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Aquatic Toxicity Data Evaluation

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CONTENTS

SUMMARY

A database, termed the ECETOC Aquatic Toxicity (EAT) database, consisting of original published information on the toxicity of substances to aquatic species in fresh and saline waters has been compiled. The principal quality criteria for acceptance of data were that test methods should be well described and the toxicant concentrations must be measured. On this basis 42% of the 530 papers examined were found to be suitable for inclusion in the EAT database.

The EAT database input software is easy to use and has been prepared for Personal Computers operating in a DOS environment. For each entry there are 21 fields of information on the substances, test species, test details, results and source references. All the references are held at ECETOC.

The EAT database includes information on 368 substances for 122 aquatic test species. Publications from 1970 to 1991 have been assessed, giving 2200 entries; organohalogens and heavy metals make up most of the data entries which reflects historical concern over these chemicals. The toxicity of all substances was evenly distributed in a log normal scale. Some groups of substances were found to be more toxic than others. The higher toxicity is not necessarily linked with substances of historical concern. Sensitivity of the test organisms to chemicals was evenly distributed. On the scale of sensitivity bacteria seem to be least sensitive and invertebrates most sensitive as a general rule.

Analysis of the data can be performed using a number of specially written routines. These include the ability to select data using various options, to prepare simple counts, frequency distributions, ratios (e.g. between acute and chronic results) and regression analyses. The regression analyses take account of the fact that in comparing toxicity test end-points there are no dependent or independent axes in the strictest sense.

In order to provide a scientific basis for application factors used in risk assessment, the ratio of acute EC_{50}:chronic NOEC was assessed for 12 different selections of data. The median ratios varied from 3.6 to 28.0. When 19 substances typical of those which could be notified under the provisions of the Seventh Amendment Directive (92/32/EEC) were considered the range of ratios was 1.25 to 28.3. The maximum acute EC_{50}:chronic NOEC value of 28.3 (for 100% of substances) is an indication that the factor of 40 (for 90% of substances) given in ECETOC (1993) may be rather conservative. The latter was derived from the same database using a different statistical approach, i.e. not allowing for the separate assessment of individual species.

This report includes a summary of approaches to hazard assessment, especially the use of different application factors and describes the result of these using three substances.

SECTION 1. INTRODUCTION

In response to the continuing demands of public, government and industry to safeguard the aquatic environment while maintaining effective and beneficial use of industrial chemicals, there is an increasing need to carry out a risk assessment of substances. A multiplicity of approaches has evolved in an attempt to meet this need.

Aquatic risk assessment requires different approaches from methods used to protect man. The protection of the aquatic environment is essentially a matter of protecting populations and their habitats. In order to do this relatively small numbers of individuals belonging to species representing the taxonomic group of concern are studied in the laboratory or in model ecosystems. In man the emphasis must be on the protection of the individual using other species to acquire the experimental data. In the safeguarding of the aquatic environment the species of concern may be examined directly, but results from a relatively small number of individuals are used to protect populations and ecosystems. Furthermore, it is necessary to extrapolate from the largely artificial nature of laboratory tests to conditions in the environment at large and, in particular, to consider the bioavailability of the substance in the environment. In carrying out aquatic risk assessment and calculations of acceptable concentrations, it has to be taken into consideration that some important industrial substances also occur naturally in surface waters, some of them even being essential for aquatic life.

In response to the need to establish methods for testing substances to define their potential for harm or hazard to the aquatic environment, a compromise has evolved between the very large testing programmes needed to acquire maximum confidence and the need to develop reasonably comprehensive but cost-effective programmes. It is recognised that the toxicity of a given compound to aquatic organisms may be influenced by a range of biological, chemical and physical factors. These include, for example, the age of the test organism, the dilution water characteristics and the test temperature. Consideration has therefore to be given to these experimental factors when evaluating aquatic toxicity data. Such considerations are included in regulatory protocols for aquatic toxicity testing which by standardisation seek to limit these confounding factors. The OECD has led these efforts internationally, producing, since 1979, guidelines for the testing of substances (OECD, 1981). The OECD guidelines have been adopted to a great extent by the European Community.

Guidelines and protocols certainly contribute to improved reproducibility of test results which has been of great importance when the objective was only to classify substances on their inherent

properties. Reproducibility was achieved at the cost of reduction in ecological relevance. With the move from hazard identification to risk assessment there is a need to bridge the gap between laboratory and field and this requires an examination of non-standard species and test conditions. The EAT database established herein draws on the literature from all types of aquatic toxicity assessment and allows an analysis of broader issues based on limited experience.

With the above in mind the Aquatic Toxicity Data Evaluation Task Force was formed initially to consider the potential toxicity of substances in the aquatic environment, the evaluation of species used for testing and the relationships between acute and chronic toxicity for aquatic organisms.

The Terms of Reference were:

- collect and review data on substances which have been tested for their effects on aquatic organisms in acute, sub-chronic and chronic tests;
- comment upon the interpretation of data on the acute toxicity and their relevance to the overall hazard posed by substances;
- examine the relationships between the results obtained from different species for acute, sub-chronic and chronic tests;
- recommend a strategy for assessing risk to the aquatic environment and identify appropriate decision criteria.

Due to the increasing intensity of debate on environmental hazard and risk assessment in Europe, the following additional terms of reference were subsequently added:

- critically review the proposed approaches to aquatic risk assessment;
- consider the practical implications for known environmental contaminants;
- recommend a scientifically sound approach for defining maximum levels of substances in the aquatic environment.

A first report is now presented. It has to be considered against legislative developments (see Section 4.1 below).

The terminology used in this report is that developed by the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992 and is also used in the EC "Risk Assessment Directive" (EEC, 1993). It differs from that which the EEC used in its workshop on risk assessment held in Ispra in October 1990 (EEC, 1990). Appendix A describes the two sets of terminology and defines other important terms used in this report.

SECTION 2. MODUS OPERANDI

2.1 CRITERIA FOR SELECTION OF DATA

In compiling the EAT database the following criteria were applied for the selection of data:

- data should be drawn from original scientific publications rather than from reviews or unpublished reports; reviews and databases were used to identify the source of original material;

- biological test methods employed were described, or reference was made to an appropriate published method;

- methods for the chemical analysis used to define the exposure concentrations of the test substance were described or referenced; thus all data represented measured rather than nominal concentrations;

- in the cases of limit tests, non-toxic substances and water solubility problems the following special criteria were applied:

  Results with substances that were non-toxic in limit tests were ignored and those which were non-toxic at 10,000 mg/l were rejected for calculation since they are considered environmentally irrelevant (they are included and indicated in the EAT database with 9999.9999). Potential problems regarding substances with low or very low solubility in water were not taken into account and the analytically verified values were taken as valid data. Studies in which vehicles (solvents, dispersants, etc.) were used to prepare sparingly water-soluble substances for testing were not excluded.

Due to the application of these selection criteria it is evident that for individual substances the database may not present the results of all valid studies performed. It is recognised that the data omitted may be of value towards other objectives than those of the present work, e.g. towards classification and labelling. On the other hand some of the data included may not be suitable for these purposes, particularly where in the case of sparingly water-soluble substances toxic concentrations could only be generated with the aid of vehicles.

2.2 SCOPE AND DEFINITIONS

Data were recorded for freshwater, estuarine and marine species.

It was found necessary to re-evaluate the definitions used for test duration, especially those used to describe 'acute' or 'chronic' toxicity. For example, a study of a few days represents a small fraction of the life cycle of a fish, a whole generation for a small crustacean or many generations of an alga.

To overcome the above inconsistencies the following definitions were applied:

> Acute exposure in animals covered any period up to one third of the time taken from 'birth' to sexual maturity provided that the animal could survive in good condition without feeding for such a period. Exposures were defined as sub-chronic if they were equivalent to no more than one third of the time taken to reach sexual maturity but feeding was required. Any more lengthy exposure was defined as chronic. For algae, chronic studies were taken to be those longer than 12 hours. Examples are given in Table 1.

Table 1 Definitions of Test Duration

Species	Usual maximum duration of test		
	Acute	Sub-chronic	Chronic
Algae	12 h	-	> acute
Daphnid	48 h	72 h	> subchronic
Zebrafish	96 h	30 d	> subchronic
Rainbow trout	7 d	250 d	> subchronic

Additional definitions may be found in Appendices A and C.

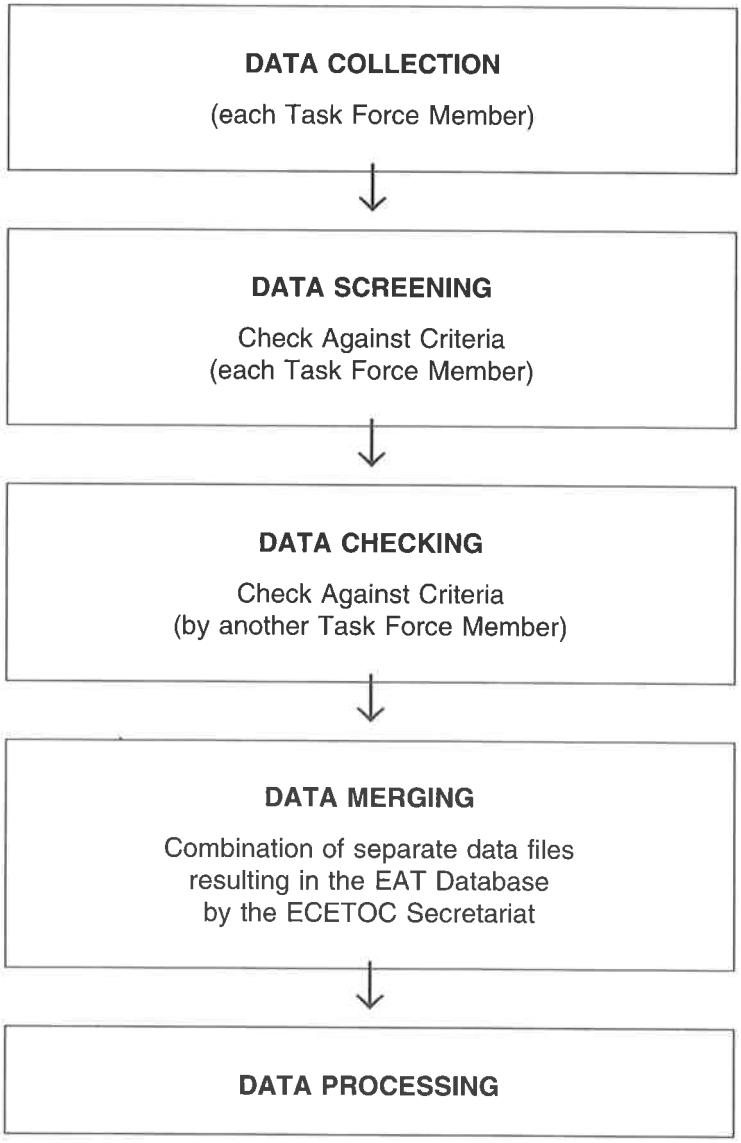
2.3 LITERATURE

Literature was gathered and screened according to the agreed criteria set out above. Applying the criteria, 530 papers were reviewed; of these 222 papers were found to be suitable for inclusion in the EAT database. The major reason for rejection of information was the failure to measure the toxicant concentration during the assay period. The literature screened dated from 1970 to 1991.

2.4 THE EAT DATABASE

A computer-based storage and retrieval system was established to aid in the processing and evaluation of the collected data which additionally permitted statistical analysis. A diagrammatic overview of the system used for data collection and evaluation is given in Figure 1. A more detailed description of the procedures used as well as a listing of the present data arranged according to Chemical Name and a CAS-No index are given in the separate Appendix C to this report.

Figure 1: Procedure of Data Collection and Evaluation



SECTION 3. RESULTS AND INTERPRETATION OF THE EAT DATABASE

3.1 MATHEMATICAL PROCEDURES FOR DATA EVALUATION

The evaluation of the data was carried out with a statistical software called SAS Version 6.04 for Personal Computers (SAS Institute Inc., Cary NC, USA) which is a menu-driven multi-window program. It offered the possibility of choosing data from the database by a selection procedure and of performing simple counts, frequency analyses, correlation studies, acute:chronic ratios and Hazen-distributions.

The principles and basic details of data evaluation in SAS are explained below.

3.1.1 Definition of "Value" and "Mean Value"

As used here, the term "value" represented an individual observation, such as an EC_{50}(96h) expressed in mg/l and was always related to one substance. Where relevant the toxicity data refer to the active form of the test material e.g. undissociated ammonia. Further detail is provided by Alabaster and Lloyd (1982).

Where for a certain selection (e.g. acute values for *Daphnia magna*) several values were found, the geometric mean of the values was calculated and this mean value used in the further evaluation.

3.1.2 Correlation Studies and Definition of "Data"

A major technique used was correlation analysis, such as species-species or acute-chronic relationships.

The values used to establish correlations were either mean values, if several values were available for a substance, or single values, if only one value was available. In the evaluation and correlation studies, the term "data" is used for both types of values.

The correlations were established using a special form of weighted linear regression for analyses written in the SAS-macro WFUNREL. Two characteristics of the data made this necessary:

- all data used to establish the correlations were (or were derived from) measured values (e.g. NOECs at the y-axis and LC_{50}s at the x-axis) with the consequence that both axes are subject to error;

- each point in the correlation was created by a single "x"-axis data point and a single "y"-axis data point; both data points, however, may be created from an unequal number of values (e.g. three values contributed to the "x"-axis data point and 15 values contributed to the "y"-axis data point).

WFUNREL took both characteristics into account by correcting for the error on both axes and including weighting factors for the different numbers of values which contributed to the "x"- and "y"-axis data point.

A typical printout is presented as an example (Figure 2). The size of the circle at each point reflects the number of "horizontal axis" and "vertical axis" values considered for each data point.

WFUNREL obtained the intercept and the slope parameters of a functional relationship and calculated the standard deviations and confidence intervals using an iterative procedure until the slope changed by less than 1%, which gave the final intercept and slope parameters.

