohols, acids	(-1.0) - 5.0	Alcohols Organic Acids	Alkyl, Phenalkyl, OH All	$\log K_{oc} = 0.47 \log K_{ow} + 0.50$	n=36, r ² =0.72, s.e.=0.39
Acetanilides	0.9 - 5.0	Anilides	CH ₃ O, Cl, Br, NO ₂ , CF ₃ , CH ₃	$\log K_{oc} = 0.40 \log K_{ow} + 1.12$	n=21, r ² =0.51, s.e.=0.34
Alcohols	(-1.0) - 5.0	Alcohols	Alkyl, Phenalkyl, OH	$\log K_{oc} = 0.39 \log K_{ow} + 0.50$	n=13, r ² =0.77, s.e.=0.40
Amides	(-1.0) - 4.0	Acetamides Benzamides	F, Cl, Br, CH ₃ O, Alkyl NO ₂ , N-Me	$\log K_{oc} = 0.33 \log K_{ow} + 1.25$	n=28, r ² =0.46, s.e.=0.49
Anilines	1.0 - 5.1	Anilines	Cl, Br, CF ₃ , CH ₃ , N-Me, N, N-di-Me	$\log K_{oc} = 0.62 \log K_{ow} + 0.85$	n=20, r ² =0.82, s.e.=0.34
Carbamates	(-1.0) - 5.0	Carbamates	Alkyl, Alkenyl, Cl, Br, N-Me, CH ₃ O	$\log K_{oc} = 0.37 \log K_{ow} + 1.14$	n=43, r ² =0.58, s.e.=0.41
Dinitroanilines	0.5 - 5.5	Dinitroanilines	CF ₃ , Alkyl-SO ₂ , NH ₂ SO ₂ , CH ₃ , t-Bu	$\log K_{oc} = 0.38 \log K_{ow} + 1.92$	n=20, r ² =0.83, s.e.=0.24

Model	X-variable domain log K _{ow} in log units	Chemical domain	Substituents	Equation	Statistics
Esters	1.0- 8.0	Phthalates Benzoates Phenylacetates Hexanoates Heptanoates Octanoates	alkyl, phenyl, Cl alkyl, phenyl, NO ₂ ,OH,Cl,NH ₂ alkyl, Phenalkyl alkyl alkyl alkyl	log K _{oc} = 0.49 log K _{ow} + 1.05	n=25, r ² =0.76, s.e.=0.46
Nitrobenzenes	1.0 - 4.5	Nitrobenzenes	Cl, Br, NH ₂	log K _{oc} = 0.77 log K _{ow} + 0.55	n=10, r ² =0.70, s.e.=0.58
Organic Acids	(-0.5) - 4.0	Organic Acids	All	log K _{oc} = 0.60 log K _{ow} + 0.32	n=23, r ² =0.75, s.e.=0.34
Phenols	0.5 - 5.5	Phenols	Cl, Br, NO ₂ , CH ₃ , CH ₃ O, OH	log K _{oc} = 0.57 log K _{ow} + 1.08	n=24, r ² =0.75, s.e.=0.37
		Benzonitriles	Cl		
Phenylureas	0.5 - 4.2	Phenylureas	CH ₃ , CH ₃ O, F, Cl, Br, Cyclo- alkyls, CF ₃ , PhO	log K _{oc} = 0.49 log K _{ow} + 1.05	n=52, r ² =0.62, s.e.=0.34
Phosphates	0.0 - 6.5	All Phosphates		log K _{oc} = 0.49 log K _{ow} + 1.17	n=41, r ² =0.73, s.e.=0.45
Triazines	1.5 - 4.0	Triazines	Cl, CH ₃ O, CH ₃ S, NH ₂ , N-Alkyl	log K _{oc} = 0.30 log K _{ow} + 1.50	n=16, r ² =0.32, s.e.=0.38
Triazoles	(-1.0) - 5.0	Triazoles	Alkyl, CH ₃ O, F, Cl, CF ₃ , NH ₂	log K _{oc} = 0.47 log K _{ow} + 1.41	n=15, r ² =0.66, s.e.=0.48

a: Overestimated: *n*-alkyl alcohols (0.9 log units) and organic acids (0.55 log units); underestimated: amino-PAHs (1-2 log units), aliphatic amines (1-2 log units) and alkyl ureas (1.0-1.5 log units).

4.2.6.2 Metals

Adsorption of metals to the solid fraction of soil, sediment or particulate (suspended) matter depends on many variables such as cation exchange capacity, organic matter content and clay content, pH, redox potential, etc. In contrast to organic compounds, there is no estimation method to predict metal-solids partitioning in environmental compartments from compound properties. Thus, partition coefficients for metals have to be determined in and retrieved from experimental studies.

The K_p values are collected from all valid studies reporting metal partition coefficients. Relevant studies are those that report partitioning or distribution coefficients, represented by K_p or K_d , respectively for sediment, soil or suspended matter determined in field samples. See Appendix 2 for an explanation on terminology of partitioning coefficients.

Batch adsorption studies, performed in the laboratory, are a second type of potentially relevant studies. A few references that are of interest are Sauvé et al. [57] and Bockting et al. [58], although values of the latter have been criticised [59]. Due to the heterogeneity of adsorbents as well as conditions encountered in various compartments, K_p values for metals usually show a high variation. Since normalisation is generally not feasible, selection of the K_p value(s) to be used in equilibrium partitioning calculations needs careful consideration. If experimental data on K_p for metals are lacking, the data gap should be reported.

When collecting suspended matter:water partitioning coefficients from field studies, it is important to establish for each study if the water fraction was filtered before the metal concentration was determined in the aqueous phase. If the water phase was not filtered before metal analysis, the water concentration represents a 'total concentration'. The resulting partition coefficient is then a $K_{p, \text{susp-water}}$ for the 'total water concentration'. If the water sample is filtered (usually using a 0.45 μm filter) before analysis, the metal concentration represents a dissolved concentration. The assessor should report for each K_p value, whether it concerns a K_p based on total or dissolved concentrations. Since ERLs are generally expressed as dissolved concentrations, only K_p values based on dissolved concentration measurements can be used to convert ERLs to a total concentration.

4.2.6.3 Derivation of the $K_{p, \text{susp-water}}$

Following WFD methodology, the $K_{p, \text{susp-water}}$ is used as a trigger to decide on derivation of ERLs for sediment. The $K_{p, \text{susp-water}}$ is also used to recalculate ERLs for water, that are originally based on dissolved concentrations, into values based on total concentrations. The $K_{p, \text{susp-water}}$ should be based on dissolved water concentrations. See previous section, where this is explained for metals.

For organic substances, $K_{p, \text{susp-water}}$ is derived from the K_{oc} value and the fraction organic carbon of suspended matter according to Equation 5. For this calculation, the selected K_{oc} value (see section 4.2.6.1) is used together with the default fraction of organic carbon $FOC_{\text{susp, REACH}}$ of 0.1 [6].

$$K_{p, \text{susp-water}} = K_{oc} \cdot FOC_{\text{susp, REACH}} \quad (1)$$

If partitioning constants for suspended matter are available these can be used directly and may be preferred.

For metals, the value for $K_{p, \text{susp-water}}$ for metals should always be derived from experimental data. If data on field determined suspended matter: water partition coefficients are available, these can be used directly and might be preferred over K_p values for suspended matter derived in the laboratory and over K_p values for soil or sediment.

4.2.7 *Data on removal processes*

Insight into the behaviour of the test substance with respect to potential removal processes during ecotoxicity testing is highly relevant in assessing the validity of these tests. We discern physical/chemical and biological removal processes.

4.2.7.1 Physical and chemical removal

Data on vapour pressure (section 4.2.1) and Henry coefficient (section 4.2.2) have been collected and indicate whether the substance volatilises easily from aqueous solution or from soil (N.B. terrestrial toxicity studies). If the data collected indicate that the substance volatilises easily, ecotoxicity studies should be checked on appropriate analysis of the test substance and/or appropriate test set up to minimise evaporation.

Data on solubility/lipophilicity (section 4.2.3, 4.2.5) have been collected and indicate low soluble/lipophilic substances, that may disappear rapidly from solution due to sorption processes to matrix, biota and test vessel material. For such substances, dissolving the substance and maintenance of exposure concentration may become challenging. Care should be taken that appropriate sampling and analysis is employed, with a method and limit of detection allowing for accurate determination of the actual exposure concentrations. In addition the test set up may need to be adapted, e.g. using a generator column or renewal or flow-through systems to enable appropriate testing of the substance.

Photodegradation data should be collected from peer reviewed assessment reports that are available from registration frameworks (PPP, biocides, REACH, OECD, etc.), databases or handbooks that contain these data. Preferred data are those that express half-life values under realistic conditions. If available, the light source used to obtain the results should be tabulated as well. If photodegradation is relevant as a removal process, the possibility of degradation in toxicity tests should be evaluated.