3.1.3 Example: Calculation of Acute to Chronic Ratios

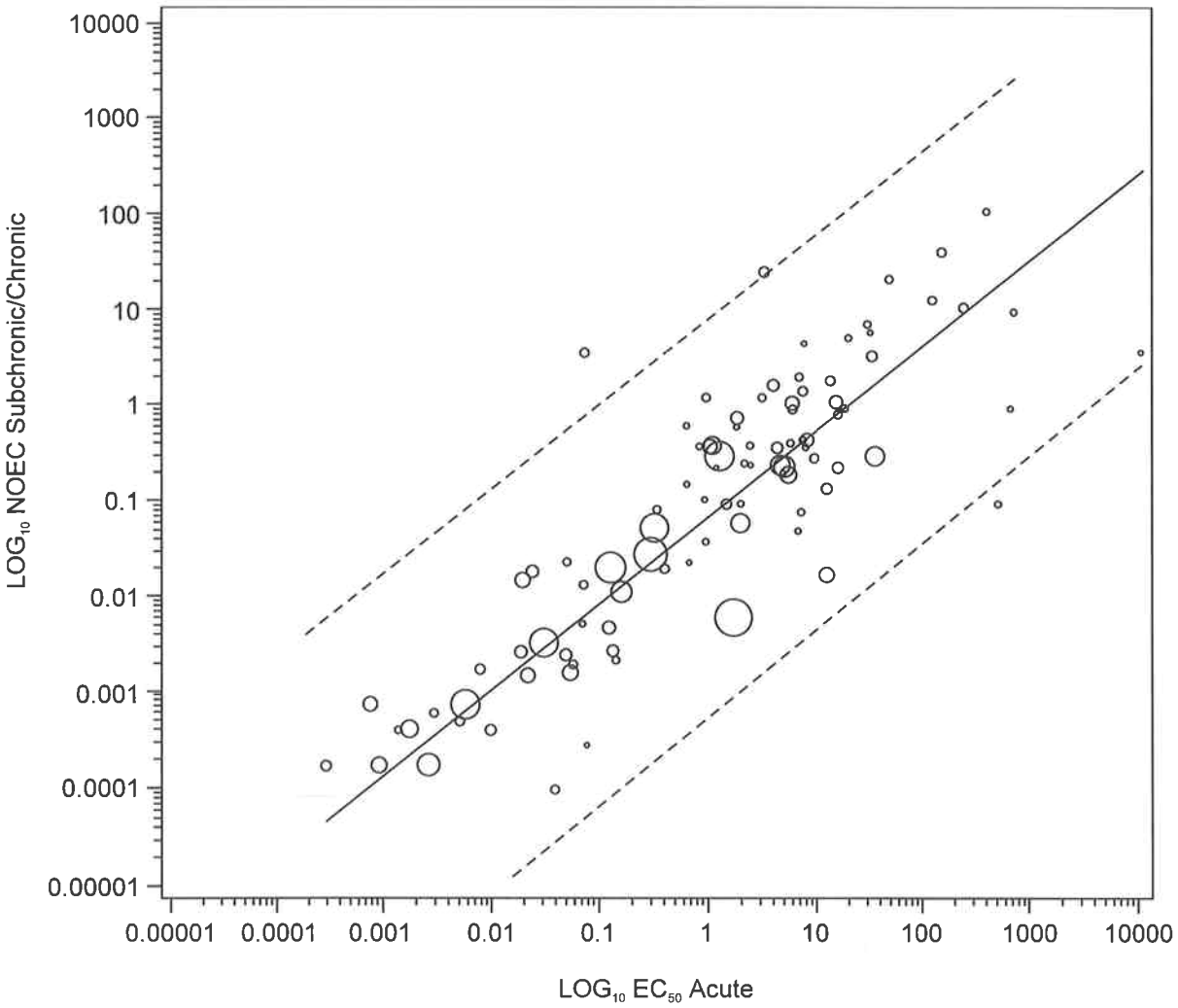
In relation to this calculation, "acute" data were defined as the acute EC_{50} and "chronic" data were defined as the chronic or sub-chronic NOEC. All other data (e.g. acute NOECs or chronic EC_{50}) were excluded from these calculations.

The data used to perform acute:chronic ratios were selected according to the following three methods:

- for each substance all available values were taken and geometric means were calculated for the combined species within "acute" or "chronic/subchronic" as defined in Table 1, this was the approach used earlier by ECETOC (1993);

- for each substance and each individual species geometric means were calculated for all the values for single species within "acute" or "chronic/subchronic" as defined in Table 1;

Figure 2 EAT Database: Mean Scores for Individual Chemicals



(96 points; F statistic (p-value) = 712.52 (0.000); R-squared = 0.883)

- the selections described before were refined in order to focus the acute:chronic ratios more precisely by choosing only data related to the following test durations:

  Daphnid acute: 48 hours,

  Daphnid chronic: 21 days,

  Fish acute: 96 hours,

  Fish chronic: 14-42 days.

3.1.4 Hazen Distribution

After calculating the ratios, they were ranked in ascending order and a "Hazen-percentile" was assigned to each.

The percentile is given for the n^{th} substance as described in Equation 1:

$$\frac{100}{2x} + \frac{100(n-1)}{x} \qquad (1)$$

where x is the total number of points in the analysis.

Thus, if there were ten points in the series the ones with the lowest (n=1) and highest (n=x) ratios were assigned, respectively:

$$\frac{100}{2\times10} + \frac{100(1-1)}{10} = \frac{100}{20} = \text{the 5 percentile} \qquad (2)$$

$$\frac{100}{2\times10} + \frac{100(10-1)}{10} = \frac{100}{20} + \frac{900}{10} = \text{the 95 percentile} \qquad (3)$$

This simply created a symmetrical plot for the cumulative distribution of the ratios as their percentiles, avoiding the statistical improbability of 0% or 100%.

3.2 SIMPLE COUNTS

Simple data point counting as presented in detail in Appendix D provides information on the nature and use of the substances included in the EAT database, the test organisms and the sensitivities between species for the various chemical classes of substances.

The sensitivity of the test organisms to the tested substances is evenly distributed on a log-normal scale (see Appendix D, Figs. D.6 and D.7). In differentiating between the sensitivity of the single groups of test organisms, it is obvious that bacteria tend to be the least sensitive whereas invertebrates (daphnids and non-daphnids) form the most sensitive component of the species spectrum tested (see Figs. D.8-D.13).

The distribution of the sensitivities (chronic NOEC) against the different chemical classes is in a log normal scale. However, particular groups can be distinguished. Heavy metals, aldehydes, organic

sulphur-, nitrogen-, and phosphorus compounds, esters and organometals are the more toxic groups whereas organic acids, alcohols, ketones and aromatic hydrocarbons are less toxic (see Figs. D.14-D.29).

3.3 INTERSPECIES COMPARISONS

Using the software described in Section 3.1, comparisons can be made between toxicity values for different species. For example, the capacity of data on one species to be used to protect all other species may be assessed. Various levels of specificity may be applied to this exercise (e.g. focusing on small ranges of exposure). As an example, the results of comparing the acute EC_{50} values of various "standard" species with the acute EC_{50} values of species or groups of species of the same or different taxonomic class are given in Table 2, Part A. It shows the percentage of substances where the standard species was more sensitive than "other" species (although the other species may include standard species). Table 2, Part B, shows the proportion of substances for which the interspecies acute EC_{50} ratios lay within a factor of 2.0. These approaches can be refined in subsequent work.

From the first assessment it can be provisionally concluded that rainbow trout (VF/SG) data would protect non-daphnid invertebrates for 90% of all substances and that data for algae (PA) would protect fish for 85% of substances. However, this is a preliminary assessment for illustrative purposes only and will be refined in subsequent reports. For interest the full data sets are given in Appendix E.

As well as comparing the relative sensitivity of a standard species to other (non-standard) species it is possible to use the regression analyses to describe the "goodness of fit" for each comparison. The proximity to 1.000 of the R-squared values shown in Table 2, Part A, demonstrates that the model provided a sufficient explanation for the distribution of the data.

Table 2 Comparison of the Sensitivity of Species to Substances in Freshwater:

Part A. Percentages of Substances where the Standard Species are More Sensitive than the Other Species

	Standard Species				
Other Species* **	*Lepomis macrochirus* (VF/LM)	*Pimephales promelas* (VF/PP)	*Salmo gairdneri* (VF/SG)	*Daphnia magna* (ID/DM)	Algae (PA)
All Fish* (VF)	55 (0.993)**	37 (0.986)	64 (0.987)	60 (0.957)	85 (0.985)
Daphnia magna (ID/DM)		44 (0.894)	54 (0.933)		
Invertebrates other than Daphnids (IO)		68 (0.925)	90 (0.966)	76 (0.947)	
All invertebrates (ID + IO)					66 (0.966)

Part B. Percentages of Substances where the Acute EC_{50} Values are within a Factor of 2***

	Standard Species				
Other Species	*Lepomis macrochirus*	*Pimephales promelas*	*Salmo gairdneri*	*Daphnia magna*	Algae
All Fish (VF)	56.5	51.3	65.9	23.8	30.8
Daphnia magna (ID/DM)		28.6	16.7		
Invertebrates other than Daphnids (IO)		28.6	42.9	0.0	
All invertebrates (ID + IO)					33.3

* Where relevant, the species of fish heading the column have been excluded from the species used in the row.
** Values in brackets are the R-squared of the regressions.
*** This will include various numbers of species depending on the data base.
**** The factor 2 is taken to include all ratios > 0.450 < 2.051.

SECTION 4. EXISTING APPROACHES TO AQUATIC RISK ASSESSMENT

4.1 OVERVIEW ON EUROPEAN LEGISLATION

In 1990, the Commission of the European Communities, Directorate General XI, organised a workshop with government, academic and industrial participants on "Environmental Hazard and Risk Assessment in the Context of Directive 79/831/EEC" (EEC, 1990). This workshop discussed and identified common principles for the environmental risk assessment of substances in order to achieve a harmonised and transparent procedure for evaluation of new substances within the Community.

Two years later, the EC published the Seventh Amendment of the Directive on the Classification, Packaging and Labelling of Dangerous Substances (92/32/EEC) (EEC, 1992); Article 3.2 of this Council Directive requires that risk assessment be carried out according to a Commission Directive laying down the principles for the assessment of risks to man and the environment of substances notified in accordance with Council Directive 67/548/EEC (the so called "Risk Assessment Directive", 93/67/EEC) (EEC, 1993a). It is intended for use by Competent Authorities implementing 92/32/EEC.

The Risk Assessment Directive requires that environmental risk characterisation shall, as far as possible, entail comparisons of the Predicted Environmental Concentration (PEC) with the Predicted No-Effect Concentration (PNEC) so that a PEC/PNEC ratio may be derived. The PNEC shall be calculated by applying an Assessment Factor to the values resulting from tests to organisms. Such Assessment Factors are specified in a Technical Guidance Note in support of the Risk Assessment Directive. It is proposed by the Commission that these Guidance Notes should be reviewed after a period of experience.

The EC Council Regulation on the evaluation and control of the risks of existing substances (EEC, 1993b) requires Competent Authorities to evaluate the real or potential risks of an existing substance to man or the environment. The regulation entered into force on 4 June 1993; manufacturers and importers have to supply data on the substances listed in Annex I of the Directive to the EC by June 1994.

4.2 DEFINITION OF RISK ASSESSMENT AND RELATED TERMS

A generally applicable scheme for environmental hazard assessment of substances was described by ECETOC (1993). The terminology used in that report was taken from the Ispra Workshop (EEC, 1990).

For the purposes of this report environmental risk assessment is the process of assessing the potential for a substance to cause adverse effects on environmental species and/or ecosystems. ('Environmental' in this context means the species in its natural environment and not in laboratory systems.)

It is necessary to describe as precisely as possible the scenario for which the assessment is carried out and to which the effects of the substance can be related.

The information needed to achieve this description is:

- the environmental exposure (in terms of the predicted environmental concentration (PEC) in the environmental compartment of concern);

- the "predicted no effect concentration" (PNEC) which has to be derived from effect data: from acute or chronic data for the species concerned or from ecosystem data in the environmental compartment of concern.

In risk assessment, these two sets of information are compared and the comparison is reported as their ratio. There is no hazard where

$$PEC / PNEC < 1 \qquad (4)$$

As a result of defining a PEC/PNEC ratio, the process of Risk Characterisation goes one step further than Hazard Identification which is limited to the definition of the inherent toxic properties of a substance. The best and most reliable data available should be used for estimating PEC and PNEC, and both values may be refined independently from each other where necessary or appropriate.

Finally, where the ratio is greater than one and the best data have been used, a hazard is perceived and control measures may have to be considered (i.e. Risk Reduction).

4.3 THE TERMINOLOGY OF RISK ASSESSMENT IN THE CONTEXT OF RECENT EUROPEAN LEGISLATION

Article 2 of the Risk Assessment Directive (93/67/EEC) in support of the Seventh Amendment of Directive 67/548/EEC defines the terms to be used in the assessment of the risk posed by substances to man and the environment (EEC, 1993a). These terms differ from those used at the Ispra Workshop (EEC, 1990). Appendix A provides the detail concerning the two sets of terminology which are not interchangeable, together with an explanation of their similarity and differences.

In summary, Directive (93/67/EEC) introduces "Risk Assessment" as the overall generic term for the whole process. "Effects Assessment" covers "Hazard Identification" and "Dose-Response Assessment". "Risk Characterisation" is now defined as an estimation of the incidence and severity of the adverse effects likely to occur and may include "Risk Estimation" (originally "Risk Assessment") as the quantification of that likelihood. The term "Risk Reduction" is now used instead of "Risk Management".

The above demonstrates the need to be clear on which terminology is being used and never to use both sets of terminology in the same document.

4.4 COMPARISON OF METHODS FOR RISK ASSESSMENT

4.4.1 Introduction

Within the terms of the Risk Assessment Directive it is necessary to compare the PNEC with the PEC and the resulting ratio may be the trigger for further testing or for risk reduction recommendations. In order to derive a PNEC, the Assessment Factors (AF) to be used are currently:

- 1,000 applied to the lowest $L(E)C_{50}$ of the "Base Set" toxicity data;
- normally 50 applied to the lower of two long-term NOECs from different taxonomic groups;
- normally 10 applied to the lowest of three long-term NOECs from different taxonomic groups.

These factors are in multiples of ten for convenience, though not through any scientific rationale. They "are not by any means fully supported by science and extrapolation from species to species,

acute to chronic endpoints and single species to ecosystem responses is still mainly qualitative." (Vosser, 1992).

The use of soundly based assessment factors is a reasonable attempt to achieve environmental protection from a limited data set and a reasonable basis for minimising expensive testing and use of test organisms.

Approaches and opinions differ on what is a safe margin between a set of E(L)C_{50}s or NOECs and a PNEC, although it is generally agreed that the larger the database for the effects data the narrower the margin can be. For example, the US EPA holds that when a specifically defined field experiment produces no measurable and significant effect the assessment factor can be 1.0.

4.4.2 Information Requirements

The following tables demonstrate features of hazard identification and risk characterisation.

The information required for hazard identification from the following bodies:

AIS	Association Internationale de la Savonnerie et de la Detergence
CH	Office fédéral de l'environnement, des forêts et du paysage (Switzerland)
EEC	European Economic Community
D-UBA	Umweltbundesamt (Germany)
NL	Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer (Netherlands)
UK-DoE	Department of the Environment (UK)
US-EPA	Environmental Protection Agency (USA)
D-BLAQZ	Bund-Länder Arbeitsgruppe Qualitätsziele (Germany)

is presented in Table 3. The footnotes to the table demonstrate a range of approaches.

Table 3 Information Required for Hazard Identification

	AIS	CH*	EEC	D-UBA	NL*	UK-DoE	US-EPA	D-BLAQZ
1. Acute Toxicity Data e.g. 6th Amendment Base Set	(1)	(2)	+	(3)	(4)	(5)	(6)	-
2. Subacute/Chronic Toxicity Data e.g. 6th Amendment Levels 1 + 2	(9)	(7)	(8)	(8)	(8)	(8)	(6)	(11)
3. Biotic/Abiotic Degradation and Physico-Chemical Data**		(10)						

Notes:

(1) Used for preliminary hazard assessment
(2) For short-term contamination
(3) Includes dose-effect, time-effect relationships ---> EC_{16}, NOEC, EC_0, slope
(4) Where 5 or more NOECs available, the 5%-ile is calculated to give Maximum Permissible Risk Level. This is 100 times Negligible Risk Level.
(5) Used to derive 'worry concentrations'
(6) Used to derive 'concern levels': these may be 1000 times lower than a single EC_{50} or QSAR-derived EC_{50} or as high as the level observed to be harmless in field studies.
(7) For continuous exposure
(8) Dependent on tonnages produced annually in total in EEC or on special request
(9) AIS suggests a need for further studies if after a first hazard assessment (function of hazard identification and exposure) safety margins are less than desirable.
(10) Plus bioaccumulation
(11) Derivation of "Quality Objectives" is based on a full data set of Level 1-NOEC-results. Persistency, bioaccumulation etc. are also taken into consideration.

* Implicitly or explicitly there are no strictly obligatory tests (except for new substances in the NL). The responsible scientist fits the test programme to the nature and pattern of use of the substances.

** Data are used for the classification "dangerous for the environment". Of course these data will also be used for the exposure and subsequent risk assessment.

Table 4 Examples of Assessment Factors and their Use

Quotient EC_{50} or NOEC/ PEC	AIS (1,2)	CH (3)	EEC	D-UBA Point source (4)	NL	UK-DoE	US-EPA	D-BLAQZ
1000	-	-	Acute (Base Set data)	Step sequence Level 1 or 2	-	-	1 acute or QSAR	
>100	No further tests if 3 species used	-		If not readily biodeg. and Pow >2.7 or toxicity v time response steep or other tox. parameters apply: 10t-50t cumul.: Level 1 tests	-	-	-	
100	-	-		-	From calculated 5%-ile NOEC (5)	Base Set LC_{50} (Worst Case) (6)	1 acute test on 3 taxa or 5 acute tests on 2 taxa	chronic tox. studies, most sensitive species for persistent substances etc.
<100 >10	-	-	2 long-term NOECs	As for >100: Additional Level 1 tests regardless of tonnage	-	-		-
<100 >1	Chronic data needed	-	-	-	-	-	-	
10	-	-	3 long-term NOECs	-	-	-	Chronic MATC; using the most sensitive species in an acute test	Chronic tox. studies, most sensitive species
<10 >1	More acute data needed	-	-	Additional tests, independent of step sequence	-	-	-	-
1	-	-	-	-	-	-	Field study	-

(1) Other trade associations use different factors.
(2) AIS uses these factors to suggest the need for further tests.
(3) Swiss approach does not foresee use of safety factors, as PEC not requested.
(4) For diffuse sources the PEC cannot generally be calculated; the need for further tests depends on Hazard Identification etc.
(5) NL approach does not use exposure assessment but employs a mathematical analysis of a (limited) database to derive a concentration predicted to have no effect on the most sensitive 5% of all species. This is the Maximum Permissible Risk Level (MPL). 1% of this value is the Negligible Risk Level, which is the target maximum concentration in the environment.
(6) Trigger for further enquiry.

4.5 DISCUSSION AND CONCLUSIONS

Examples of assessment factors and their uses are given in Table 4. The Swiss approach does not require the use of such factors. The EEC, UK-DoE and D-UBA approaches are related to tonnages marketed. The NL approach is an attempt to safeguard all species by extrapolation. The US-EPA approach bases assessment factors on the depth of investigation of effects (this is also at the heart of the EEC and D-UBA approaches).

In order to compare the various modes of assessment, three well-understood environmental pollutants were examined using either a single limited database or a single full database for each substance and PNECs were predicted using the methods described in the different approaches. The results are shown in Figures 3, 4 and 5 for ammonia, copper and pentachlorophenol respectively.

The following observations can be made:

1. The resulting "Negligible Risk Levels" (NRLs) vary by about two orders of magnitude.

2. The approaches should be designed in such a way that the evaluation of a small database (e.g. "Base Set" data) leads to a more conservative PNEC whereas the evaluation of more refined data should lead to a higher but more realistic value. The results show that this is not always the case. For example, when very large data sets are subjected to an approximation of the extrapolation procedure proposed in the Netherlands, permissible concentrations become extremely small. For ammonia the quotient of the mandatory value of the Freshwater Fish Directive (EEC, 1978) and the NRL is from 160 to 800. For copper the quotient is 400 to 2000.

3. At present there appears to be little recognition of the need to differentiate between short-term local exposures from a point source and large scale, more uniform, exposure from diffuse sources. In the former situation, it seems useful to rely mostly on acute data, while in the latter, chronic data are more relevant.

As a result of the analysis of the various approaches (for their advantages and disadvantages see Table 5) the Task Force drew the following conclusions:

1. The basis of the assessment system should be scientific, not arbitrary or the subject of excessive extrapolation. One of the objectives of the Task Force is to provide a scientific base to the use of assessment factors which we shall term Application Factors.

2. The system should comprise a tiered approach using relatively large application factors for a small database and providing the possibility for refinements of the PNEC and/or the PEC by generating more reliable effects and/or exposure data.

3. Each stage of data acquisition should pay due regard to the results of the previous stage, even to the point where it is decided that sufficient data have been gathered and no more are required.

Figure 3 "Negligible Risk Levels" (NRLs) for Unionised Ammonia Calculated According to Various Approches and on the Basis of Different Data Sets

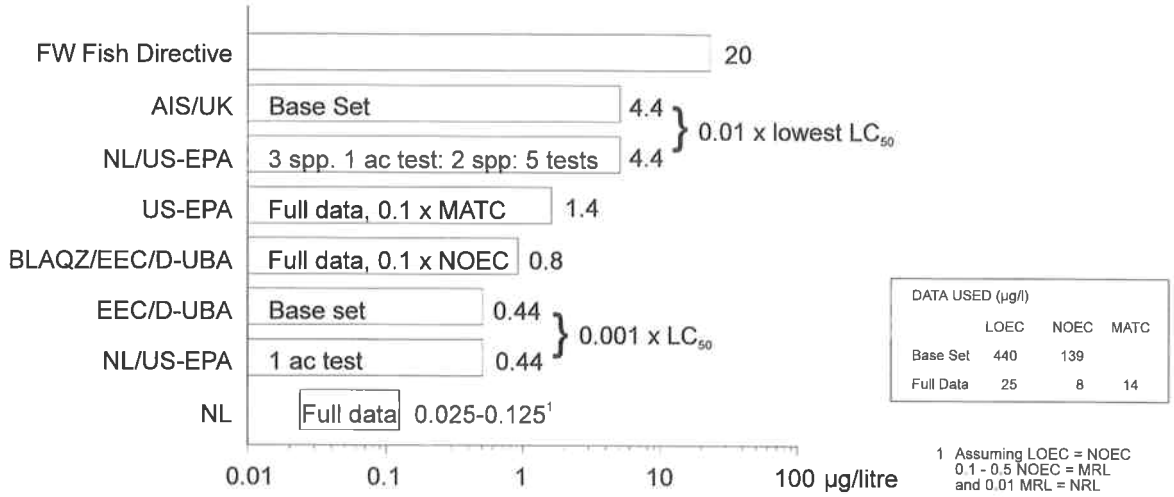


Figure 4 "Negligible Risk Levels" (NRLs) for Copper Calculated According to Various Approaches and on the Basis of Different Data Sets

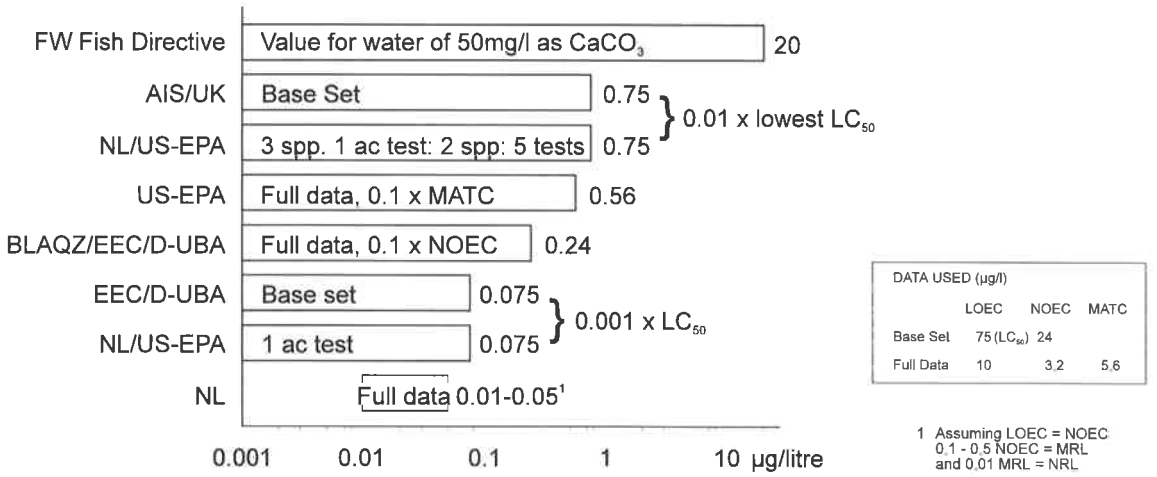


Figure 5 "Negligible Risk Levels" (NRLs) for Pentachlorophenol Calculated According to Various Approaches and on the Basis of Different Data Sets

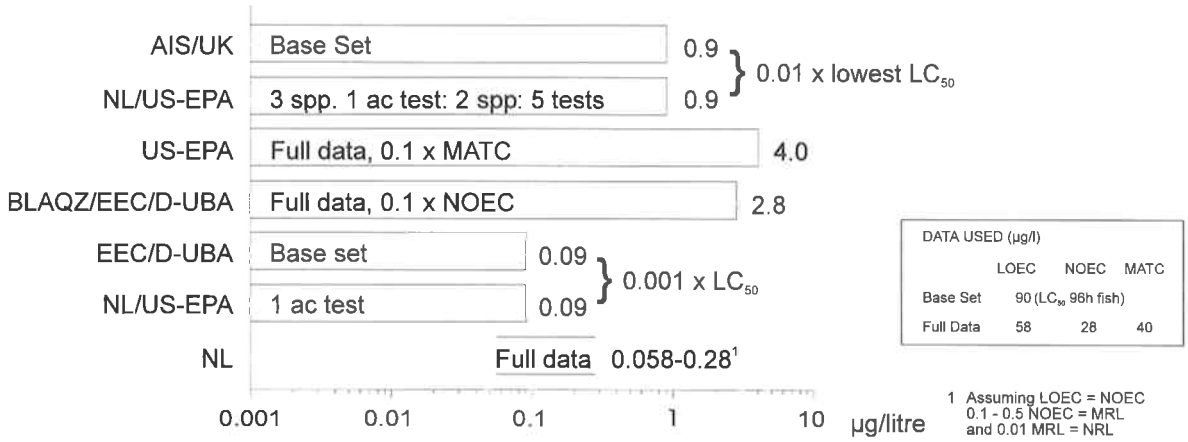


Table 5 Good and Problematic Points in Present Hazard Assessment Approaches

	AIS	CH	EEC	D-UBA	NL	UK-DOE	USA-EPA	D-BLAQZ
GOOD POINTS								
- Case by case pragmatic approach	+	+	+	(23 groups)	+	+	+	+
- For existing substances	+	+	-	-	+	+	-	+
- for new substances	+	+	+	+	+	+	+	+
- for mixtures	-	+	-	-	-	-	-	-
- Testing flexibility (limited)	+	+	(+)	(+)		(+)	+	(+)
- Possibility of treating groups of substances with similar uses (e.g. dyes...)	Surfactants only	+	+	+ (also for groups of chemically related substances)		+		
- Inclusion of biodegradability	+	+	+	+		After first stage	+	Only if not biodegrad-able
PARTICULAR PROBLEMATIC POINTS*								
- Extrapolation beyond experimental demand					+		+ (from QSAR)	
- Need for chronic data at start					+			+
- Not amenable to mechanical analysis	+					+		
- Introduction of unusual parameters				+ (EC_{16} or EC_0)				Results often below detection. No use of field test data

* Difficulties which are directly linked to the experimental acquisition of data (e.g. sparingly soluble substances, substances in dispersion etc.) are not included. These substances will *a priori* cause difficulties when interpreting their toxicity data for a hazard assessment.

SECTION 5. STRATEGY FOR EFFECTS ASSESSMENT

5.1 INTRODUCTION

This report is principally concerned with deriving the predicted no effect concentration (PNEC) and providing a database for examining other aspects of 'hazard identification'.

PNEC is an estimated safe level for the environment but, of necessity, has to be evolved from databases which are limited with respect to:

- number of species/trophic levels/life-history stages;
- period of exposure/environmental compartments/environmental conditions;
- inter-species interactions.

Recognising these problems, ecotoxicologists apply assessment factors in order to better estimate the safe level of a substance in the environment. According to current procedures, these factors are large where the database is small or based on short-term studies; they are small where there is a larger database or where long-term data are included.

5.2 TECHNIQUE FOR DERIVING APPLICATION FACTORS

A full description of the technique for deriving application factors has already been given by ECETOC (1993). Further explanation, analysis and justification of the factors is given below.

5.2.1 Basic Principles

A number of principles or assumptions apply in the derivation of application factors. These are:

- Data from studies of acute and chronic toxicity of substances in the laboratory or in artificial (or natural) ecosystems can be used to derive empirical relationships between test types and can then be employed on other substances, having more restricted data, to predict toxicity values.

- In order to predict long-term effects (or safe levels) in ecosystems, data from short-term studies can be divided firstly by a factor to convert acute data to predicted chronic data and secondly by a factor to convert the chronic data to safe levels in the appropriate ecosystem.

- Although the list of species commonly studied is very limited, these species are generally accepted to be rather sensitive within their trophic levels.

- The published literature on toxicity has naturally focused on the more toxic and 'interesting' substances.

- Not all substances can be dealt with satisfactorily by generic application factors but there may be value in examining groups of substances in relation to their mode of use (e.g. pesticides) or their chemical features (e.g. metals, organo-metals, inorganic non-metals, "other organics").

- For the purposes of the Risk Assessment Directive and its guidelines for new substances, it is likely to be the category 'Other Organics' (i.e. neither pesticide active ingredients nor organo-metals) which will most closely resemble those being notified.

- Data used in the generation or the subsequent use of application factors and derived from studies with a comparatively 'clean' dilution water will tend to provide an extra margin of safety over data from more realistic dilution waters. This is because in the latter there will be opportunities for reductions in bioavailability and thus toxicity, due to adsorption, complexation or neutralisation for example.

5.2.2 Combining Application Factors

From the principles defined above, especially the second, it follows that application factors can be derived for acute:chronic [A:C] laboratory studies and chronic laboratory: ecosystem studies [C:E]. Multiplying these factors gives a conversion from acute data to a predicted safe level for ecosystems [A:E].

$$[A:C] \times [C:E] = [A:E] \quad (5)$$

The question then occurs of which toxicity test result to use. The commonest options are E(L)C_{50}, LOEC or NOEC. Although all three can be obtained from most types of study, it is generally accepted that for acute studies the EC_{50} should be used and for chronic or ecosystem studies the

NOEC. As in an acute study precision will be generally lower, this effect can be minimised by the use of the most powerful statistic (the EC_{50}). The NOEC of a well-conducted ecosystem study can be regarded highest in the hierarchy of experimental test results and the best approximation to the field NOEC.

In the process of selecting data a number of choices had to be made on sorting fields. Examples of the fields used for establishing Acute:Chronic ratios are given in Table 6. Moving from the top to the bottom of the table increases the specificity of the choice in each column. Comparisons can be made between any one level in each column. Thus the overall picture can be given by selecting levels 1.1, 2.1 and 3.1 while the most specific comparisons arise by selecting from 1.4, 2.3 and 3.2.

Table 6 Comparisons Between End-Points/Exposure Periods (Acute EC_{50}: Chronic NOEC) Choices of Levels of Detail

SUBSTANCES EVALUATED	BIOLOGICAL TEST SYSTEM	ENVIRONMENT
1.1 All types	2.1 All species	3.1 Both fresh and saline waters
1.2 Major applications: e.g. Pesticides Detergents Solvents	2.2 Major groups: e.g. Fish Invertebrates Algae	3.2 Separate: Fresh water Saline water
1.3 General chemical groups e.g. Metals Organo metals Pesticides Other inorganics Other organics	2.3 Individual species	
1.4 Individual substances		

The exposure period can be used as an additional sorting field. The EAT database includes exposure periods from a few hours to hundreds of days. As the data were added, each exposure period was given (as hours or days) but also as Acute, Sub-chronic or Chronic (A, S, C). Selections can equally be made as ≥ x hrs ≤ y hrs or as A, S, C or S/C.