Hydrolysis. Data should be collected from peer reviewed assessment reports that are available from registration frameworks (PPP, biocides, REACH, OECD, etc.), databases or handbooks that contain these data. The temperature and pH at which the hydrolysis rate is determined should be tabulated as well. If hydrolysis is relevant at ambient temperature and environmentally relevant pH levels, this should be addressed when interpreting the ecotoxicity tests. When interpreting hydrolysis tests for lipophilic substances, care should be taken that disappearance of the substance is not automatically interpreted as hydrolysis. A mass balance determination in the OECD 111 [60]

hydrolysis test is optional, especially when non-radiolabelled test substances are used. If a mass balance (at all sampling points during the test) has not been established, disappearance of the substance, measured only by a reduction of the analyte concentration in water may be caused by adsorption to test vessel material or volatilization.

4.2.7.2 Biological removal

Half-life values for biodegradation of the test substance in water, sediment or soil are collected. It is generally sufficient to tabulating data found in other data sources. If a general picture on the biodegradability of the substance emerges, this is normally sufficient to aid in evaluation of ecotoxicity studies. In specific cases, biodegradation may be a crucial parameter and in depth analysis of the data and thus underlying studies may be warranted. This approach is considered an exception rather than the rule and is not the standard approach.

5 Ecotoxicity data

5.1 Data collection

As indicated in section 2.1, the collection of ecotoxicity data consists of multiple steps. If the ERL is being updated, the former derivation report is taken as a starting point. For all other ERLs, first, data are gathered from secondary sources (databases, evaluation reports or risk limit derivations prepared by other countries). Next, the underlying studies are collected and evaluated and additional primary data are retrieved from open literature and other public sources. A thorough evaluation of all relevant studies is needed, using the appropriate evaluation methodology (see below). Due to data protection, it is often hard to get access to original study reports that are prepared by industry parties for registration purposes. An option that should always be considered is to explicitly invite stakeholders to submit their data for ERL derivation.

As an alternative option, we also accept summaries prepared for authorisation of compounds under various (European) legal frameworks, provided that those summaries contain sufficient information needed for evaluation of reliability (see below). Examples are the summaries prepared by industry within the context of REACH and the Competent Authority Reports (CARs) for biocides that can be accessed via the European Chemicals Agency (ECHA^{2,3}), and the Draft Assessment Reports (DARs) for plant protection products that are prepared by member states under EU regulation 1107/2009 and can be obtained from the European Food Safety Authority (EFSA⁴).

Please note that even though these data have been used within another framework, this does not mean that these data are automatically reliable within the context of the ERL derivation framework, and they should be evaluated according to the methodology as described below. When using summaries prepared in other frameworks, the citation of these data should always include the year in which these summaries were published. The year in which the study was conducted should be contained in the study summary.

5.1.1 Data sources

For the collection of ecotoxicity data, the following sources should preferably be used (not necessarily in the order presented here):

1. Previous ERL derivations by RIVM.
For current standards available via <https://rvs.rivm.nl/>, or all reports via <https://www.rivm.nl/publicaties>
2. ERL derivations by regulatory agencies in other countries
An overview of quality standards of various countries is available via a database of the German Umweltbundesamt at <http://webetox.uba.de/webETOX/index.do>. Several countries

² <http://echa.europa.eu/information-on-chemicals>

³ <http://www.echa.europa.eu/web/guest/information-on-chemicals/biocidal-active-substances>

⁴ <http://www.efsa.europa.eu/en/pesticidespeerreview/assessmentreports.htm>

publish ERL derivations, risk assessment reports and/or datasheets on the web. Contact persons are consulted for access to risk limit derivations and/or specific information on ecotoxicity.

3. Stakeholders
Industry parties involved in production or use of the compound(s) under investigation are invited to submit relevant studies, which will be treated as public literature.
4. Open literature
Relevant literature is retrieved by screening systems like Scopus or Web of Science. It is important to perform a retrospective literature search. The reference lists of publications or reports obtained should be carefully checked for related studies that have been published at earlier dates. A copy or pdf-file of each study that is deemed relevant should be obtained.
5. Databases
 - a. The OECD eChem Portal connects to several databases with information on physical chemical properties, ecotoxicity, environmental fate and behaviour, toxicity. <https://www.echemportal.org/echemportal/index.action>
 - b. The ECOTOX database from the US EPA [61] . A copy or pdf of the study report or peer-reviewed literature article underlying the results retrieved from this database is necessary to be able to assess the results. The database can be found at <https://cfpub.epa.gov/ecotox/>
ECHA database <https://echa.europa.eu/information-on-chemicals> for information on substances that are registered under REACH.
Note that the US EPA ECOTOX database and REACH dossiers are included in the OECD QSAR Toolbox, but depending on the release date of the latter, the underlying databases may contain additional information.
 - c. The database of the Japanese National Institute of Technology and Evaluation (NITE):
<https://www.nite.go.jp/index-e.html>.
6. EU-Risk Assessment Reports
Risk assessment reports (EU-RARs) published under the former Directive 67/548/EEC and following Regulation (EC) 1488/94, can be found at the ECHA website, <https://echa.europa.eu/nl/information-on-chemicals>. Note that some of the EU-RARs have not been finalised before REACH came into force and are indicated as so-called “Annex XV transitional reports”.
7. OECD assessments
The OECD works with member countries and other stakeholders to cooperatively assess the hazards of industrial chemicals. The Screening Information Dataset (SIDS) documents can be found via the Existing Chemicals Database <https://hpcchemicals.oecd.org/ui/Default.aspx> . As for studies

from other frameworks, studies included in the OECD SIDS documents are not automatically used without further evaluation.

8. Pesticides and biocides

European assessment reports are available online at several locations.

- a. Draft Assessment Reports (DARs) and draft Renewal Assessment Reports (RARs) prepared for agricultural pesticides by EU member states in the context of European approval under 1107/2009/EC can be obtained via EFSA. The easiest way is to search for the active substance on the EFSA-website, the internet page with the conclusions of the peer review contains links to the underlying documentation. The final List of Endpoints is attached as Appendix or as supplemental information to the official publication in the EFSA-journal.
- b. Assessment Reports (ARs) prepared for biocides by EU member states in the context of European authorisation under 98/9/EC and 528/2012/EC can be obtained via <https://echa.europa.eu/nl/information-on-chemicals> or via <https://www.echa.europa.eu/nl/information-on-chemicals/biocidal-active-substances>.

Assessment reports of individual countries may also be consulted. Evaluation reports from the US EPA may be retrieved via

<https://iaspub.epa.gov/apex/pesticides/f?p=CHEMICALSEARCH:1:>, under the tab 'dockets', evaluation report from Canada via <https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/decisions-updates.html#erc-re>.

9. Pharmaceuticals

Information can be obtained from published assessment reports (EPARs or PuARs), at <https://www.ema.europa.eu/en>. Also check <https://www.fass.se/LIF/startpage> and <http://www.wikipharma.org/welcome.asp>

If no or very few data are found in the steps described above, an additional internet search can be performed on the chemical name and CAS number of the compound using established search engines.

5.1.2 *Type of data considered*

For aquatic ERLs, ecotoxicity studies conducted in freshwater, seawater, and brackish water are potentially relevant and should be evaluated. For soil, experimental data on soil organisms are preferred, but if few data are available, ERLs are derived by equilibrium partitioning, meaning that all relevant aquatic data should be evaluated. A similar approach is followed for sediment. For groundwater organisms usually no experimental data are available, and aquatic ERLs are used as a substitute. ERLs for air are in most cases based on human-toxicological risk limits for inhalation, but in some cases specific information on ecosystem effects (e.g. plants) may be retrieved.

Whether or not data on secondary poisoning should be collected is dependent on some trigger values, for further guidance see ERL Report 03 for the aquatic compartment. The literature should be searched for bioaccumulation data if the log K_{ow} value of the substance is equal to or larger than 3, or if there is any other indication of a bioaccumulation potential of the substance. Useful data sources for bioconcentration factors (BCF) are the physico-chemical properties and environmental fate handbook [19] and ECOTOX database [61]. In case assessment of secondary poisoning is triggered, toxicity data for birds and mammals should be collected, by screening the appropriate sources as described above. In the case of toxicity to birds, short-term 5-day LC50 studies should be collected too if no adequate chronic data on birds are available [3].

➔ Location in WFD guidance: Appendix A1.3.1, p. 132.

5.2 Data evaluation and selection: procedure and general aspects

This section gives general guidance on data evaluation and lists some aspects that are relevant for all environmental compartments.

5.2.1 Procedure

An outline of the general procedure of the evaluation of the ecotoxicity data is given below.

All retrieved literature is read and evaluated with respect to its usefulness and reliability (see 2.2). After evaluating a study, the results of the study are summarised by entering it into the appropriate data tables. Some general items are listed below, specific guidance and examples of datatables for water are given in ERL Report 03, for birds and mammals refer to section 6 of this report.

In the toxicity data tables, all tested species are clustered in taxonomic groups. The taxonomic classification used within the project is given in ERL Report 11 and should be followed in all ERL derivations. Each row of the toxicity data table contains a test result for one species, endpoint and criterion. The columns of the toxicity data table contain the various study parameters. Columns should be filled as completely as possible. When there is no value for a given parameter, the table cell is left empty.

Data on aquatic, terrestrial, and benthic species are separated into acute and chronic data, with a separate table for each category. For aquatic toxicity data, data on freshwater organisms and data on marine organisms are placed in separate tables. Terrestrial toxicity data are divided into toxicity data on terrestrial species and data on terrestrial microbial processes and enzymatic reactions. Toxicity data on birds and mammals are placed in separate tables. If many data are available, a distinction can be made between studies with oral dosing (capsule, gavage) and dietary (food) exposure. All references of ecotoxicity studies mentioned in the data tables should be included in one or more reference lists.

A series of toxicity data tables has now been created, the number of which depends on the compartments of interest (e.g. secondary

poisoning may or may not have been triggered, etc.). Next, from each toxicity data table, the selected toxicity data are aggregated to *one toxicity value per species*. Such an aggregated data table is created for all compartments. The table will contain the data that are used for the actual risk limit derivation. The guidance on compilation of this table is given in section 5.3.

➔ Location in WFD guidance: Appendix A1.3.2, p. 132.

5.2.2 *Acute and chronic ecotoxicity data used for ERL derivation*

In the context of ecotoxicological testing, the terms 'acute' and 'chronic' refer to the test duration in relation to the generation time of an organism and the endpoint studied. Acute and chronic can not be translated with the terms 'short-term' and 'long-term' as the latter indicate only the length of the exposure time in the toxicity test. E.g. short-term is days to one week, long-term is weeks to months. Note that this terminology allows for a border area where both terms may apply. Effect levels or no effect levels such as EC50 or NOEC can be derived from chronic as well as acute tests and may refer to lethal as well as sub-lethal parameters [62]. The principal ecotoxicological test results used in ERL derivation are EC50 or LC50 values from acute studies and NOEC, EC10 or LC10 values from chronic studies, the latter usually on sublethal endpoints. See Table 6 for an overview. Within the context of this guidance, a chronic toxicity study is defined as a study in which:

1. the species is exposed to the toxicant for at least one complete life cycle, or
2. the species is exposed to the toxicant during one or more sensitive life stages.

This definition is in line with REACH (and WFD) guidance, which state that NOECs from chronic/long-term studies should preferably be derived from full life-cycle or multi-generation studies [3,9]. True chronic studies cover all sensitive life stages. Hence, an acute study is a study in which the species is exposed to the toxicant for a part of its life cycle and not during a sensitive life stage.

To decide on classification of tests in the ERL data tables (acute or chronic), the above definition of chronic is leading. If a study is not chronic following the definition, it is tabulated under the acute tests. E.g. a 14-day fish study, which is not an early life stage, embryo or developmental test. Considering the exposure duration only, such a test would perhaps be called a sub-chronic test, rather than 'acute'. For the sake of ERL derivation it classifies as 'acute'. This guidance cannot cover all cases and borderline cases have to be judged upon by expert judgment.

Tests with algae are considered as short-term studies, i.e. lasting only a few days, but in view of the generation time of algae, the obtained endpoints are considered to refer to chronic effects rather than acute effects. However, due to the inability to maintain exponential growth in an algal culture for a longer period of time, the EC50 of this test is used as an acute value, while the NOEC or EC10 of such a test is a chronic

value (see [4], p. 24). For all Daphnid species, the standard exposure time for acute toxicity is 48 hours, but with regard to chronic toxicity, there is a factor of three difference between the tests with *Daphnia magna* (21 days) and *Ceriodaphnia dubia* (7 days), the latter having a much shorter generation time. Similarly, short term tests with first instar larvae of insect species are not considered as chronic tests. With regard to the most common aquatic species, toxicity studies with fish are considered acute if mortality is considered after 96 hours (standard acute test) or after 14 days (prolonged acute toxicity test). The most common chronic toxicity tests for fish are early life-stage tests (ELS), in which eggs or larvae are exposed and the effects on hatching, malformation and growth are considered. Most ELS tests for fish, but also for other species such as amphibians (FETAX test), larval growth tests for molluscs (often performed with *Crassostrea* sp., but other species are used as well) or echinoderms, can be considered as chronic or sub-chronic toxicity studies, even if the duration of exposure is only a couple of days (see also [4]).

For terrestrial organisms, the division into acute and chronic is less clear, because the minimum duration of the available OECD tests is a few weeks. According to the REACH guidance [4], the LC50 from a 14-days earthworm study should be considered as an acute endpoint, while the NOEC for reproduction from a 56 day study is a chronic endpoint. However, if a NOEC for mortality of adults is obtained from the first phase of this study, this is also considered as a chronic endpoint. For plants, the updated OECD guideline 208 is designed to assess the potential effects of substances on seedling emergence and growth. Therefore, it is specific to a part of the plants life-cycle and does not cover chronic effects or effects on reproduction, however it is assumed to cover a sensitive stage in the life-cycle of a plant and therefore data obtained from this study have been used as estimates of chronic toxicity [4].

The test results commonly encountered in ecotoxicological tests are summarised in Table 6. Their use (or not) in ERL derivation is described in columns 3 and 4 of this table. For explanation of abbreviations please see the List of abbreviations. The most common endpoints are either EC50 or LC50 in the case of acute toxicity tests and EC10 or NOEC in the case of a chronic test. Other examples of endpoints that are regularly found in the literature are LOEC, MATC (the geometric mean of NOEC and LOEC) and TLm, which is equivalent to the LC50. If a NOEC is reported, the LOEC can be omitted from the reporting table. For reasons of completeness and as supporting information for the derivation of the ERLs, EC50 and LC50 values from chronic studies as well as NOEC and EC10 values from acute studies may be documented in the data tables.

If the endpoint presented is an ECx or LOEC value with an effect between 10 and 20% (i.e. $x = 10-20$), then a NOEC can be derived according to REACH Guidance R10 (Table R.10-1), by dividing the ECx by a factor of 2. In such a case, the NOEC can be presented in the toxicity data table, with a note that this value is estimated from an ECx value. In a strict sense, calculating NOEC as $ECx/2$, according to REACH guidance, is only allowed for ECx values with an effect smaller than 20%. However, EC20 values are often presented in the literature. If there is no other information on the dose-response relationship (e.g. a companion EC50, which enables the calculation of an EC10), the EC20 divided by 2 can be considered as NOEC as well, accompanied by a footnote in the table with selected toxicity data (see section 5.3). However, in all cases, the information on a dose-response relationship must be used as much as possible. If it is possible to derive EC50 and EC10 values from a range of tabulated or graphically presented ECx values, these derived endpoints can be included in the toxicity data table as well, accompanied by a footnote stating the method of derivation.

Table 6 Criteria derived from toxicity studies and their use in ERL derivation – summary.

Test type	Criterion	Use in ERL derivation?	Action
acute test	EC10 or LC10	No ^a	Tabulate value; may be valuable as additional information
acute test	EC50 or LC50	Yes	Tabulate value
acute test	ECx or LCx	No	Tabulate value; may be valuable as additional information
acute test	LOEC	No	Omit if NOEC is also available from same experiment Else: tabulate value; may be valuable as additional information
acute test	MATC ^b	No	Omit if NOEC is also available from same experiment Else: tabulate value; may be valuable as additional information
acute test	NOEC	No ^a	Tabulate value; may be valuable as additional information
acute test	TLm	Yes	Tabulate as LC50 ^c
chronic test	EC10 or LC10	Yes	Tabulate value
chronic test	EC50 or LC50	No ^a	Tabulate value; may be valuable as additional information
chronic test	ECx (x < 10)	No	Omit if NOEC is also available from same experiment If more than one ECx value is available, try to establish an EC10 from a statistically reliable dose-response relationship Else: tabulate value; may be valuable as additional information
chronic test	ECx (10 < x < 20)	Yes	Omit if NOEC is also available from same experiment If more than one ECx value is available, try to establish an EC10 from a statistically reliable dose-response relationship Tabulate value if the ECx is the lowest effect concentration measured. Calculate NOEC = ECx/2 (REACH Guidance ; Table R.10-1) and tabulate this NOEC ^d
chronic test	ECx (x ≥ 20)	No	Tabulate value; may be valuable as additional information If more than one ECx value is available, try to establish an EC10 from a statistically reliable dose-response relationship
chronic test	LOEC	No	Omit if NOEC is also available from same experiment

Test type	Criterion	Use in ERL derivation?	Action
			Else: (i) if percentage effect is known, see ECx in this table for further guidance Else: (ii) if percentage effect is unknown: tabulate value; may be valuable as additional information
chronic test	MATC ^b - single value, no further information	Yes	Omit if NOEC is also available from same experiment Else, if no further information is available, calculate NOEC = MATC/√2 (REACH Guidance ; Table R.10-1) and tabulate this NOEC ^e
chronic test	MATC ^b - reported as a range	Yes	Omit if NOEC is also available from same experiment Else, if no further information is available, tabulate the lowest value of the range as NOEC ^f
chronic test	MATC – spacing factor ^g is given ^f	Yes	Omit if NOEC is also available from same experiment Else, if no further information is available, calculate NOEC = MATC/√(spacing factor) ^g and tabulate this NOEC ^h
chronic test	NOEC	Yes	Omit LOEC if it is also available from same experiment

a: For toxicity tests with algae and Lemna sp., both the EC50 and the EC10 or NOEC are used in the ERL derivation, if available.

b: The MATC is the geometric mean of NOEC and LOEC.

c: A footnote should be added to the toxicity data table stating that the TLM is used as LC50.

d: A footnote should be added to the toxicity data table stating that the NOEC is calculated as ECx/2.

e: A footnote should be added to the toxicity data table stating that the NOEC is calculated as MATC/√2.

f: A footnote should be added to the toxicity data table stating that the lowest value of the MATC range is taken as NOEC.

g: The spacing factor is the factor of difference between two subsequent testing concentrations employed in the toxicity experiment.

h: A footnote should be added to the toxicity data table stating that the NOEC is calculated as MATC/√(spacing factor).