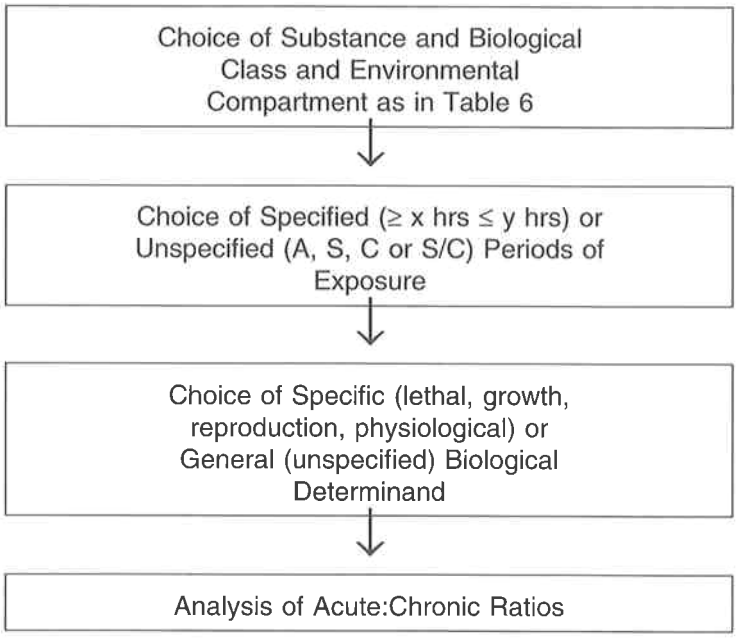
For the Risk Assessment Directive, both the Base Set and Level 1 specify exposure periods. Unspecified A and S/C periods and specified A and S/C periods were therefore both used for

comparative purposes (see 5.3.1). The analyses leading towards Application Factors can compare the broader and finer focus.

5.2.3 Scheme of Analysis

The scheme of analysis followed that given in Figure 6. The combination of choices depends on the proposed use of the data. Not every possibility is exhaustively pursued in this report.

Figure 6. Decision Leading to Analysis



5.3 APPLICATION FACTORS DERIVED FROM THE EAT DATABASE

5.3.1 Acute: Chronic ratios

Given the variables available in the EAT database and the scheme for choosing and analysing them shown in Table 6 and Figure 6, this section provides an example of a sequence of increasingly specific data for the determination of the factor

Acute EC_{50}	:	Chronic NOEC.
(mostly lethal)		(all types of response)

The sequence is given in Table 7 below.

Examples of the data and graphical output appropriate to Table 7 are to be found in Appendix D and in Table D.1.

The increase in specificity referred to above need not necessarily result in smaller Acute:Chronic ratios. For example, Column 7 in Table 7 is a more specific version of Column 1 because the former does not mix the species in any given ratio. In other words, Column 7 is equivalent to the level of detail given as 2.3 in Table 6 whereas Column 1 is equivalent to 2.1 in that table. However, Column 1 gives lower ratios for all parameters except 95%-ile in Table 7. On the other hand the two columns are not strictly comparable because the more specific Column 7 could not be applied to 22 of the substances used in Column 1, due to the lack of matching species.

Similarly, Column 12 (precisely defined periods of exposure) might have been expected to give lower ratios than Column 11. It does not, except for the medians. It does, however, avoid the anomaly of an Acute:Chronic ratio of less than 1.0 which should not (except for minor infringements) occur in studies where the species is the same and the test conditions are very similar.

The ratios given in Column 12 relate to organic substances with the exception of pesticide active ingredients (which are designed to be biologically active) and organo-metals. As such, Column 12 is of most interest to the scope of the Risk Assessment Directive (93/67/EEC) (EEC, 1993a).

An examination has been made of the pattern of distribution of these ratios and close correspondence with a log-normal distribution was found (see Appendix D.2). Given that Acute:Chronic ratios do fit log-normal distributions it may be possible to make statements about the likelihood of ratios falling inside or outside the range (1.25 to 28.3) so far observed. This can be tested with independent data when the EAT database is expanded or if notified data are made available.

The data in Table 7 also strongly suggest that for other types of substance (as in Columns 8-10) it would often be more appropriate to measure chronic toxicity than to estimate it, because ratios may vary over the range 1 to 1000 or more.

The results obtained for Columns 11 or 12 may be compared with earlier ratios, as used by ECETOC (1993). These earlier ratios were derived from the same database for all substances except inorganics and organo-metals also excluding substances having only one $L(E)C_{50}$ and one NOEC, but not treating species separately. This can now be set against the most specifically defined ratio (Column 12) to give the following comparison.

Table 7 Summary of Acute EC_{50} : Chronic NOEC Ratios

APPROACH NO.	1	2	3	4	5	6	7	8	9	10	11	12
Substances considered	All	All	All	All	All	All	All	Agro-chem. a.i.	Metals/ organo-metals	Other inorganics	Other organics	Other organics
Species*	All	All	All	VF, IO, ID	IO, ID	VF	All	All	All	All	All	All
Environment	Both	Fresh	Salt	Fresh	Fresh	Fresh	Both	Both	Both	Both	Both	Both
Exposure period ac, subchr/chr	+	+	+	+	+	+	+	+	+	+	+	
Specific No. of hours, days												+
Geometric means: Species combined	+	+	+	+	+	+						
Species separate							+	+	+	+	+	+
No.of substances	94	80	28	73	20	51	72	25	13	7	28	19
No.of entries							130	52	35	15	28	21
Ratios												
- minimum	0.060	0.004	0.735	0.004	1.60	1.88	0.126	2.07	0.300	2.92	0.126	1.25
- maximum	668	668	303	668	1030	250	1290	371	1290	69.3	27.5	28.3
- 50%-ile	8.77	12.6	4.01	12.6	22.1	11.2	9.00	12.2	28.0	8.39	3.98	3.60
- 90%-ile	62.7	73.4	45.3	63.0	144	59.8	72.9	74.6	184	20.1	16.0	24.5
- 95%-ile	213	247	194	213	430	75.2	130	94.9	244	50.9	26.5	27.8

* ID = Daphnids; IO = Other Invertebrates; VF = Fish (see Section C.2.3: taxonomic code

Table 8 Summary of the Acute:Chronic Ratios Derived for Organic Substances (Excluding Organo-Metals)

Level of protection* %	Species and environment considered	Ratio	Source
90	Fresh and saline water, all species	28.5	ECETOC, 1993
90	Fresh water, all species	29.7	ECETOC, 1993
90	Fresh water, fish and invertebrates	30.1	ECETOC, 1993
90	Fresh water, invertebrates	40.1	ECETOC, 1993
90	Fresh water, fish	31.6	ECETOC, 1993
90	Saline water, all species	26.7	ECETOC, 1993
100	All aquatic species and environments	28.3	Table 7 of this report

* The percentage of substances covered by the given ratio

5.3.2 Chronic NOECs to Ecosystem NOECs

Unlike ecotoxicity tests with single species, there are no generally accepted common ecosystem studies which cover all aspects of highly integrated test systems.

Being aware of that restriction, ecosystem studies were treated as a "black box" and all test systems beyond single species tests were regarded equally well suited. This pragmatic approach is realistic as literature meeting the criteria for acceptance to the EAT database are few in number. There is an urgent need to increase the number of relevant ecosystem studies in the EAT database. Nevertheless, for two substances common pairs between chronic NOECs and ecosystem NOECs could be traced. Table 9 gives all values and their corresponding ratios.

Table 9 EAT Database.
NOEC Values from Single Species Chronic Test Systems and Ecosystem Studies

SUBSTANCE	ORGANISM	CHRONIC NOEC mg/l	ECOSYSTEM NOEC mg/l	RATIO
4-chlorophenol	*Daphnia magna*	0.63	0.1	6.3
2,4-dichlorophenol	*Daphnia magna*	0.21 0.74 0.74 1.48	0.1	2.1 7.4 7.4 14.8

Due to the lack of data the ratios between laboratory chronic NOECs and ecosystem NOECs have been calculated for both substances with the single values. This yields only five ratios which is too few to analyse usefully.

5.3.3 Acute EC_{50}: Ecosystem NOEC Ratios

Given that only two substances were available for the analysis of Chronic NOEC: Ecosystem NOEC no conclusion could be drawn. ECETOC (1993) used the lowest mean NOEC for a given species and end-point, and ten active ingredients of pesticides from outside the EAT database were added to give 13 ratios ranging from less than 1.0 to 6.3. ECETOC (1993) concluded that the value for 90% of substances (about 5) should be used with the Acute:Chronic ratio of 40 (see Section 5.3.1) to give a total application factor "Acute EC_{50} to Ecosystem Predicted No Effect Concentration" of 200. We have no basis for modifying this figure at present, although the data summarised in Table 8 suggest that the ratio 200 may eventually prove conservative.

SECTION 6. CONCLUSIONS

A database, termed the EAT database, containing original, high quality, published information on the toxicity of substances to aquatic species has been compiled. The majority of data originated from studies on freshwater fish, with invertebrates comprising the second largest input. More data are needed from studies on algae and on ecosystems.

Toxic substances such as organohalogens and heavy metals made up most of the data entries, reflecting the level of concern on these groups of substances. Organic acids and organosilicon compounds contributed data to a lesser extent. The toxicity data were evenly distributed, some groups of substances tended to be more toxic than others. The higher toxicity was not necessarily linked to substances of high public concern.

Bacterial test systems seemed generally to be less sensitive whilst in contrast invertebrate test systems were generally more sensitive than the average.

Based on a first assessment of interspecies sensitivity comparisons it can be provisionally concluded that rainbow trout (SG) and *Daphnia magna* (DM) data can be used to predict toxicity for the protection of non-daphnid invertebrates and that data for algae (PA) would predict toxicity for fish for more than 75 per cent of substances. This preliminary assessment needs to be refined by addition of further information to the EAT database.

In order to provide a scientific basis for application factors used in risk assessment, the ratio acute EC_{50}:chronic NOEC was assessed for 12 groups of data. Ratios could vary from an anomalous 0.004 to 1290 but the median ratios for half the substances in any of the 12 data points only varied from 3.6 to 28.0. When 19 organic substances typical of those which could be notified under the provisions of the Seventh Amendment Directive (92/32/EEC) were considered the range of ratios was 1.25 to 28.3. The ratios were log-normally distributed. The value of 28 may prove a suitable, though conservative value to be used for the development of an application factor by which an ecosystem predicted no effect concentration could be calculated from an acute EC_{50} value.

The acute EC_{50}:chronic NOEC value of 28 may be contrasted with that of 40 given by ECETOC (1993) which was applicable to 90% of substances but did not allow for the separate assessment of individual species.

For other types of substance (heavy metals, other inorganic substances, organometals and pesticide active ingredients) acute:chronic ratios occupied a wider range (medians: 8.4 to 28; maxima: 69 to 1290). Measurement of toxicity in chronic studies rather than the use of an empirically derived application factor may be desirable for this type of substance.

The EAT database contained too few ecosystem data for any conclusion to be drawn on the ratio chronic NOEC: ecosystem NOEC.

From the above it was concluded that, as yet, insufficient evidence exists to modify the application factors suggested by ECETOC (1993), i.e. a factor of 200 applied to the lowest acute EC_{50} of at least three diverse species. This factor was considered to be sufficient to protect ecosystems from the effects of 90% of general organic substances. It was composed of an acute:chronic ratio of 40 multiplied by a chronic:ecosystem ratio of 5 multiplied by an ecosystem:field ratio of 1.

When considering that the acute:chronic ratio derived from the EAT database was 28 for 100% of general organics, the factor of 200 may be rather conservative. On the other hand there were far too few chronic NOEC : ecosystem NOEC ratios in the EAT database to make any statement concerning the entire application factor. Additional data will need to be evaluated before the factors can be revised.

SECTION 7. RECOMMENDATIONS

The ECETOC Aquatic Toxicity (EAT) database will be maintained and updated using the same quality criteria and taking in toxicity data up to 1993. Evaluations of the bigger database will be reported. It is strongly recommended that the database should not be corrupted by the addition of data not complying with the selection criteria specified in this report.

It would be desirable to establish a parallel database using the same software with an independent set of data. Suitable data could be those on the substances so far notified under the provisions of the Sixth and Seventh Amendments of Directive 67/548/EEC. The data could be used to assess interspecies variability at the Base Set, acute EC_{50}:chronic NOEC ratios, etc. An opportunity should also be taken to compare the findings from the current EAT database with data from studies where the concentrations of test substance were not measured.

Acute:chronic ratios should be derived from the regression line/confidence limits rather than the constituent points.

It is generally recommended that as opportunities arise, studies should be directed towards adding different substances to the world's literature and not adding further data on substances already well covered. In order to aid analyses such as those reported here, the exposure concentrations should be measured. Target species data would also strengthen the value of the database.

In chronic studies note should be taken of the definitions of LOEC and NOEC used here, and both should be reported.

Ecosystem studies on a selected range of substances should be made in order to give confidence to acute EC_{50}:chronic NOEC:ecosystem NOEC comparisons and thus application factors. Before this can take place there should be broad agreement on the principles and broad design of ecosystem studies. These questions are presently being studied by another ECETOC Task Force.

APPENDIX A. DEFINITIONS AND TERMINOLOGY OF RISK

ACUTE TOXICITY:

The harmful properties of a substance which are demonstrated within a short period (hours for e.g. algae to days for e.g. crustaceans, fish) of exposure. For macro-invertebrates and fish normally no food is given during the test. No effects should be seen in the controls.

ACUTE TOXICITY TEST:

An experiment which provides information on acute toxicity over a range of concentration levels. This may include information on the lethal concentration, the organs, tissues and functions affected and the time to onset, duration and severity of effects.

ASSESSMENT FACTOR:

A factor applied to a data point when assessing a substance in order to derive a safe level of that substance in the environment.

APPLICATION FACTOR:

A factor for converting data from one exposure period or end point to another, e.g. from acute EC_{50} (measured) to chronic NOEC (predicted).

CHRONIC TOXICITY:

The harmful properties of a substance which are demonstrated only after long term exposure in relation to the life of the test organism.

CHRONIC TOXICITY TEST:

A toxicity test of long duration in relation to the life of the test organism which may include more than one generation.

EC_{50} VALUE (MEDIAN EFFECT CONCENTRATION):

A statistically-derived concentration which, over a defined period of exposure, is expected to cause a specified toxic effect in 50% of the test population.

HAZARD IDENTIFICATION:

See Table A.1 below.

HAZARD ASSESSMENT:

See Table A.1 below.

LC_{50} VALUE (MEDIAN LETHAL CONCENTRATION):

A statistically-derived concentration which, over a defined period of exposure, is expected to cause 50% mortality in the test population.

LC_{50} TEST:

An experiment which aims at determining an LC_{50} value.

LOEC (LOWEST OBSERVED EFFECT CONCENTRATION) (THRESHOLD LEVEL OF OBSERVED EFFECTS):

The lowest test concentration at which the substance is observed to have a "statistically significant" and unequivocal effect on the test species.

MAXIMUM ACCEPTABLE TOLERANCE CONCENTRATION (MATC):

The geometric mean of the NOEC and the LOEC values, also sometimes referred to as the "Chronic Value" (ChV).

MAXIMUM PERMISSIBLE RISK LEVEL (MRL):

Defined in the NL as the concentration of a substance at which 95% of the species in an ecosystem are protected.