5.2.3 *Relevant ecotoxicity endpoints*

In general only those endpoints are considered that have consequences at the population level of the test species (see also WFD guidance). The list below shows some population-relevant parameters:

- growth (weight, length, growth rate, biomass)
- number (cells, population)
- mortality
- immobilisation
- reproduction
- hatching (rate, time, percentage)
- sex ratio
- development (egg, embryo, life stage)
- malformations (teratogenicity)
- proliferation (cells)
- filtration rate (bivalve molluscs)
- carbon uptake (algae)
- reburial (of e.g. certain crustacean species)

This list is not exhaustive. Demographic parameters (e.g. age distribution) and data from biomarkers may be used as endpoints if they are relevant in terms of population dynamics. Similarly, inhibition of photosynthesis in may be included as a marker for reduced viability of algae. Toxicity test results based on parameters for which the relationship to effects at the population level is uncertain or not established, are not used as a basis for ERL derivation. Some examples of endpoints where effects at population level are unclear include:

- blood or plasma protein levels,
- certain histopathological endpoints,
- organ weights (e.g. hepatosomatic index, gonadosomatic index),
- mRNA induction,
- endpoints determined *in vitro* tests,
- behavioural responses (e.g. swimming behaviour, antenna motility, etc.),
- coloration.

Note however, that the use of these types of endpoints for ERL derivation might be reconsidered when a definite correlation or causal relationship with an effect at the population level is established [9]. Regarding histopathology, clear effects on reproductive organs may be considered more closely related with population-level effects than changes in e.g. liver structure. This also holds for behavioural responses such as feeding and (in)ability to escape from predator attack.

Based on an exploratory literature review on this topic, it was concluded recently that for fish and crustaceans sufficient evidence exists that effects on movement and feeding should be treated in a same manner as 'traditional' response parameters such as growth and reproduction [63]. Available evidence from a meta-analysis demonstrates that the sensitivity of acute behavioural responses was more or less comparable to chronic effects on growth and reproduction. For species already present in the dataset with test results on growth and reproduction, inclusion of behavioural parameters may thus not lead

to markedly different NOEC values. However, inclusion of such information may substantially increase the dataset with species for which those apical endpoints (e.g. growth, reproduction) are not available and may thus give a better picture of the variation in species sensitivity. The authors of the literature review advise to gather and graphically present all available information instead of starting an environmental risk assessment with eliminating information on 'non-traditional' parameters [63]. An example of such a graphical representation of results is given below (Figure 1). According to the authors, in such a case an ERL can still be based on traditional endpoints and at the same time be compared with additional information to judge whether the ERL is sufficiently protective. In addition, if effects are observed for parameters for which a relationship with population development has not (yet) been established, this may still be a reason to adapt the assessment factor if these effects appear at lower concentrations than the lowest valid endpoint.

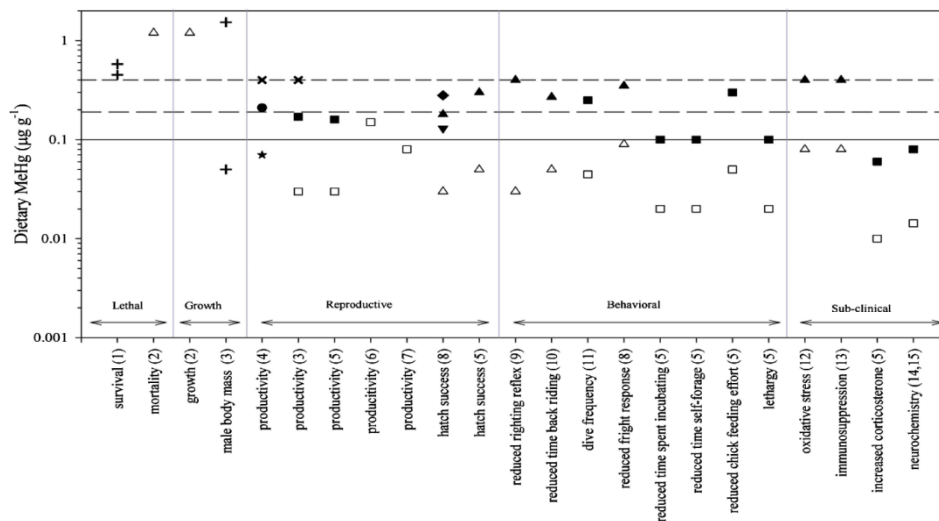


Figure 1 Graphical representation of data found in the literature for the effect of methyl mercury on different endpoints in the common loon *Gavia immer*. Figure copied from [64].

5.2.4

Toxicity values higher or lower than range of test concentration

If the highest concentration in an ecotoxicity test is not high enough to determine the NOEC or L(E)C50, the result of that study should be tabulated as 'NOEC \geq ' or 'L(E)C50 $>$ ', followed by the value of the highest test concentration. This test result should be reported in the toxicity data tables, but is not used as a basis for the ERLs. However, it is valuable information that a species from this taxon (or trophic level) has been tested and that it was not sensitive to the toxicant at a known concentration, especially when the data set is limited. Because of this, the presence of this toxicity value may influence the height of the assessment factor. For example: when NOEC values for algae, *Daphnia* and fish are found, of which one is a 'NOEC \geq ' value, and this value is not the lowest effect concentration, an assessment factor of 10 may be applied, whereas this would have been 50 if the study had been rejected.

For similar reasons, data from tests resulting in an effect at the lowest test concentration should be tabulated as NOEC < or L(E)C50 <, followed by the value of the lowest test concentration. Although these values cannot be used directly for the derivation of the risk limits, the information is useful to compare the sensitivity of that specific species with the derived risk limit. This comparison may influence the choice for the final assessment factor that is applied for the derivation of the risk limit.

5.2.5 *Purity and identity of the test substance*

In some tests the identity of the test substance is largely unknown or the purity of the test substance is very low. Depending on the nature of the impurities present, if these have been identified at all, a minimum purity of 80% is required, unless it is known that the impurities do not cause any toxic effects by themselves and do not influence the toxicity of the substance of interest. When the purity of the tested compound is < 90%, the test result should be corrected for purity. For technical mixtures of compounds of which a substantial fraction (impurity) consists of one or more compounds structurally related to the test compound, it is subject to expert judgement whether the test result is useful for risk limit derivation or not. For pesticides, toxicity should be expressed in terms of the concentration of active ingredient. If a formulation has been tested, but due to missing information it is not possible to express the endpoint on the basis of the active ingredient, the study is assigned Ri 3 (see section 2.2).

5.2.6 *Use of co-solvents, emulsifiers and dispersants, formulated products*

Sometimes, the solubility of a compound is so low that a solvent, emulsifier or dispersant is used to prepare suitably concentrated stock solutions of the test substances. Such vehicles may not be used to enhance the solubility of the test substance in the test medium, and in any case the compounds used for this purpose may not be toxic to the tested species. Therefore, a control with the vehicle (solvent control) used should be incorporated in the set-up of the test. According to several OECD test guidelines for aquatic toxicity testing, the concentrations of the solvent, emulsifier or dispersant should not exceed 100 mg/L (or 100 µg/mL or 0.01%). In terrestrial studies, a common procedure for addition of substances that are insoluble in water is to add the compound as a solution in acetone, after which the vessels are left overnight to let the solvent evaporate (e.g. OECD guidelines 207, 232).

For derivation of ERLs for pesticides, studies with the active ingredient are considered most appropriate. Effects of formulations, if present, will be relevant shortly after application and in the near vicinity of the site of use, but less so for generic long-term quality standards. When for a given species results are available from similar tests with the active and with formulations (for comparable endpoints), it should be determined whether or not the results can be pooled. Recently, it was proposed to use the geometric mean of the available values for studies with the active ingredient only and studies with formulations, if the standard deviation of the log-transformed individual toxicity values is <0.5 [62]. However, further analysis of this proposal reveals that with small datasets, endpoints differing by more than a factor of 10 can also meet this criterion. Therefore a more arbitrary cut-off value is advised: if the

endpoints for studies with formulations and studies with the active ingredient only differ by more than a factor of 3, the value of the studies with the active ingredient is used, also when this results in a higher value. However, if for a species the most critical endpoint originates from a test with a formulated product, and no comparable endpoint from a test with the active substance is available, this endpoint of the formulation is used for risk limit derivation.

5.2.7 *Comparison of toxicity values with water solubility*

In principle, toxicity studies that have been conducted at concentrations above the water solubility should not be used for ERL derivation. However, depending on the uncertainty in the estimate of the water solubility (see section 4.2.3 on how to determine and choose solubility values), test results (L(E)C50, NOEC, EC10) that are ≤ 2 times the estimated solubility value might be included in the risk assessment. The factor of 2 is a rather arbitrary value; when experimental data show that the variation in the estimate of the water solubility is lower, it should be lowered accordingly. When the variation in the estimate of the water solubility is higher than a factor of 2, it may be increased to a factor of 3 (maximum). Toxicity studies showing results above the water solubility receive a footnote stating: 'test result above water solubility'. For terrestrial studies, it should be considered if saturation of pore water has been likely at the soil concentrations tested. When deriving ERLs for PAHs, it was concluded that some NOECs expressed on the basis of total soil concentrations were of limited relevance, because pore water was already saturated at levels far below the concentrations used in the test [65].

5.2.8 *pH, pK_a and ionisation of test compound*

When a test has been performed according to a guideline, the pH should be within the required range for this test and, if not, it should be checked whether the test can still be considered valid. Expert judgement should be employed to determine if a test result should be excluded. A test may become invalid because the test organisms naturally occur at other pH values. For non-standard guideline studies, expert judgement is needed to decide on this.

In some cases, the compound itself may alter the pH strongly. In such cases, it should always be checked whether the observed toxicity might be caused by this change in pH. If so, the test must be considered as invalid, because the buffering capacity of the environment will prevent such a pH effect in the field. For compounds containing functional groups with acidic or basic properties, the pK_a value(s) should be reported in the table with physico-chemical properties (section 4.2, Table 3). Attention should be paid to possible relationships between pH and toxicity of the tested compound, for example, due to a reduced availability (speciation, precipitation, hydrolysis, etc.) of the test compound. The toxicity of a compound may be influenced by its degree of ionisation⁵. Hydrophobicity, and consequently solubility and bioavailability of a given compound may vary dramatically even within

⁵ 'Degree of ionisation' as used in this section expresses the ratio of the number of charged molecules over the total number of neutral and charged molecules at a given concentration and at a given pH.

an environmentally relevant pH range [66]. In general, neutral forms tend to be more toxic than ionised forms. However, since uptake may also be influenced by the degree of ionisation, the net effect on toxicity may differ. The degree of ionisation of a compound in a toxicity test therefore is an important factor which is determined by several factors:

- the pKa value(s) of the test compound,
- the concentration of the test compound,
- pH of the test compartment (soil, water, sediment),
- the buffering capacity of the test-matrix.

In practice:

- a compound's potential to ionise (pK_a in physico-chemical table) should be checked (see also section 4.2.4);
- presence of one or more pKa value(s), or ionisable group(s), triggers the attention for pH effects in toxicity studies;
- if toxicity test results reveal that toxicity is dependent on the pH of the test-matrix (soil, water, sediment), it might be considered to reject test results if the pH falls outside the range of what can be expected naturally.

Test results should be rejected when it can be inferred that the toxicity in a given study is not caused by the compound alone, but also by a pH change. Hence, results from tests with ionisable compounds performed in buffered media (providing sufficient buffering capacity) may be considered more reliable than those performed without a buffer. Those studies that explicitly mention a measured pH after addition of the toxicant are most useful in this respect.

5.2.9 *Ecotoxicity studies performed in other media*

For the purpose of ERL derivation, only studies are considered in which the species are tested in medium that resembles their natural habitat. If this is not the case, as for example with terrestrial plant toxicity studies that were conducted in nutrient solution or toxicity studies with earthworms on filter paper, these studies are not used as a basis for ERL derivation. Effect concentrations for terrestrial species should be expressed in weight units per kg dry soil, and this is impossible when a study was conducted in water or filter paper. Generally, these studies are not reported in the data tables in which all toxicity studies are collected, but they may still be used for purposes of comparison.

Terrestrial species tested in nutrient solutions can be compared with aquatic species if equilibrium partitioning is used to derive the environmental risk limits for soil. If data on aquatic macrophytes are missing, terrestrial plant species tested in water may give an indication of the expected (in)sensitivity and be used for justification of assessment factors or to judge if a Species Sensitivity Distribution (SSD) may be constructed despite a missing taxon.

In some terrestrial toxicity studies, concentrations in pore water are reported. Results from these studies can only be used if truly dissolved concentrations have been measured (e.g. by SPME or SPMD techniques). Analyses in pore water obtained after centrifugation are not useful in this respect since the water fraction obtained in this way may still contain a fraction of a substance associated with DOC, or associated

with the POC fraction that is too light to be centrifuged or a fraction of substance in colloidal form, if applicable to the substance in question. Equilibrium partitioning should be applied to the pore water concentration, in order to calculate a concentration in soil that can be used in ERL derivation.

Benthic species are often tested in a water-only system or a system with inert substrates (e.g. glass beads, quartz sand). In such cases the data are still tabulated, and may be used for derivation of risk limits for water.

5.3 Selection and aggregation of laboratory ecotoxicity data

One toxicity value per species is selected/calculated for use in the assessments. Where multiple data are available for the same species/endpoints that are obtained under comparable test conditions, individual toxicity data may be aggregated using the same principles as those in Chapter R.10 of the REACH Guidance [3]. Below, some general points are listed which should be considered when grouping data per species, based on several guidance documents [3,9,10,62,66]. For specific items, see also the ERL documents on water, sediment and soil.

1. Identify particularly sensitive species and/or endpoints that may be lost upon averaging data to single values.
2. Investigate multiple values for the same endpoint on a case by case basis and look for the cause of differences between results.
3. Where valid data show high variation that can be explained, grouping of data is considered, e.g. by pH ranges.
4. If an effect of test conditions is expected to be the cause of variation in toxicity values, averaging of data per species should not be performed. Examples are: hardness of test water, life stage of the test animal, pH, clay content of soil, test duration, bioavailability governed by interactions other than hydrophobic sorption alone, etc.
5. For non-standard test species, preference is given to endpoints for parameters that are applicable to related standard test species, e.g. immobility for non-standard crustaceans or reproduction of non-standard worm species. Whether or not non-standard endpoints can be included in the dataset has to be judged on a case-by-case basis.
6. If results are available from test(s) with different exposure durations, preference is given to the results from tests that followed the (minimum) test duration as specified in the guideline. E.g. when an EC10 for algal growth rate after 24, 48 and 72 h exposure is available, the 72 h result will be used when this is consistent with an existing guideline. The same holds when a 24 h EC10 after and a 72 h EC10 are available for the same species but from different tests. Both studies and results are

tabulated, but the 72 h value is preferred and selected for use in ERL derivation⁶.

7. Data for derivation of ERLs should be selected on the relevance of test conditions (pH, hardness, etc.) to the field. However, deselection of data on the basis of presumed irrelevant test conditions should only be done if it is clear that the conditions have a major influence on the test result.
8. If the variation in test results of different life stages of a test animal is such that averaging data would cause significant under-protection of sensitive life stages, only the data for the most sensitive life stage should be selected. In other words, it is important that sensitive life stages are protected.
9. If differences in the chemical form of the test compound (congeners, stereoisomers, etc.) are the cause of variation in toxicity values for a test species, data should not be averaged. In these cases, separate ERLs should be derived for each chemical form.
10. Based on the aforementioned considerations, calculate the geometric mean of multiple comparable toxicity values for the same species and the same endpoint. This applies to both acute and chronic data.
11. If multiple toxicity values or geometric means for different endpoints are available for one species, the most sensitive endpoint is selected as long as it is relevant to population sustainability. If multiple valid toxicity data for one species are left that cannot be averaged, the lowest value is selected.

Example. There are values (NOECs or EC10 values) for three different endpoints, derived from several chronic studies with *Daphnia magna*. The geometric mean of NOECs for reproduction is 0.49 mg/L, the geometric mean of NOECs for mortality = 3.1 mg/L and there is a single EC10 value for growth of 0.67 mg/L. The geometric mean value of 0.49 mg/L for reproduction is selected for use in ERL derivation.

Particular steps have been developed for metals to account for variations in the toxicity of different metal species. This will be elaborated on in a future ERL report.

The aggregated data should be presented in a new table. The selected acute and chronic values are presented separately for each species, and a footnote is added to explain how the value is derived from the summary data tables. Examples of such tables are presented in the ERL document on water (see ERL Report 03). These documents also contain more detailed information on test systems for those specific compartments.

⁶ Prerequisite for this is that exposure to the test substance is well identified in both tests.

6 Evaluation and selection of bird and mammal toxicity data

6.1 Data collection and evaluation

6.1.1 *General*

International guidelines exist for performing ecotoxicity studies for a number of species. The most frequently used guidelines are summarised in Appendix 1.

The use of chronic studies is preferred, but according to WFD guidance, short term dietary toxicity studies with birds (OECD 205) may also be taken into account. Data from single dosing via gavage or capsules (OECD 223) are not mentioned in the REACH guidance and are in general not taken into account for the assessment of secondary poisoning in the WFD guidance. However, if single dose gavage data indicate high toxicity, and no other data are available, these data may be used for ERL derivation.

➔ Location in WFD guidance: Appendix A1.3.5, p. 148-150.

Results of mammal studies are usually expressed as a (dietary) dose in mg/kg_{bw}/d. For birds, this is also the case for acute studies, and for dietary studies performed in line with EFSA guidance [67]. Results of older dietary studies, however, are usually expressed as a concentration in food (mg/kg_{food}). Options for conversion are given below (sections 6.1.2.13, 6.1.2.14, and 6.2). However, applying the new method for assessing secondary poisoning (see ERL Report 07), by which diet concentrations are normalized to the energy content of the diet, is preferred over this conversion.