NEGLIGIBLE RISK LEVEL (NRL):

Defined in the NL as 1% of MRL.

NOEC (NO OBSERVED EFFECT CONCENTRATION):

The highest tested concentration below the LOEC where the stated effect was not observed. The NOEC is usually connected with chronic effects.

"STATISTICALLY SIGNIFICANT" EFFECT:

An effect considered to be significant according to defined mathematical, statistical and/or descriptive methods.

SUBCHRONIC TOXICITY TEST:

A toxicity test designed to investigate possible adverse effects occurring as a result of continuous or repeated exposure of several groups of experimental animals to a series of concentrations at the test substance for a period not exceeding one third of the time taken to reach sexual maturity.

TOXICITY:

The inherent property of a substance to cause adverse biological effects at specific concentrations.

THRESHOLD CONCENTRATION:

See LOEC.

Table A.1 Terminology of Risk

Risk Assessment Directive 93/67/EEC	Document XI/730/89 rev.3 (Ispra)	NOTES
RISK ASSESSMENT A generic term describing an administrative and technical process which entails some or all of the elements below	No equivalent term	Note much wider meaning of the term than at Ispra
EFFECTS ASSESSMENT i) HAZARD IDENTIFICATION Identification of the adverse effects which a substance has an inherent capacity to cause; and, where possible and/or appropriate, the assessment of a particular effect ii) DOSE-RESPONSE ASSESSMENT Estimation of the relationship between dose (or level of exposure) and the incidence and severity of an effect	HAZARD IDENTIFICATION Identification of a substance as a substance of concern: takes into account the inherent hazardous properties and exposure-related aspects	These two terms are synonymous They describe inherent properties
EXPOSURE ASSESSMENT Determination of the emissions, pathways and rates of movement of a substance and its transformation or degradation in order to estimate the concentrations/doses to which human populations or environmental compartments are or may be exposed	HAZARD ASSESSMENT (Part only) = 'environmental exposure'	This part of Hazard Assessment (Ispra) is synonymous with Exposure Assessment (Draft Directive) Leads to PEC
	HAZARD ASSESSMENT (Part only) = 'effect data with reference to the environmental compartment of concern'	This is aided by a knowledge of Hazard Identification (Ispra) Leads to PNEC
EFFECTS ASSESSMENT PLUS EXPOSURE ASSESSMENT	HAZARD ASSESSMENT	Synonymous terms Comparison of PEC and PNEC
RISK CHARACTERISATION Estimation of the incidence and severity of the adverse effects likely to occur in a human population or environmental compartment due to actual or predicted exposure to a substance and may include	RISK ASSESSMENT (See below) PLUS HAZARD ASSESSMENT	Synonymous terms ie PEC/PNEC ratios against a probability scale
RISK ESTIMATION Quantification of the likelihood of the incidence and severity of the adverse effects	RISK ASSESSMENT Estimation of the probability that a substance causes adverse effects as a result of its presence in the environment at a given concentration	Synonymous terms
RISK REDUCTION Measures which would enable the risks for man and/or the environment in connection with the marketing of the substances to be lessened	RISK MANAGEMENT The taking of measures appropriate at least to diminish significantly the presence of a substance in the environmental compartments of concern	Synonymous terms e.g. special use and disposal instructions, emission control measures, restrictions on types of use, total ban of use

APPENDIX B. CONCLUSIONS OF THE ISPRA WORKSHOP (EEC, 1990)

1. Environmental hazard and risk assessment should be an iterative process. Such a process is outlined in Doc. XI/730/89 rev. 3 as a suitable guidance and framework within the scope of Directive 79/831/EEC (Sixth Amendment).

2. The National Competent Authorities for the implementation of Directive 79/831/EEC will make use of this approach for the environmental hazard and risk assessment of new substances, notified under the Directive 79/831/EEC.

3. The estimation of exposure concentrations (PEC) considers the designated use of a substance. Therefore the exposure scenarios are developed for "use families" based on use specific emission patterns.

   In order to differentiate between local exposure following the release of substances from point sources, and the exposure due to more widespread, diffuse release, the local, regional and global aspects have to be dealt with separately with regard to the subsequent assessment of the substance.

4. The development of "use family" specific exposure scenarios still imposes some open problems:

   - the scenarios have to represent realistic worst cases;

   - these models should take into account the diversity of the environmental conditions across the Community.

5. Future work:

- Following the developing experiences by using the system, amendments will be made as needed.

- Further development and validation of family exposure scenarios is necessary and will be done in collaboration by Competent Authorities and Industry.

- The development of those scenarios includes the elaboration of realistic worst case conditions, also considering the diversity of the environmental conditions across the Community.

APPENDIX C. THE DATABASE

The ECETOC Aquatic Toxicity Database including a description of field names and codes is published as a separate document together with the bibliography used for the establishing of the database. This publication is an interim report and the database which will be upgraded shortly has not yet been fully evaluated. Results of statistical evaluations will be published as soon as they become available. After finalisation of the evaluations it is intended to make the ECETOC Aquatic Toxicity Database available as a data file on floppy disk.

The references evaluated and used for the database are listed in Section "Bibliography". A listing of papers considered but not accepted because they did not meet the criteria specified in Section 2.1 may be obtained from the Secretariat upon request.

APPENDIX D. STATISTICAL ANALYSES OF THE DATABASE

D.1 SIMPLE COUNTS

The simple counts presented here are divided into three different parts: general, sensitivity of the test organism, and sensitivity to chemical classes.

D.1.1 General Information

Considering the application of substances i.e. their use pattern, the majority of substances belonged to the group of "general application", comprising about 55% of the counts. This was followed by the pesticide entries with nearly 40% of the input data. Solvents and detergents made up the remainder (see Fig. D.1).

The highest number of substances investigated were the organohalogens followed by heavy metals, inorganics and aromatic hydrocarbons. Little information was available on organosilicas and organic acids (see Fig. D.2). This sequence clearly demonstrated the historical concern over certain types of substances which is not necessarily correlated with the actual risk a substance may pose.

Concerning the species studied, we found the majority of data (70%) originated from studies on fish followed by invertebrates (non-daphnids and daphnids) which represent nearly 30% of the entries. Obvious gaps can be identified in our knowledge of ecotoxicity towards algae, bacteria and ecosystems (see Fig. D.3). Most test organisms were juveniles with only few entries on early life stage tests (see Fig. D.4). This also reflects the duration of the tests: 70% of all data are from acute studies (see Fig. D.5).

The majority (85%) of data were for the fresh water compartment and only 15% for the marine environment.

D.1.2 Sensitivity of Test Organisms

The acute sensitivity of the organisms to the substances tested was evenly distributed in a log-normal scale (see Fig. D.6), ranging from the µg/l range up to the g/l range. The midpoint fell into the lower mg/l range. The same distribution pattern was found for NOEC values from long term studies with a slight shift towards lower concentrations (see Fig. D.7).

Differentiating between the sensitivities of the groups of test organisms, it was observed that invertebrates (daphnids and non-daphnids) tend to be more on the sensitive side (see Fig. D.9-D.11), whereas bacteria represent the more tolerant part of the species tested (see Fig. D.8). Vertebrates including fish (Fig. D.12), higher plants and algae (Fig. D.13) occupied the midpoint in the sensitivity range.

D.1.3 Sensitivity Against Chemical Classes

The various degrees of sensitivity to different chemical classes are shown as distributions of NOEC values (see Fig. D.14-D.29). Overall, the distribution is even in a log-normal scale. However, distinctive groups can be distinguished. Heavy metals, aldehydes, organic sulphur-, nitrogen-, and phosphorus compounds, esters, and organo-metals were recognised as the more toxic groups whereas organic acids, alcohols, ketones, and aromatic hydrocarbons appeared to be less toxic. The remaining subtance groups are in the mid-range of chronic toxicity.

Figure D.1 Application Categories

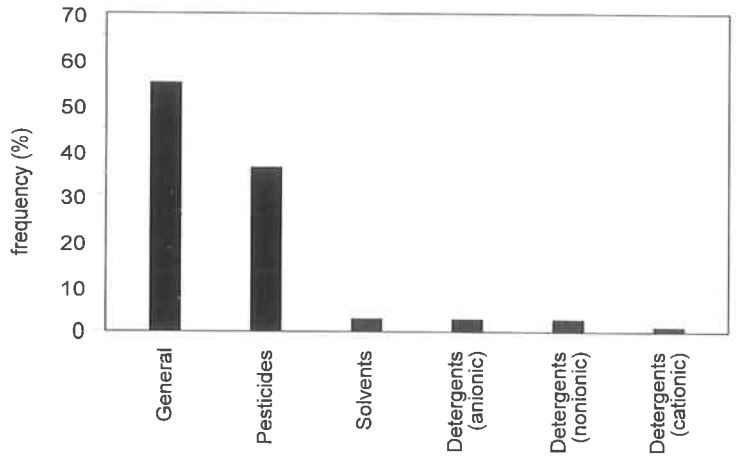


Figure D.2 Chemical Categories

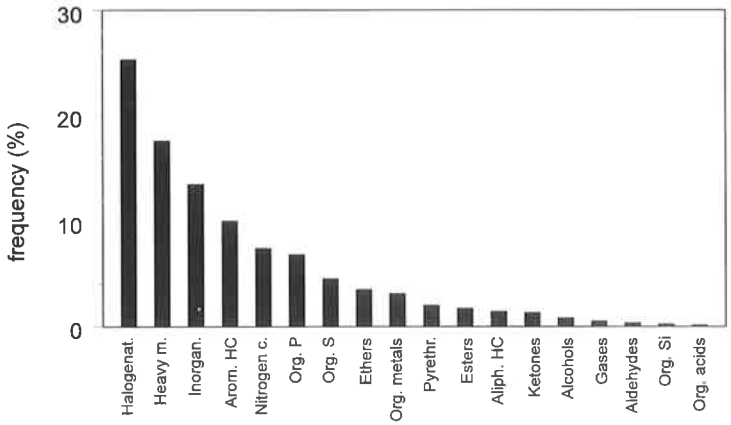


Figure D.3 Taxonomic Categories

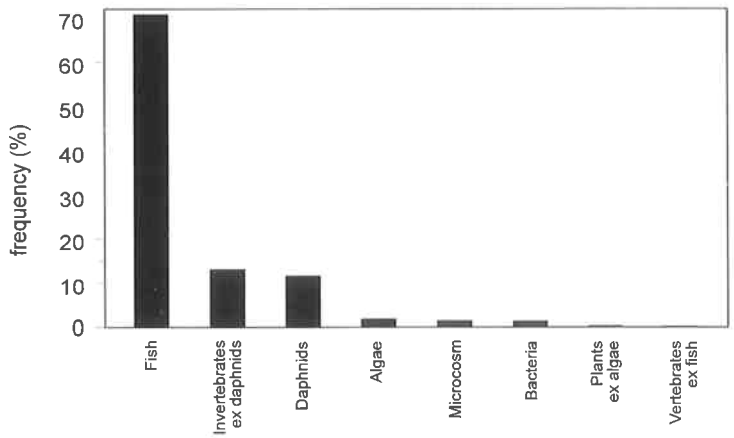


Figure D.4 Lifestage Categories

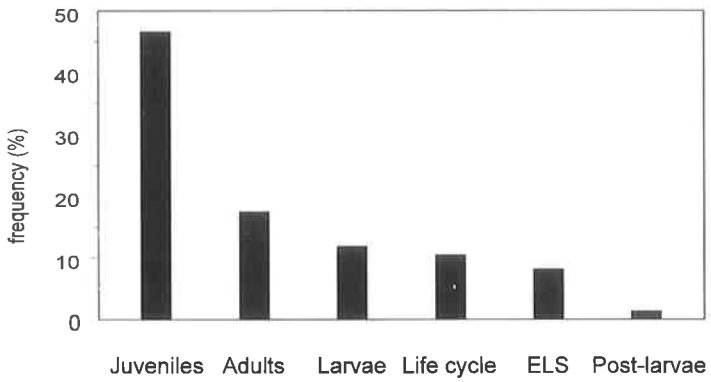


Figure D.5 Test Classification Categories

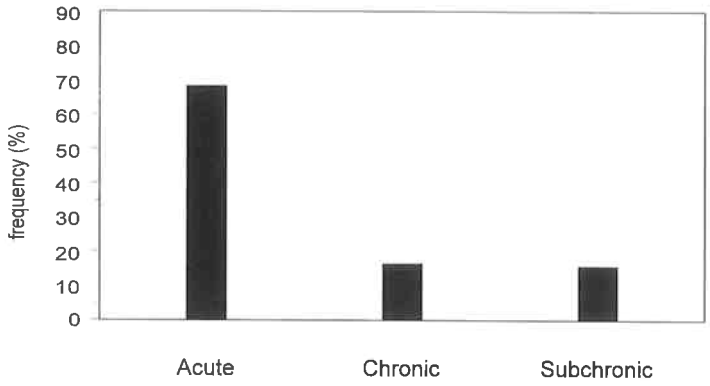


Figure D.6 Frequency Distribution Acute LC/EC_{50} Values, All Species

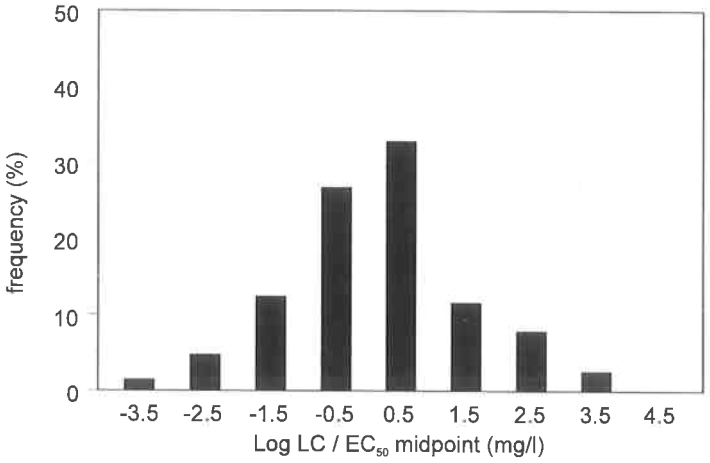


Figure D.7 Frequency Distribution NOEC Values, All Species

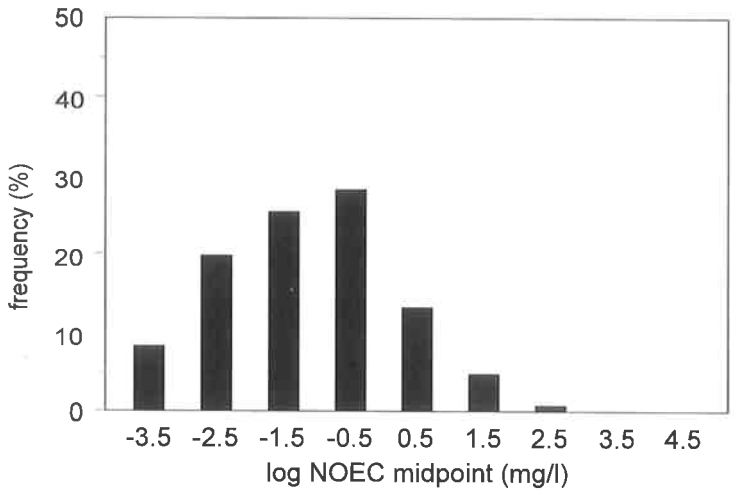


Figure D.8 Frequency Distribution Acute LC/EC$_{50}$ Values, Bacteria

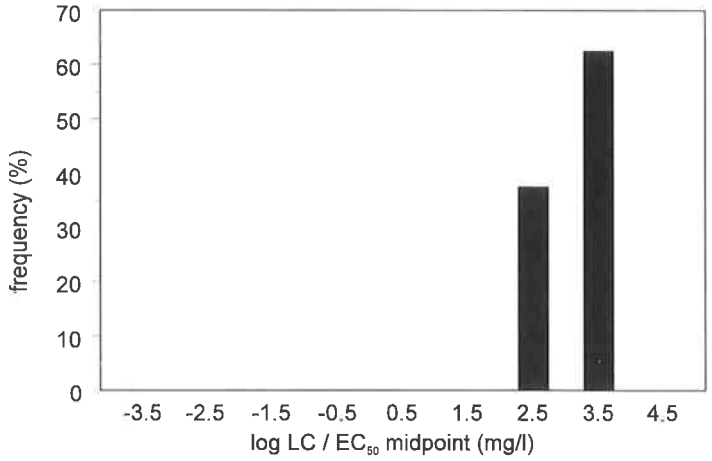


Figure D.9 Frequency Distribution Acute LC/EC$_{50}$ Values, Invertebrates

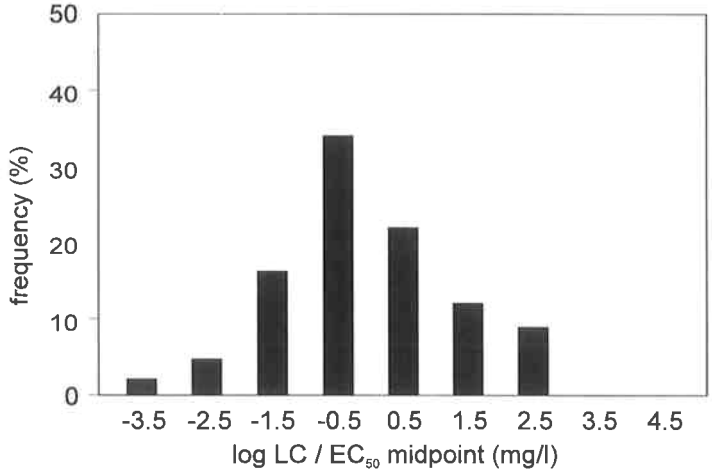


Figure D.10 Frequency Distribution Acute LC/EC$_{50}$ Values, Invertebrates Except Daphnids