When assessing secondary poisoning, data on bioconcentration, bioaccumulation and biomagnification should be collected as well. For information on the collection of these parameters, see the sections on aquatic bioaccumulation in the relevant ERL document (ERL Report 03).

6.1.2 *Data tables for laboratory toxicity studies with birds and mammals*

Results from toxicity studies with birds and mammals are tabulated separately from other ecotoxicity data tables. Only data on oral exposure are relevant for the route secondary poisoning. Depending on the number of data, it may be considered to combine the data for birds and mammals into one table, or to present different tables. The following sections (6.1.2.1 to 6.1.2.17) discuss the parameters that are reported in the bird and mammal toxicity data tables, an example of which is presented in Table 7.

Table 7 Example of a data table for birds and mammals.

Legend to column headings	
Species properties	relevant characteristics of the test species, such as sex, age, size, origin
Purity	refers to purity of active substance or content of active substance in formulation; ag = analytical grade; tg = technical grade
Appl. Route	diet = dietary; water = drinking water; gav = oral gavage (intubation); caps = oral capsule
DFI	Daily Food Intake
Ri	Reliability index according to [11]. Valid studies (Ri 2 or higher) are considered for ERL derivation

Species	Species properties	Test compound	Purity [%]	Appl. route	Vehicle	Diet type	DFI [kg _{food} /kg _{bw} /d]	Duration	Exp. time	Criterion	Endpoint	Value [mg/kg _{bw} /d]	Value [mg/kg _{rd}]	Ri	Note	Ref.
Birds																
<i>Anas platyrhynchos</i>	9 d	active	96.9	diet		fodder		8 d	5 d	LC50	mortality	> 2000		3	1	[a]
<i>Colinus virginianus</i>	9-12 m	active	ag	diet		fodder		24 w	21 w	NOEC	reproduction		1800	2	2,3	[b]
Mammals																
<i>Rattus norvegicus</i>	> 8 w	active	99.5%	diet		fodder	0.16	90 d	90 d	NOAEL	body weight	80	500	2	4	[c]
<i>Rattus norvegicus</i>	pregnant	active	97.5%	gav	oil			gestation days	14 d	NOEC	embryo development	10		2		[d]
<i>Rattus norvegicus</i>	adult	active	95.8	diet		fodder		2 gen		NOAEL	body weight	50		2	3	[e]

Notes

- 1 according to OECD guideline; repellency and vomiting noted, actual ingestion not clear
- 2 OECD guidelines
- 3 DFI not given
- 4 dietary dose calculated from dietary concentration using DFI

- 6.1.2.1 **Species**
In the toxicity data table all available toxicity data for a given compound are ordered by test organism. Species are grouped in taxonomic groups (i.e. birds or mammals). A comprehensive list of taxonomic groups is shown in ERL Report 11. Latin names are used for species names. Species names within a taxon are listed in alphabetical order.
- 6.1.2.2 **Species properties**
The most relevant properties of the test organism are mentioned in this column; e.g. age, size, weight or life stage. Toxicity data for organisms with different age, size, life stage etc., are presented as individual entries (i.e. one entry in each row) in the data table.
If the body weight of the test species is reported in the study it should be entered in this column. Body weight is especially important for estimating the daily energy expenditure of an organism. This parameter can be used to calculate energy-normalized diet concentrations.
- 6.1.2.3 **Product or substance**
Toxicity studies on birds or mammals may also be carried out with formulations or products rather than individual substances. Report the name of the substance, product of formulation that has been used in this column.
- 6.1.2.4 **Purity or a.i. content**
In case a product (or formulation) is tested, report the content of active ingredient (a.i.) present in the product, expressed in %. If the purity of the active ingredient (used in formulation) is also known, report this in a footnote.
If a single substance has been applied in the test, report the purity of the tested compound in this column.
- 6.1.2.5 **Application route**
Relevant are those toxicity tests in which the animals are dosed orally. This might be achieved via a direct method (intubation, gavage, capsule) or by dosing via food (diet) or drinking water.
- 6.1.2.6 **Vehicle**
The carrier that is used with the test substance when dosing is reported here (e.g. corn oil).
- 6.1.2.7 **Diet**
The type of food that is administered to the test animals during the study is reported here. This can be any type of laboratory fodder, but also fish, meat, vegetables, fruit and so on. The type of food is important, because it may strongly differ in energy content. This is directly related to the amount of food that is required by the animal per day to meet its daily energy expenditure. As such, the type of food is also related to the daily food intake (see next section). If given, the energy content of the food should be reported as well.
In the column 'Notes' (section 6.1.2.16) indicate whether the food was analysed for presence of the test substance and if yes, report the outcome.

6.1.2.8 Daily food intake per body weight

Unit: $\text{kg}_{\text{food}}/\text{kg}_{\text{bw}}/\text{d}$

The daily food intake per body weight (DFI) is the ratio of the daily consumed mass of food and the body weight of the animal. It can be used to express doses as diet concentrations and vice versa. If the DFI is given per bird, use the body weight for conversion. If body weight is not given, the DFI may be presented as $\text{kg}_{\text{food}}/\text{animal}/\text{d}$.

6.1.2.9 Test duration

The value in this column reports the total duration of the test. Use abbreviations hours (h), days (d), weeks (w), months (mo) and years (y). This column should also be filled in when the test duration is equal to the exposure duration. The test duration might be longer than the exposure time, which is reported in the next column (Exposure time). For example in the acute avian dietary toxicity test, in which the exposure lasts 5 days, the minimal recommended test duration is 8 days. Durations may be also expressed in general terms such as “two generations” or “during gestation”, which can be used to classify exposure duration as chronic or short-term.

6.1.2.10 Exposure time

The duration of exposure to the toxicant in the toxicity experiment is expressed in this column. Use abbreviations for hours (h), days (d), weeks (w), months (m) and years (y).

6.1.2.11 Criterion

Short term toxicity tests will yield an LC50 or an LD50. Long-term toxicity tests will generally result in a NOEC or a NOEL (No Observed Effect Level). Results from long-term toxicity tests may also be reported as a NOAEL, which is the no observed adverse effect level. However, the effects observed for the derivation of the NOEC/NOEL are generally adverse to the organisms. Results may be expressed as a (dietary) dose in $\text{mg}/\text{kg}_{\text{bw}}/\text{d}$ (see 6.1.2.13), or as a concentration in food (see 6.1.2.14).

6.1.2.12 Test endpoint

The toxicological parameter for which the test result is obtained is tabulated here. Screening for clinical parameters at haematological, histopathological or biochemical level is common in these types of tests, but not necessarily directly related to population effects. The list below is not exhaustive, it shows some of the relevant endpoints:

- body weight
- litter size
- pup weight
- egg production
- eggshell thickness
- hatchability
- hatchling survival
- mortality
- reproduction
- viability (percentage of viable embryos per total number of eggs)

- 6.1.2.13 Value as (dietary) dose (rate)
Unit: mg/kg_{bw}/d
Results of bird and mammal repetitive oral dosing studies are expressed in mg/kg_{bw}/d. In dietary studies the result is also often expressed as dietary dose, expressed in mg/kg_{bw}/d too. If body weight is known, the value should also be tabulated (In the column Species properties, see section 6.1.2.2), because the daily energy expenditure (DEE) will be calculated from body weight in the secondary poisoning assessment. As part of that assessment the dietary dose will be recalculated into a concentration in biota based on this DEE and tabulated energy contents of different food items. See further ERL Report 07.
- 6.1.2.14 Value as dietary concentration
Unit: mg/kg_{fd}
The results of toxicity tests in which the substance of interest is administered via the food are often expressed in mg/kg_{fd}. The results of dietary studies (LC50, or NOEC values) are reported in this column. For recent guideline studies with birds, the dietary dose is often already calculated from the DFI (see 6.1.2.8) and presented in the study report. A dietary dose should also be listed in the previous column. If the dietary dose is not presented in the report, but the DFI and bodyweight are known, the dietary dose should be calculated and entered in the previous column (section 6.1.2.13).
- 6.1.2.15 Food energy content
Unit: kJ/g_{dw}
If the energy content of the laboratory food used in the study is reported, or can be deduced from other sources, this should be tabulated here. In the secondary poisoning assessment, the dietary concentration will be recalculated into a concentration in biota based on tabulated energy contents of different food items.
- 6.1.2.16 Reliability
This column contains a number (1, 2, 3 or 4), indicating the quality of the study summarised according to section 2.2.
- 6.1.2.17 Notes
This column contains references to footnotes that are listed below the toxicity data tables. Numbers are used to refer to footnotes.
- 6.1.2.18 Reference
The reference to the study from which data are tabulated, All cited references are listed in a reference list. If references are generated using bibliographic software (e.g. Endnote), it is most convenient to list all references, including those of the Annexes, into one single reference list.

6.2 Selection of bird and mammal toxicity data

All valid ($R_i = 1$ and 2) data are selected for derivation of the PNEC. For derivation of risk limits covering secondary poisoning, the methodology described in ERL Report 07 is followed, which allows for correction of differences in caloric content between the dietary items in the field and the diets provided in the laboratory studies. In order to apply this methodology, study results expressed as dietary concentrations as well as those expressed as dose rates are converted to energy normalised concentrations in mg/kJ. See section 2.7 of ERL Report 07 for equations.