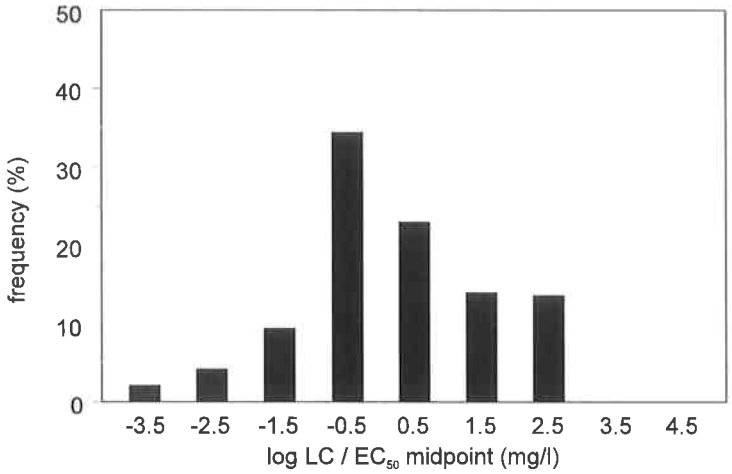


Figure D.11 Frequency Distribution Acute LC/EC_{50} Values, Daphnids

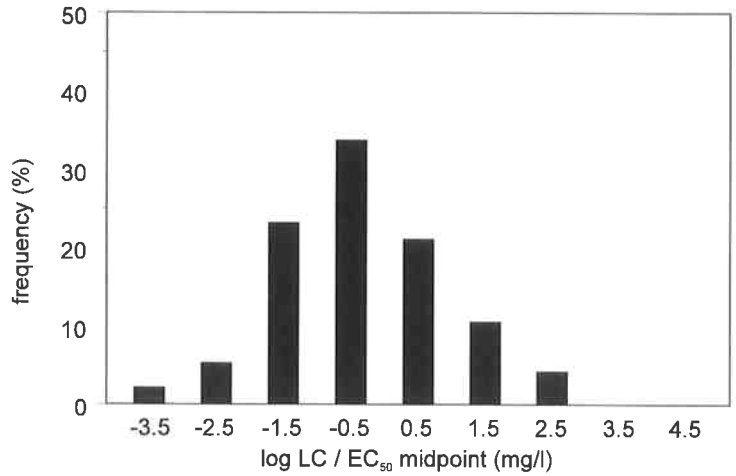


Figure D.12 Frequency Distribution Acute LC/EC_{50} Values, Fish

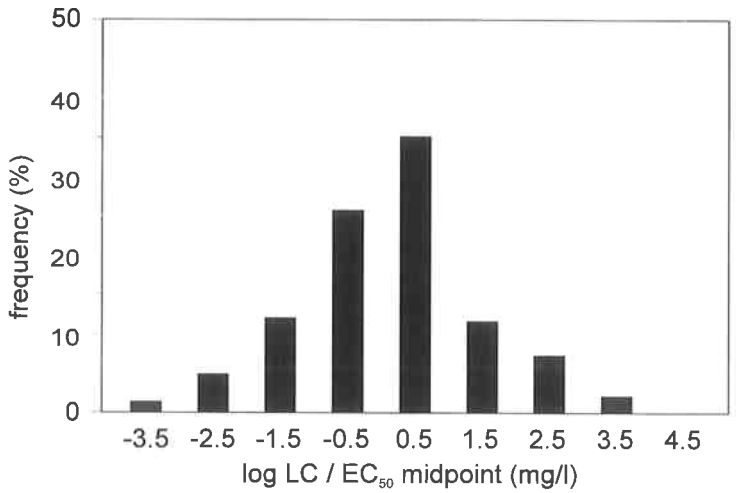


Figure D.13 Frequency Distribution Acute LC/EC_{50} Values, Algae

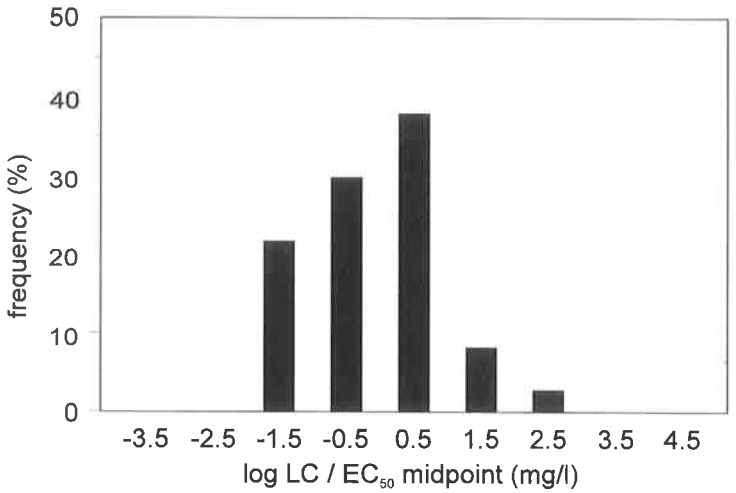


Figure D.14 Frequency Distribution NOEC Values, All Species, Organic Acids

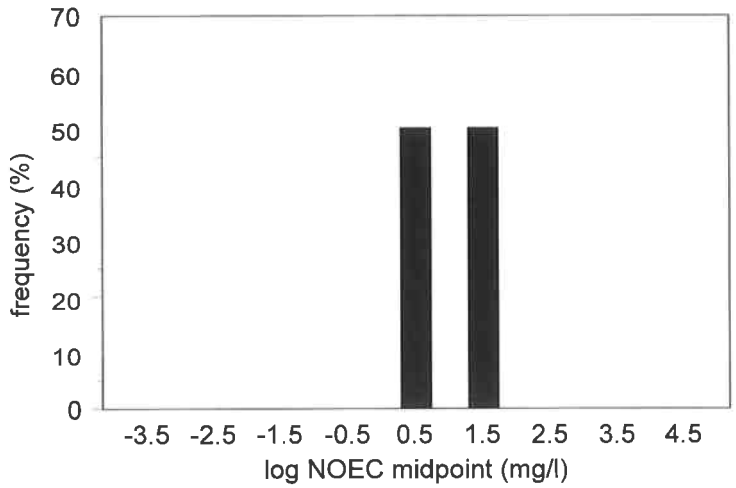


Figure D.15 Frequency Distribution NOEC Values, All Species, Inorganics

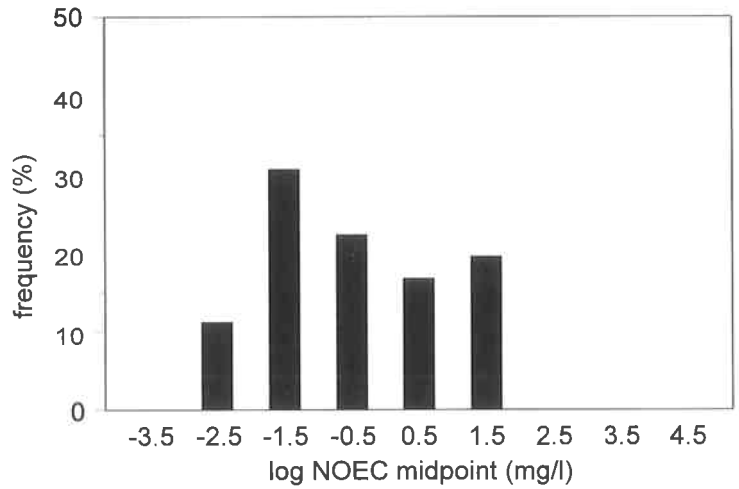


Figure D.16 Frequency Distribution NOEC Values, All Species, Heavy Metals

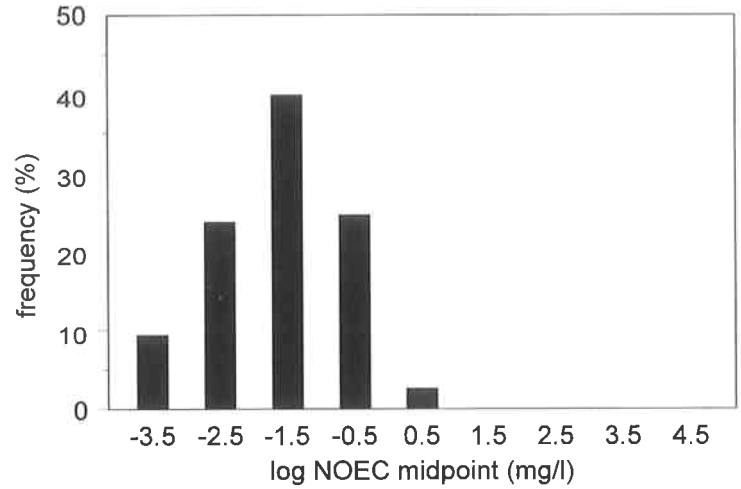


Figure D.17 Frequency Distribution NOEC Values, All Species, Alcohols

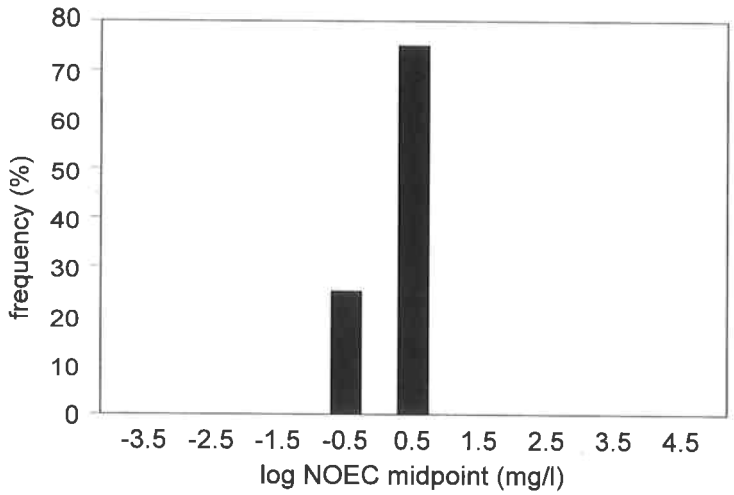


Figure D.18 Frequency Distribution NOEC Values, All Species, Ketones

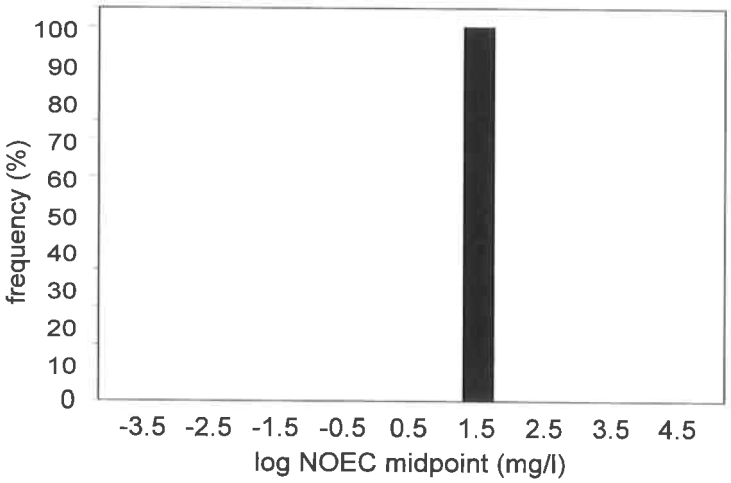


Figure D.19 Frequency Distribution NOEC Values, All Species, Aldehydes

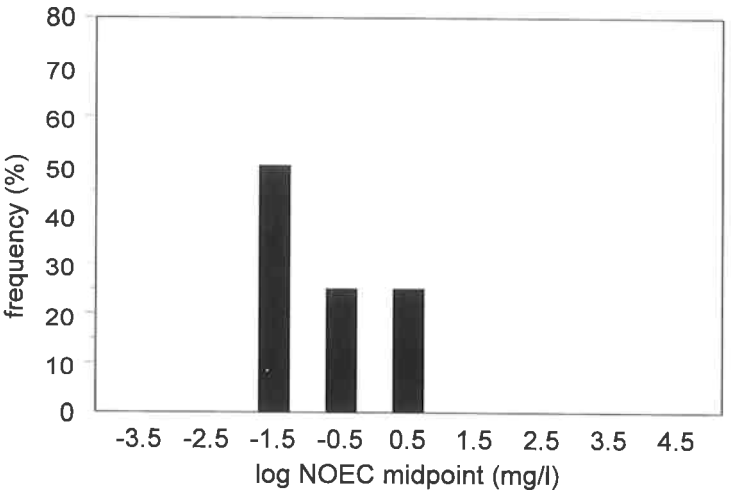


Figure D.20 Frequency Distribution NOEC Values, All Species, Nitrogen Compounds

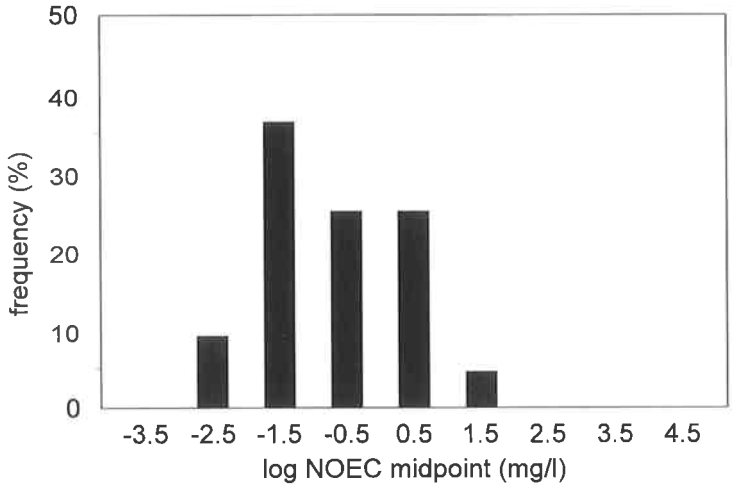


Figure D.21 Frequency Distribution NOEC Values, All Species, Sulphur Compounds

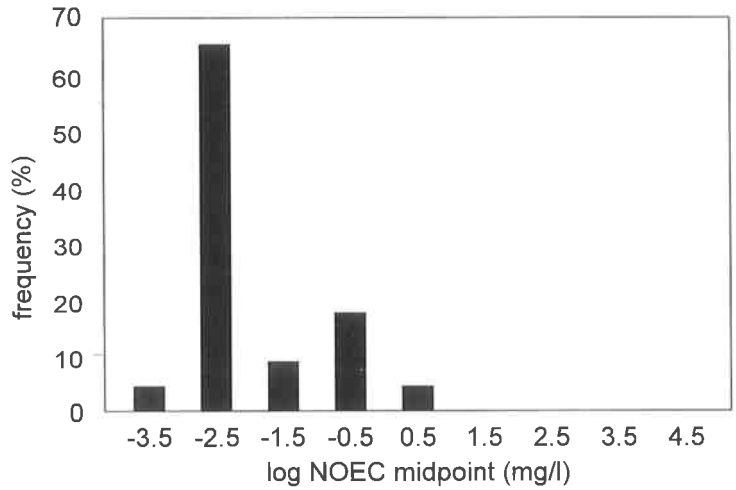


Figure D.22 Frequency Distribution NOEC Values, All Species, Halogenated Compounds