If the data do not allow for the calculation of energy based diet concentrations, the methodology below is followed. For each of the selected avian or mammalian toxicity studies, the test result is expressed as a $NOEC_{oral}$ in mg/kg_{food}. If the test result is expressed as a dose in mg/kg_{bw}/d, and conversion to a dietary concentration cannot be performed on the basis of reported DFI and bodyweight, equations 4 and 5 are used with default conversion factors (CONV, see Table 8). For other species than listed in this table, a suitable conversion factor should be used on the basis of knowledge on similarity with the listed species with respect to feeding characteristic.

$$NOEC_{bird} = NOAEL_{bird} \cdot CONV_{bird} \quad (6)$$

$$NOEC_{mammal, food_chr} = NOAEL_{mammal, oral_chr} \cdot CONV_{mammal} \quad (7)$$

Table 8 Conversion factors ($CONV_{bird}$ or $CONV_{mammal}$) from NOAEL to NOEC for several species.

Species	Common name	CONV [bw/dfi]
<i>Canis domesticus</i>	Dog	40
<i>Macaca</i> sp.	Macaque species (monkey)	20
<i>Microtus</i> spp.	Vole species	8.3
<i>Mus musculus</i>	House mouse	8.3
<i>Oryctolagus cuniculus</i>	European rabbit	33.3
<i>Rattus norvegicus</i> (>6 weeks)	Brown rat	20
<i>Rattus norvegicus</i> (≤ 6 weeks)	Brown rat	10
<i>Gallus domesticus</i>	Chicken	8

bw = body weight (g); dfi = daily food intake (g/d).

7 Human toxicological threshold limits

A human toxicological threshold value (TTL_{hh}) is needed at several places in ERL derivation:

- in the derivation of the water quality standard for surface waters based on human consumption of fishery products ($QS_{water, hh\ food}$, see ERL Report 03)
- in the derivation of the quality standard for surface water intended for drinking water abstraction ($QS_{dw, hh}$, see ERL Report 03)
- in the derivation of the risk limits for soil based on indirect exposure of humans (ERL report to be developed).
- in the derivation of MPC_{air} , see ERL Report 06)

For derivation of MPC_{air} , the TCA (Tolerable Concentration in Air) is used or the $CR_{inhalation}$ (inhalatory Cancer Risk) for genotoxic carcinogens. See section 2.1 of ERL Report 06 for further guidance.

For the other three ERLs listed above, the TTL_{hh} values that can be used are the ADI (acceptable daily intake) and the TDI (tolerable daily intake). The US ATSDR uses the term MRL (minimum risk level) while the US EPA uses the term RfD (reference dose). A list of organisations or frameworks that have published human toxicological threshold limits is presented in Table 9.

In general, it is advised to take the most recent value and consult a human toxicologist on the final choice of the value. If a clear value is reported in a European risk assessment report, or a value for TTL_{hh} is derived in the Netherlands (often denoted as MPC_{human} or MPR_{human}), these values should preferably be used because of consistency with other national frameworks. However, a human toxicologist should be consulted to check if new data exist that require updating of those values. For substances for which a threshold level cannot be given (e.g. genotoxic carcinogens), unit risk values corresponding to an additional cancer risk may be used, if available (see also section 4.5 of ERL Report 01). The risk levels to be used for the respective compartments are explained in the specific chapters.

The basis for the human-toxicological threshold levels is in principle a NO(A)EL from a mammalian toxicity study, which is useful if established threshold levels are unavailable. However, the NOAEL is not a human toxicological threshold value and an AF (typically 100) must be used. To derive a TDI or ADI from a NOAEL, a human toxicologist should be consulted. Effect data can be obtained from the human health section of risk assessments according to e.g. REACH (Regulation (EC) No. 1907/2006) [68] or its legal predecessor, Council Regulation (EEC) No. 793/93 [69], Regulation (EC) 1107/2009 [70] or its predecessor Council Directive 91/414/EEC [71].

In recent years, overarching databases have become available. These systems give access to existing (inter)national databases with toxicological information, including most of the abovementioned ones. Two important databases to obtain toxicological information are: eChemPortal (<https://www.echemportal.org/echemportal/index.action>) US EPA (<http://actor.epa.gov/toxrefdb/faces/Home.jsp>).

Table 9 Sources for the retrieval of human toxicological threshold limits.

Source name and publisher	Available at
ATSDR Toxicological Profiles (ATSDR)	https://www.atsdr.cdc.gov/toxprofiledocs/index.html
German BfR summary of ADIs for pesticides	Via https://link.springer.com/article/10.1007%2Fs00103-007-0303-x
IPCS (CICAD)	http://www.inchem.org/pages/cicads.html
DWQG (WHO)	http://www.who.int/water_sanitation_health/dwg/guidelines/en/
EFSA	http://www.efsa.europa.eu/
Environmental Health Criteria (EHC) (WHO/IPCS)	http://www.inchem.org/pages/ehc.html
EU pesticides database	http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&language=EN
HSDB (NLM/NIH)	https://toxnet.nlm.nih.gov/newtoxnet/hsdb.htm
HSG (WHO)	http://www.inchem.org/pages/hsg.html
IARC Monographs (WHO)	https://monographs.iarc.fr/ http://www.inchem.org/pages/iarc.html
ICSC (IPCS-EU)	http://www.inchem.org/pages/icsc.html
IRIS (US EPA)	https://www.epa.gov/IRIS/
ITER (TERA)	https://www.tera.org/iter/
JECFA Monographs (WHO/FAO)	http://www.inchem.org/pages/jecfa.html
JMPR Monographs (WHO/FAO)	http://www.inchem.org/pages/jmpr.html
OEHHA Toxicity Criteria Database (Cal-EPA)	https://oehha.ca.gov/chemicals
RIVM	https://rvs.rivm.nl/#
RIVM: MPC _{human} values for the derivation of SRC _{human}	https://www.rivm.nl/bibliotheek/rapporten/711701025.pdf
SIDS (OECD-UNEP)	https://hvpchemicals.oecd.org/ui/Default.aspx
WHO Air Quality Guidelines	https://www.who.int/phe/health_topics/outdoorair/outdoorair_aqg/en/ http://www.euro.who.int/_data/assets/pdf_file/0005/74732/E71922.pdf

#: this website does not contain a list of ADI- or TDI-values, but can be used to find documentation on the substance of concern.

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List of abbreviations

ADI	acceptable daily intake
AF	assessment factor
a.i.	active ingredient
US ATSDR	United States Agency for Toxic Substances and Disease Registry
BfR	Bundesinstitut für Risikobewertung
BCF	bioconcentration factor
bw	body weight
CAR	competent authority report in the context of European biocide authorisation under 98/9/EC and 528/2012/EC
CAS	Chemical Abstract Service
ClogP	calculated log octanol/water partitioning coefficient by the software program BioLoom [21]
CONV	conversion factor
d	days
DAR	draft assessment report in the context of EU Regulation 1107/2009
DEE	daily energy expenditure
DFI	daily food intake
DT50	dissipation time for 50% of the substance
DWQG	drinking water quality guidelines
EC	European Commission
ECHA	European Chemicals Agency
EC _x	effect concentration at which an effect of x% is observed, generally EC10 and EC50 are calculated
EEC	European Economic Community (replaced by EU)
EFSA	European Food Safety Authority
EHC	Environmental Health Criteria
ELS	early life stage
EPAR	European public assessment report (pharmaceuticals)
EPI suite	estimation programs interface suite
EPICS	equilibrium partitioning in closed systems
ERL	environmental risk limit
EU	European Union
EU-RAR	European Union-Risk Assessment Report in the context of the former the former Directive 67/548/EEC and following Regulation (EC) 1488/94
FAO	Food and Agriculture Organisation
FETAX	frog embryo teratogenesis assay
GC	gas chromatography
GLP	Good Laboratory Practice
h	hours
HPLC	high performance liquid chromatography
HSDB	hazardous substances databank
HSG	health and safety guides
IARC	International Agency for Research on Cancer
ICSC	International Chemical Safety Cards
INS	International and National Environmental Quality Standards for Substances in the Netherlands In Dutch: (Inter)nationale Normen Stoffen