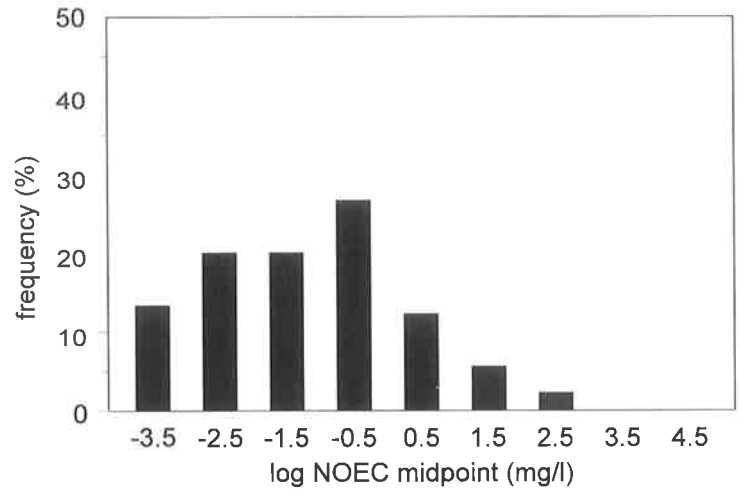


Figure D.23 Frequency Distribution NOEC Values, All Species, Organo-Phosphates

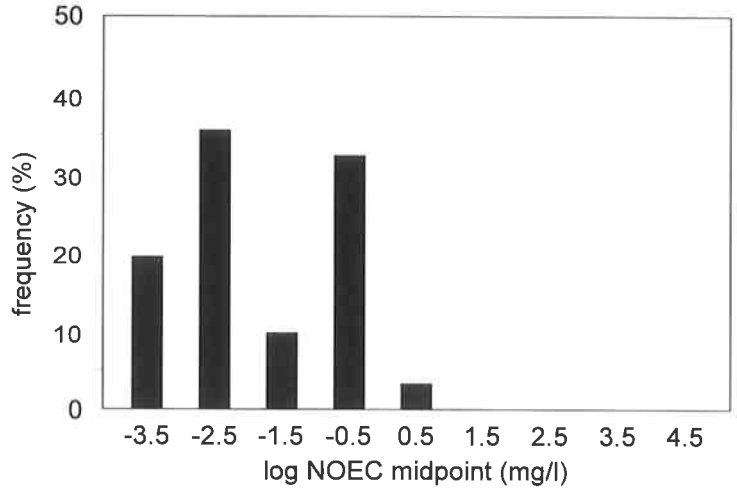


Figure D.24 Frequency Distribution NOEC Values, All Species, Aliphatic Hydrocarbons

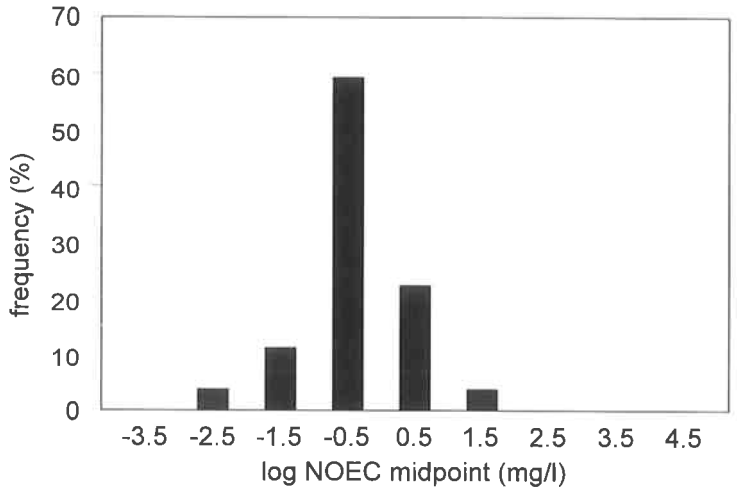


Figure D.25 Frequency Distribution NOEC Values, All Species, Aromatic Hydrocarbons

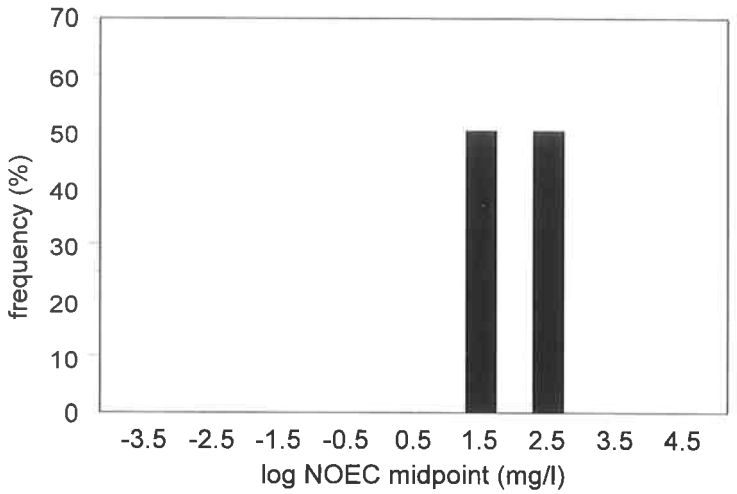


Figure D.26 Frequency Distribution NOEC Values, All Species, Silicon Compounds

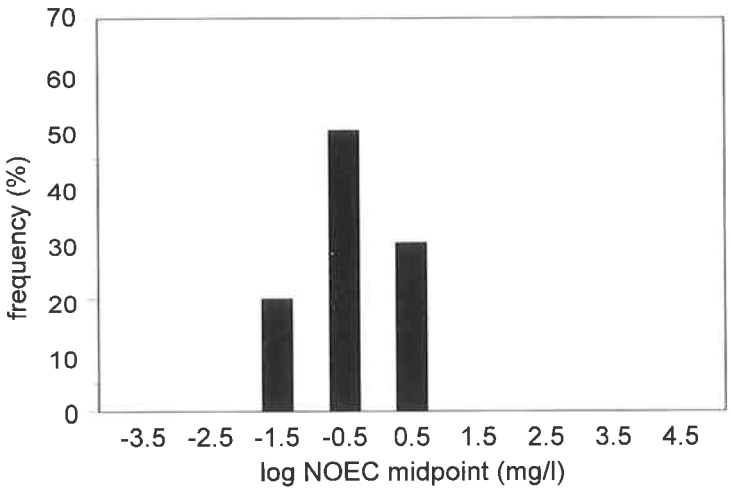


Figure D.27 Frequency Distribution NOEC Values, All Species, Ethers

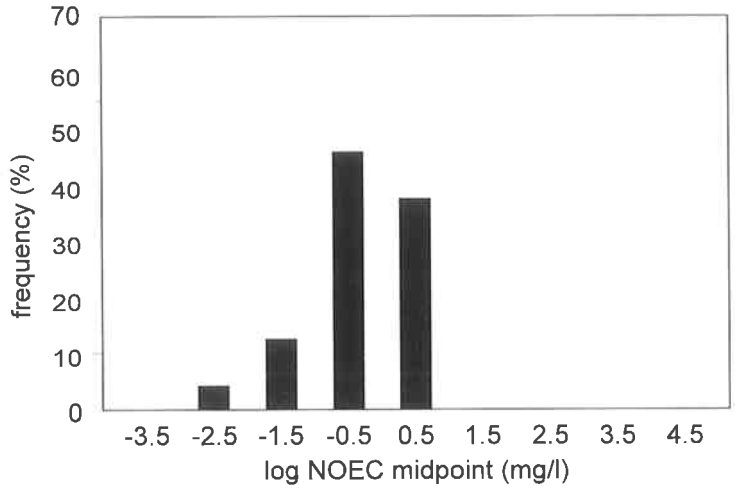


Figure D.28 Frequency Distribution NOEC Values, All Species, Esters

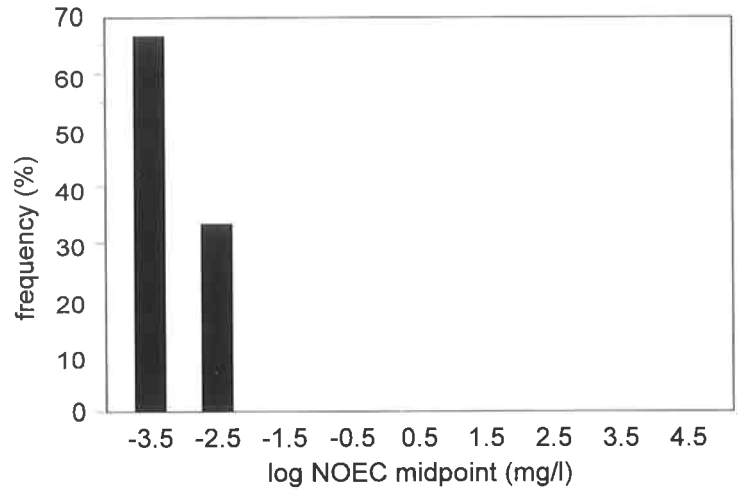
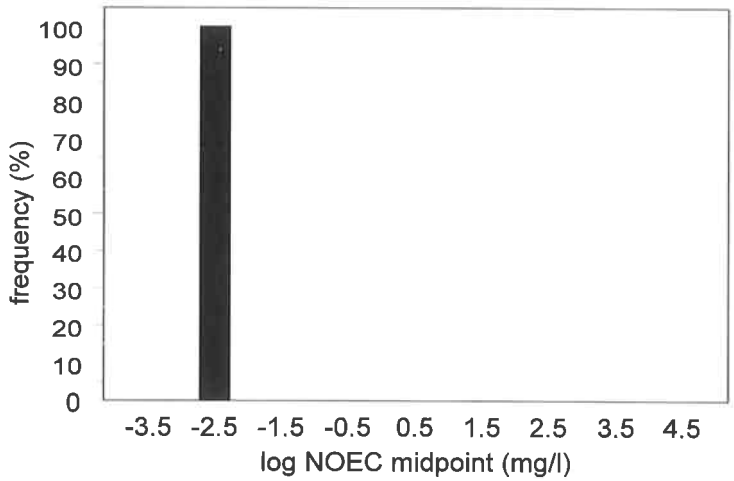


Figure D.29 Frequency Distribution NOEC Values, All Species, Organo-Metallics



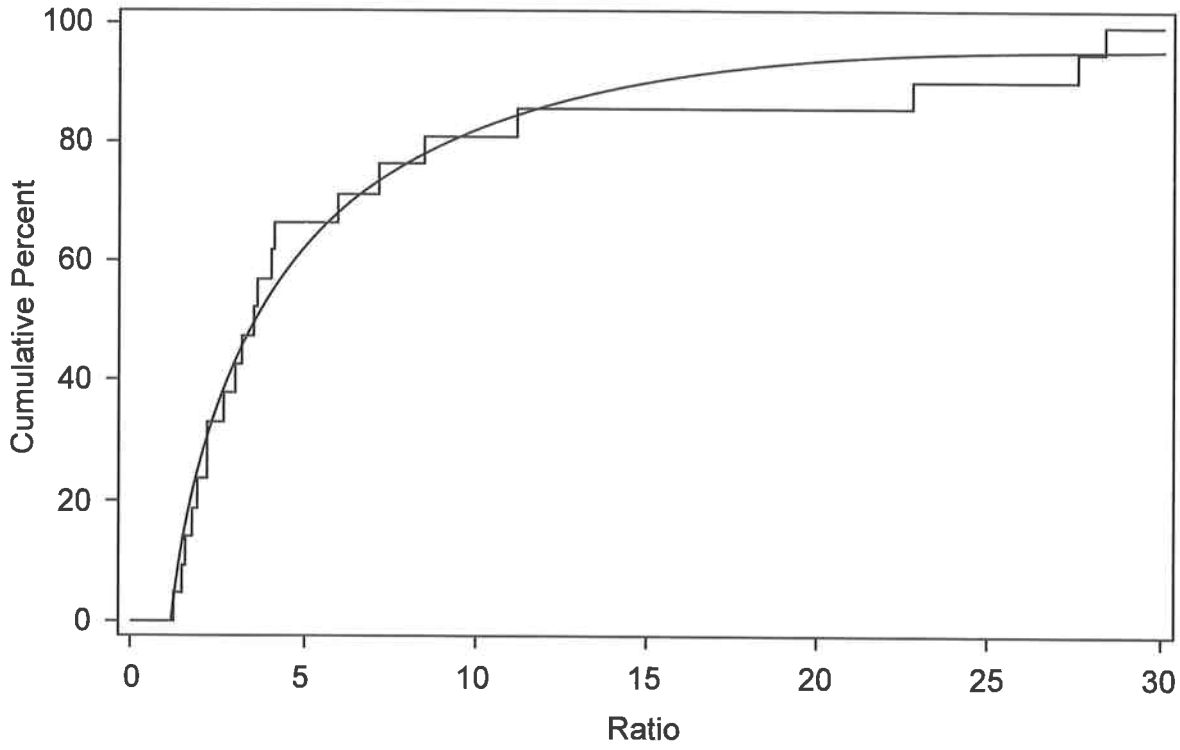
D.2 REGRESSION ANALYSES USED FOR DERIVING APPLICATION FACTORS

The names of the 19 substances and the 21 ratios obtained and used in Column 12 of Table 7 are given in Table D.1. An examination has been made of the pattern of distribution of these ratios. The null hypothesis was constructed that the distribution was not log-normal and this was tested using the Kolmogorov-Smirnov (K-S) technique. A constraint was incorporated - that the threshold of the curve could not be less than 1.0, because an Acute:Chronic ratio of less than 1.0 was not a practical possibility. The resulting curve, set against the observed ratios is shown in Figure D.30. Clearly there is close correspondence with a log-normal distribution and the null hypothesis could not be rejected. The K-S statistic was 0.124 and this was not significant at the P value 0.05, nor indeed at P = 0.15. (The distribution was still log-normal when the threshold was set inappropriately at 0.0.)

Table D.1 Acute EC_{50}:Chronic NOEC Ratios of 19 Substances Summarised in Column 12 of Table 7

SUBSTANCE	SPECIES	RATIO
Acenaphthene	*Cyprinodon variegatus*	5.96
Acenaphthene	*Pimephales promelas*	4.11
Adipic acid (2-ethylhexyl) ester	*Daphnia magna*	27.50
Alkylbenzene sulphonate linear (C11.2)	*Pimephales promelas*	1.88
Alkylbenzene sulphonate linear (C11.7)	*Pimephales promelas*	11.18
Bromoform	*Cyprinodon variegatus*	1.48
Chloronaphthalene, 1-	*Cyprinodon variegatus*	1.77
Dichlorophenol, 2,4-	*Pimephales promelas*	28.28
Dimethylphenol, 2,4-	*Pimephales promelas*	8.50
Isophorone	*Cyprinodon variegatus*	1.25
Nitrophenol, 4-	*Cyprinodon variegatus*	3.20
Phenol	*Pimephales promelas*	22.73
Phthalic-acid, di-n-butylester	*Daphnia magna*	7.18
Phthalic-acid, di-n-butylester	*Pimephales promelas*	2.21
Tetrachlorobenzene, 1,2,4,5-	*Cyprinodon variegatus*	3.67
Tetrachloroethane, 1,1,2,2-	*Jordanella floridae*	3.01
Tetrachloroethylene	*Jordanella floridae*	3.60
Toluene	*Cyprinodon variegatus*	4.06
Trichloroethane, 1,1,2-	*Jordanella floridae*	1.55
Trichloroethylene	*Jordanella floridae*	2.67
Trichlorophenol, 2,4,6-	*Jordanella floridae*	2.18

Figure D.30 Acute:Chronic Ratios for 19 Substances (Column 12 of Table 7)



Lognormal curve: ——— Threshold = 1; Shape = 1.3122; Scale = 0.994

APPENDIX E. INTER-SPECIFIC COMPARISONS OF ACUTE EC_{50} DATA FOR ALL SUBSTANCES IN FRESHWATER

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species NE LM
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species= LM
Test Class= Acute
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/species group shown in the vertical axis.

Horizontal axis ***<Lepomis macrochirus>***
Vertical axis **<All species of freshwater fish except for *L. macrochirus*>**

Chemical	Percentile	Ratio
BENZALDEHYDE	2.17	0.1061
CHLORPYRIFOS	6.52	0.1369
HYDRAZINE	10.87	0.1559
HYDROGEN SULFIDE	15.22	0.4447
ATRAZINE	19.57	0.6892
PENTACHLOROPHENOL	23.91	0.7009
CHLOROETHANOL, 2-	28.26	0.7409
PENTANEDIONE, 2, 4-	32.61	0.7444
DIMETHYLFORMAMIDE	36.96	0.7570
DIETHYLENEGLYCOL DINITRATE	41.30	0.7618
ACRYLAMIDE MONOMER	45.65	0.7664
HEXACHLOROETHANE	50.00	0.7954
AMMONIA	54.35	0.9900
LINDANE	58.70	1.0483
HYDROGEN CYANIDE	63.04	1.2239
CARBARYL	67.39	1.4506
BROMO-DIMETHOXYACETOPHENONE	71.74	1.5043
CHLORINE DIOXIDE	76.09	2.5725
ZINC	80.43	2.7976
CADMIUM	84.78	4.4712
POTASSIUM DICHROMATE	89.13	5.1856
PARATHION	93.48	7.2962
OZONE	97.83	14.8994

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species NE PP
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species= PP
Test Class= Acute
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/species group shown in the vertical axis.

Horizontal axis **<*Pimephales promelas*>**
Vertical axis **<All species of freshwater fish except for *P. promelas*>**

Chemical	Percentile	Ratio
POTASSIUM DICHROMATE	1.28	0.1928
ZINC	3.85	0.3061
BENZOQUINONE, 4-	6.41	0.3600
CHLORINE DIOXIDE	8.97	0.3887
CATECHOL	11.54	0.3933
ENDOSULFAN	14.10	0.4451
DICHLORO 1,3- DINITROBENZENE	16.67	0.5433
BROMO-DIMETHOXYACETOPHENONE	19.23	0.6803
FENVALERATE	21.79	0.7191
SILVER NITRATE	24.36	0.7532
COPPER	26.92	0.7796
CADMIUM	29.49	0.8812
ACRYLAMIDE MONOMER	32.05	0.9728
CARBARYL	34.62	0.9761
HYDROGEN SULFIDE	37.18	0.9827
HEXACHLOROETHANE	39.74	1.0917
DISULFOTON	42.31	1.1704
HYDROGEN CYANIDE	44.87	1.2777
LINDANE	47.44	1.3632
CHLOROETHANOL, 2-	50.00	1.5848
DIETHYLENEGLYCOL DINITRATE	52.56	1.7985
KELTHANE	55.13	1.8585
PERMETHRIN	57.69	1.8626
PENTANEDIONE, 2,4-	60.26	1.8662
ACENAPHTHENE	62.82	1.9317
ENDRIN	65.38	2.0162
CRESOL, 2-	67.95	2.1667
BENZALDEHYDE	70.51	2.2694
ATRAZINE	73.08	2.3088
AMMONIA	75.64	2.3973
PENTACHLOROPHENOL	78.21	2.4800
NICKEL	80.77	3.0003
PHENOL	83.33	3.2041
TRICHLOROPHENOL, 2,4,6-	85.90	3.4131
CRESOL, 4-	88.46	3.6203
PARATHION	91.03	4.9384
CRESOL, 3-	93.59	6.2809
HYDRAZINE	96.15	6.4140
CHLORPYRIFOS	98.72	10.4920

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species NE SG
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species= SG
Test Class= Acute
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/species group shown in the vertical axis.

Horizontal axis **<*Salmo gairdneri* ie *Oncorhynchus mykiss*>**

Vertical axis **<All species of freshwater fish except for *S. gairdneri*>**

Chemical	Percentile	Ratio
CADMIUM	1.14	0.0009
SODIUM NITRITE	3.41	0.0570
OZONE	5.68	0.0671
CHLORPYRIFOS	7.95	0.0745
CARBARYL	10.23	0.1178
CRESOL, 3-	12.50	0.1592
TRIBUTYLTIN	14.77	0.2692
CRESOL, 4-	17.05	0.2762
COPPER	19.32	0.2970
NICKEL	21.59	0.3333
LEAD	23.86	0.3866
HYDROGEN CYANIDE	26.14	0.4013
CRESOL, 2-	28.41	0.4615
DICHLOROPHENOXY ACETIC ACID	30.68	0.4798
PERMETHRIN	32.95	0.5369
KELTHANE	35.23	0.5381
TETRACHLOROETHYLENE	37.50	0.5919
BROMO-DIMETHOXYACETOPHENONE	39.77	0.6803
AMMONIA	42.05	0.6892
TRICHLORO-2-PYRIDINOL, 3,5,6-	44.32	0.6977
PENTANEDIONE, 2, 4-	46.59	0.7107
THIOBENCARB	48.86	0.7798
HEXACHLOROETHANE	51.14	0.7954
DISULFOTON	53.41	0.8544
DIETHYLENEGLYCOL DINITRATE	55.68	0.8662
PHENOL	57.95	0.8879
MOLINATE	60.23	0.9151
ACENAPHTHENE	62.50	0.9308
SODIUM NITRATE	64.77	1.0064
ACRYLAMIDE MONOMER	67.05	1.0092
TRICLOPYR	69.32	1.0274
GARLON 3ATM (Formulation)	71.59	1.2496
DIMETHYLFORMAMIDE	73.86	1.3211
FENVALERATE	76.14	1.3907
CHLOROETHANOL, 2-	78.41	1.3917
METHOXY-3,5,6-TRICHLOROPYRI	80.68	1.4084
GARLON 4TM (Formulation)	82.95	1.5899
TRIFLUOROMETHYL-4-NITROPHEN	85.23	1.6455
ZINC	87.50	1.6655
TRICLOPYRESTER	89.77	1.8429
BENZALDEHYDE	92.05	1.9982
CATECHOL	94.32	2.5429
BENZOQUINONE, 4-	96.59	2.7778
DICHLORO 1,3- DINITROBENZENE	98.86	7.0571

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= IO
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species= SG
Test Class= Acute
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/ species group shown in the vertical axis.

Horizontal axis **<*Salmo gairdneri* ie *Oncorhynchus mykiss*>**
Vertical axis **<All invertebrates other than Daphnids in fresh water>**

Chemical	Percentile	Ratio
CADMIUM	7.14	0.0003
AMMONIA	21.43	0.0588
HYDROGEN CYANIDE	35.71	0.1158
COPPER	50.00	0.2175
ACRYLAMIDE MONOMER	64.29	0.4537
PENTANEDIONE, 2, 4 -	78.57	0.4619
DIETHYLENEGLYCOL DINITRATE	92.86	1.0564

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= ID
Species= DM
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species= PP
Test Class= Acute
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/ species group shown in the vertical axis.

Horizontal axis **<*Pimephales promelas*>**
Vertical axis **<*Daphnia magna*>**

Chemical	Percentile	Ratio
ENDOSULFAN	3.57	0.0060
HEPTACHLOR	10.71	0.1400
LINDANE	17.86	0.1425
PHTHALIC ACID, DI-N-BUTYLESTER	25.00	0.2377
BISPHENOL A	32.14	0.3738
AMMONIA	39.29	0.4813
TRIFLURALIN	46.43	1.1500
ACRYLAMIDE MONOMER	53.57	1.2117
ACROLEIN	60.71	1.4737
ATRAZINE	67.86	2.1739
DIETHYLENEGLYCOL DINITRATE	75.00	5.4539
COPPER	82.14	22.5234
CADMIUM	89.29	24.2765
PARATHION	96.43	498.6230

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= IO
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species= PP
Test Class= Acute
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/ species group shown in the vertical axis.

Horizontal axis ***<Pimephales promelas>***
Vertical axis **<Invertebrates in freshwater other than Daphnids>**

Chemical	Percentile	Ratio
HEPTACHLOR	3.57	0.0048
SILVER NITRATE	10.71	0.0712
AMMONIA	17.86	0.1102
CADMIUM	25.00	0.1478
HYDROGEN CYANIDE	32.14	0.3239
LINDANE	39.29	0.3900
COPPER	46.43	0.3910
ACRYLAMIDE MONOMER	53.57	0.4402
PENTACHLOROPHENOL	60.71	0.6701
PENTANEDIONE, 2, 4-	67.86	1.0000
DIETHYLENEGLYCOL DINITRATE	75.00	1.8272
HYDROGEN SULFIDE	82.14	1.9574
ATRAZINE	89.29	7.4044
PARATHION	96.43	145.8778

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= IO
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= ID
Species= DM
Test Class= Acute
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/ species group shown in the vertical axis.

Horizontal axis ***<Daphnia magna>***
Vertical axis **<Non-daphnid invertebrates in freshwater>**

Chemical	Percentile	Ratio
CADMIUM	5.56	0.0061
COPPER	16.67	0.0174
HEPTACHLOR	27.78	0.0345
AMMONIA	38.89	0.2289
PARATHION	50.00	0.2926
DIETHYLENEGLYCOL DINITRATE	61.11	0.3350
ACRYLAMIDE MONOMER	72.22	0.3633
LINDANE	83.33	2.7370
ATRAZINE	94.44	3.4060

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= VF
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= ID
Species= DM
Test Class= Acute
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/ species group shown in the vertical axis.

Horizontal axis **<*Daphnia magna*>**
Vertical axis **<All species of fish in freshwater>**

Chemical	Percentile	Ratio
PARATHION	2.38	0.0061
COPPER	7.14	0.0350
CADMIUM	11.90	0.0368
ALKYL (C12-14) MONOMETHYLDIHY	16.67	0.0388
TETRABUTYLTIN	21.43	0.2222
DIETHYLENEGLYCOL DINITRATE	26.19	0.2848
DIBUTYLTIN DILAURATE	30.95	0.3300
FENBUTATINOXIDE	35.71	0.4000
ALKYL ETHOXYLATE (C14-15)	40.48	0.5468
ACROLEIN	45.24	0.6786
ATRAZINE	50.00	0.8036
ACRYLAMIDE MONOMER	54.76	0.8060
TRIFLURALIN	59.52	0.8696
ALKYLBENZENE SULPHONATE, LINEAR	64.29	2.0979
BISPHENOL A	69.05	2.6753
AMMONIA	73.81	2.7465
PHTHALIC ACID, DI-N-BUTYLESTER	78.57	4.2068
HEPTACHLOR	83.33	7.1429
LINDANE	88.10	8.6292
TRIBUTYLTIN	92.86	13.3425
ENDOSULFAN	97.62	87.2159

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= VF
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= PA
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/ species group shown in the vertical axis.

Horizontal axis **<Algae in freshwater (not necessarily acute)>**
Vertical axis **<All species of fish in freshwater>**

Chemical	Percentile	Ratio
POTASSIUM DICHROMATE	3.85	0.0069
DIETHYLENEGLYCOL DINITRATE	11.54	0.1236
TOLUENE	19.23	0.1621
XYLENE, 3-	26.92	0.2437
XYLENE, 4-	34.62	0.2444
XYLENE, 2-	42.31	0.3231
ALKYL ETHOXYLATE (C14-15)	50.00	0.3747
COPPER	57.69	0.4004
BISPHENOL A	65.38	0.6190
CADMIUM	73.08	0.7139
BENZENE	80.77	0.8913
LEAD	88.46	1.1939
ALKYLBENZENE SULPHONATE, LINEAR	96.15	3.0052

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= ID IO
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= PA
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/ species group shown in the vertical axis.

Horizontal axis **<Algae in freshwater (not necessarily acute)>**
Vertical axis **<All species of invertebrates in freshwater>**

Chemical	Percentile	Ratio
DIETHYLENEGLYCOL DINITRATE	5.56	0.1911
BISPHENOL A	16.67	0.2314
XYLENE, 4-	27.78	0.4135
COPPER	38.89	0.4155
CADMIUM	50.00	0.6205
ALKYL ETHOXYLATE (C14-15)	61.11	0.6852
ALKYLBENZENE SULPHONATE, LINEAR	72.22	1.4325
POTASSIUM DICHROMATE	83.33	2.9255
BENZENE	94.44	25.7862

EAT Database: Mean Scores for Individual Chemicals

Choices from database

Vertical Axis= EC_{50} (LOG)

Taxonomic Code= ID
Species= DM
Test Class= Acute
Environment= Freshwater

Horizontal Axis= EC_{50} (LOG)

Taxonomic Code= VF
Species= SG
Test Class= Acute
Environment= Freshwater

Ratios between the acute EC_{50} values of species or species groups, ranked in order of ascending "horizontal axis": "vertical axis". Where the ratio is >1 the species/species group shown in the horizontal axis is more tolerant of the given substance than the species/ species group shown in the vertical axis.

Horizontal axis **<*Salmo gairdneri* ie *Oncorhynchus mykiss*>**
Vertical axis **<*Daphnia magna*>**

Chemical	Percentile	Ratio
TRIBUTYLTIN	8.33	0.0389
CADMIUM	25.00	0.0486
AMMONIA	41.67	0.2570
ACRYLAMIDE MONOMER	58.33	1.2488
DIETHYLENEGLYCOL DINITRATE	75.00	3.1532
COPPER	91.67	12.5293

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