IPCS	International Programme on Chemical Safety
IRIS	Integrated Risk Information System
ITER	International Toxicity Estimates for Risk assessment
IUPAC	International Union of Pure and Applied Chemistry
JECFA	Joint Expert Committee on Food Additives
JMPR	Joint Meeting on Pesticide Residues
LC _x	effect concentration at which x% lethality is observed, generally LC50 and LC10 are calculated
LD50	dose that is lethal to 50% of the tested animals
LOEC	lowest observed effect concentration
MATC	maximum acceptable toxicant concentration
MC1	molecular connectivity indices
MlogP	measured log octanol/water partitioning coefficient selected by the software program BioLoom
mo	months
MPC	maximum permissible concentration
MPR	maximum permissible risk level
MRL	minimum risk level
mRNA	messenger ribonucleic acid
NIH	national institutes of health
NITE	(Japanese) National Institute of Technology and Evaluation
NLM	National Library of Medicine
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
NOEL	no observed effect level
oc	organic carbon
OECD	Organization for Economic Co-operation and Development
OEHHA	Office of Environmental Health Hazard Assessment
om	organic matter
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PNEC	predicted no effect concentration
PSD	Pesticides Safety Directorate (United Kingdom)
PuAR	public assessment report (pharmaceuticals)
QS	quality standard
QSAR	quantitative structure activity relationship
REACH	Registration, Evaluation, Authorisation and Restriction of Chemical substances.
RfD	reference dose
Ri	reliability index
RIVM	National Institute for Public Health and the Environment
SIDS	screening information data set (OECD)
SMILES	simplified molecular input line entry system
sp.	species
SPM	suspended particulate matter
SPMD	semi permeable membrane device
SPME	solid phase micro extraction
SRC	Syracuse Research Company
SRC _{human}	serious risk concentration for humans
susp	suspended particulate matter
SSD	species sensitivity distribution
TDI	tolerable daily intake
TERA	Toxicology Excellence for Risk Assessment
TGD	Technical Guidance Document

TTL _{hh}	threshold level for human health
TL _m	median tolerance limit; also encountered as: median threshold limit
UK	United Kingdom
US EPA	United States Environmental Protection Agency
w	Weeks
WAF	water accommodated fraction
WFD	Water Framework Directive
WHO	World Health Organization
y	Years

Appendix 1. Established guidelines for bird and mammal tests

OECD 205 (1984)

Avian Dietary Toxicity Test. This test can be used as an acute toxicity test with birds for the assessment of secondary poisoning. Birds are exposed to the test substance via the diet for five days. From day 6 onwards birds are fed a basal diet, for a period three days (recovery period). Concentration in the diet should be maintained at $\geq 80\%$ of nominal during the exposure period. The lowest test concentration should not display any toxic effects in the birds. Species described as suitable in this TG are, *Anas platyrhynchos* (Mallard duck), *Colinus virginianus* (Bobwhite quail), *Columba livia* (Pigeon), *Coturnix coturnix* (Japanese quail), *Phasianus colchicus* (Ring-necked pheasant), *Alectoris rufa* (Redlegged

partridge) but other species may be tested using this set up as well. Birds should be 10-17 days of age, except *C. livia*, which should be 56-70 days. Recorded are intoxication/behaviour symptoms, mortality, weight and food consumption. The expressed effect level is the LC50 (mg/kg_{food}). The testing limit is 5000 mg/kg_{fd}. Note that the composition including nutrient analysis: protein, carbohydrate, fat, calcium, phosphorus, etc.) of the basal diet (i.e. the diet without the test substance) should be reported.

OECD 206 (1984)

Avian Reproduction Test. This test can be used as a chronic toxicity test with birds for the assessment of secondary poisoning, because the exposure duration is at least 20 weeks. Species described as suitable in this TG are, *Anas platyrhynchos* (Mallard duck), *Colinus virginianus* (Bobwhite quail) and *Coturnix coturnix* (Japanese quail). Other species may be tested, but this selection should be justified in the report. Age of the birds at test start is ca. 2-9 months for duck and 20-24 weeks for Bobwhite. Japanese quails should be proven breeders. Birds cohorts of comparable age are fed the test substance via the diet for the entire exposure period. Birds are induced to lay eggs, which are collected, incubated and hatched and young maintained for 14 days. There are at least three test concentrations, the highest 0.5 x acute LC10. Maximum dose is 1000 mg/kg_{fd}. A carrier (water, corn oil, etc.) may be used at maximally 2% (w/w) diet. Analytical measurements of diet concentrations are prescribed in the test (see TG for details) and test concentrations should be carefully maintained.

For adults: toxicity symptoms, mortality, weight, food consumption and pathology are recorded. For young birds, weight (14 d) and food consumption are recorded. Reproduction related parameters reported are: egg production, percentage of cracked eggs, egg shell thickness, viability, hatchability and effects on young birds are the investigated parameters. The expressed effect level for these endpoints is a NOEC (mg/kg_{fd}). Any statistically significant levels should be reported as well. In addition to tests on birds (OECD guidelines 205 and 206), the OECD has a series of guidelines of toxicity tests with mammals for use in human health risk assessment. These data might also be used in the derivation of EQSs (secondary poisoning of top predators) provided that

the test endpoints relate to the effects at the population level of the species (see section 6.1.2.12). The following OECD guidelines are most important in this respect: OECD 407, 409, 414, 415, 416 and 443.

Appendix 2. Partition coefficients – glossary

This appendix gives a brief overview of terminology and equations used with respect to partition coefficients encountered in soil and sediment adsorption studies.

In the field of environmental chemistry and ecotoxicology, the distribution of a compound over two different environmental compartments is commonly described using an equilibrium constant, expressed by the capital letter *K*. The equilibrium constant describes a ratio of concentrations of a chemical compound in two different phases, similar to the description of the dissociation constant of acids and bases at equilibrium (usually pK_a).

Since the solute solvent sorbent system is assumed to be in thermodynamic equilibrium, *K* can be considered a constant; however, it is valid only for the conditions (pH, temperature, concentration range, type of sorbent, etc.) employed during its determination. To illustrate that the ratio refers to the *distribution* of a compound over two phases rather than a concentration ratio in identical phases, a subscript d (for distribution) is added: K_d .

The term *partitioning* is also used to describe the distribution of a compound over different phases, e.g. when describing the partitioning of a compound between octanol and water: K_{ow} . The same parameter is also found as P_{ow} .

In practice, distribution constants of metals between water and soil (or sediment, or suspended matter) are often expressed as K_p values, and are then referred to as partition coefficients (rather than constants). In fact, both K_d and K_p are used here to describe the same process (i.e. adsorption) and can be seen as synonyms. In the pesticide registration framework, $K_{s/l}$ is also used to describe the same parameter and is called solid/liquid partition coefficient.

When sorption is independent of the concentration of the compound of interest, the sorption isotherm⁷ is linear and K_d is calculated as follows:

$$K_d = K_p = \frac{C_s}{C_w} \quad (8)$$

in which

- K_d and K_p are the linear distribution coefficient, linear partition coefficient or simply: linear sorption coefficient [L/kg]
- C_s is the concentration in the solid phase [mg/kg]
- C_w is the concentration in the aqueous phase [mg/L]

The units presented are those most commonly encountered in scientific literature, but different units may also be used.

⁷ A sorption isotherm is the relationship between the adsorbed concentration (dependent variable) and the dissolved concentration of a compound, determined at a constant temperature.

The relationship most often used to describe non linear sorption is the (empirical) Freundlich model:

$$C_s = K_f \times C_w^{\frac{1}{n}} \quad (9)$$

in which

- K_f is the Freundlich sorption coefficient [L/kg, when $1/n=1^8$]
- n is an empirically determined parameter [-]

When $n = 1$, sorption is linear and $K_f = K_d$. When $n > 1$, the sorption isotherm is curved downward, with $n < 1$, the sorption isotherm is curved upward. It is not possible to specifically address the causes of non linearity of sorption isotherms. Both compound properties and sorbent characteristics influence sorption behaviour and at present, no general agreement exists on the mechanism(s) of sorption (Ten Hulscher, 2005).

Linearity or non linearity of sorption can be investigated by plotting logarithms of C_s versus logarithms of C_w . The slope of the linear function fitted through the data points is $1/n$ and the logarithmic form of equation 9 is a linear relationship when $n = 1$. In evaluating adsorption studies in the framework of Dutch pesticide registration, K_f values are considered acceptable when $1/n$ is within the range of 0.7 – 1.1 [13]. We refer to Mensink *et al.* for quality criteria when reviewing batch adsorption studies.

K_f values are accepted as K_d values without correction when $1/n$ values are within the range of 0.7 – 1.1. K_f values with $1/n$ values outside the range of 0.7 – 1.1 are considered unreliable and are not used for ERL derivation.

For many organic compounds (in particular, neutral hydrophobic compounds), the sorption constant is directly proportional to the quantity of organic matter of the sorbent (Boethling and Mackay, 2000). K_p can then be normalised to the organic carbon content of the sorbent:

$$K_{oc} = \frac{K_p}{F_{oc}} \quad (102)$$

in which

- K_{oc} is organic carbon normalised sorption coefficient [L/kg_{oc}]
- K_p is the partition coefficient [L/kg_{dw}]
- F_{oc} is the fraction organic carbon of the sorbent [kg_{oc}/kg_{dw}]

When the percentage of organic carbon of the sorbent is not reported it can be calculated from the percentage organic matter using a conversion factor. In equation:

$$\%O.C. = \frac{\%O.M.}{1.7} \quad (11)$$

⁸ When $1/n \neq 1$, K_f has the unit $L^{1/n} \cdot mg^{1-1/n}/kg$.

in which

- % o.c. is the percentage organic carbon of the sorbent [% (w/w)]
- % o.m. is the percentage organic matter of the sorbent [% (w/w)]
- 1.7 is a conversion factor representing the ratio of soil organic matter content over organic carbon content [$\text{kg}_{\text{om}}/\text{kg}_{\text{oc}}$]

As a general rule it is assumed that organic matter contains $1/1.7 \times 100\% = 58.8\%$ organic carbon.