DEVELOPMENT OF AN EUROPEAN QUANTITATIVE EUTROPHICATION RISK ASSESSMENT OF POLYPHOSPHATES IN DETERGENTS

MODEL VALIDATION USING THE WFD INTERCALIBRATION DATA, MODEL RE-CALIBRATION, AND Pan-EUROPEAN ASSESSMENT OF THE EUTROPHICATION RISK ASSOCIATED TO THE USE OF PHOSPHATES IN DETERGENTS

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ANNEXES

EXECUTIVE SUMMARY

This report presents the results obtained for the study entitled: "MODEL VALIDATION USING THE WFD INTERCALIBRATION DATA, MODEL RE-CALIBRATION, AND PAN-EUROPEAN ASSESSMENT OF THE EUTROPHICATION RISK ASSOCIATED TO THE USE OF PHOSPHATES IN DETERGENTS" conducted within the project "DEVELOPMENT OF AN EUROPEAN QUANTITATIVE EUTROPHICATION RISK ASSESSMENT OF PHOSPHATES IN DETERGENTS". The report includes the updated estimations obtained after the validation and recalibration process using the WFD Lake Intercalibration database, and substitutes those presented previously.

The report is presented in five sections plus a final discussion summarising the updated estimations. Section 1 describes the previous developments, including the conceptual model, exposure scenarios, effect evaluation and risk assessment proposal. Section 2 describes the validation process and the new conceptual developments. Section 3 introduces the Water Framework Directive Inter-Calibration database that constitutes the basis for the validation process, this section also includes the statistical analysis conducted with the databases, and presents the updated risk-response curves. Section 4 includes the results obtained with the recalibrated model, including a set of deterministic and probabilistic estimations. Section 5 describes some complementary studies, presenting some preliminary results for expanding the model to the Baltic Sea and the updated estimations for the Tajo, Ebro and Danube Rivers. The final part of the report discusses the results and summarizes the quantitative estimations of the contribution of P-based laundry and dishwashing detergents to the eutrophication risk for the different ecoregions.

The proposed risk assessment protocol is a higher tier method with probabilistic estimations for the effect assessments and the risk characterization. As there are several relevant sources of phosphate emission, the risk is presented as a comparative risk assessment.

Problem formulation: The risk to be assessed has been defined according to the European chemicals policy rules and regulations: the identification of the risk associated to a specific chemical substance under the conditions expected for the uses defined by the industrial producer. The risk to be quantified is the eutrophication risk associated to the emissions of phosphorus resulting from the use of phosphates in domestic detergents. The assessed substance, phosphorus (P), is widely distributed in the environment and there are many sources of environmental release other than the one addressed in this study (presence of phosphates in detergents). The risk assessment methodology should be able to identify the risk associated to the specifically addressed source using comparative risk assessment methods. Similarly, the risk is addressed in a way that could be directly used as supporting tool for risk management measures at the European level. Therefore, the methodology is based on generic risk estimations for sensitive ecosystems potentially exposed; and does not pretend to identify where these conditions exist. Historical pollution, synergistic or antagonistic effects with other substances, adaptation mechanisms, etc., are also excluded from the problem formulation; however, it must be considered that as the effect assessment is based on real field data, part of the observed variability should be attributed to these phenomena.

Exposure assessment: Following the SCHER and expert recommendations, the assessment must be based on realistic phosphorous concentrations. The simplified exposure assessment model developed in the previous study did not accounted for the sedimentation process within the river basin; and, therefore, over-predicted the phosphorous concentration. Thus, the model predictions have not been used in this updated report. Instead, realistic values selected from measured levels in European water bodied, have been used. For the deterministic estimations, the calculations have been repeated for three total phosphorous levels, representing low, medium and high realistic concentrations. For the probabilistic estimations, distributions of measured values for each ecoregion have been employed.

The simplified exposure assessment model has been modified for providing the relative contribution of each source of phosphorous: laundry detergents, dishwashing detergents, human metabolisms and diffuse sources. The obtained percentages are assigned to the selected total phosphorous concentration. The mathematical implementation of the model allows probabilistic assessments covering variability and uncertainty using Monte Carlo analysis.

Effect assessment: The assessment of the effects associated to phosphorus releases constitutes the key aspect of this study, requiring a high level of innovation, as the European environmental risk assessment protocols focus on the toxicity of the substance, not on nutrient enrichment. The adopted solution is based on the combination of information obtained from field studies representing real situations. The initial proposal was developed through the analysis of published field studies validated one by one, according to the principles for assessing adverse effects linked to nutrient enrichment, developed for the implementation of the European Water Framework Directive (WFD). The validation exercise included in this report has been conducted using a database generated by the Joint Research Centre, European Commission, using the data collected for the Inter-Calibration exercise under the Water Framework Directive. The use of this database was recommended by the SCHER, and DG Enterprise facilitated the contact with the JRC, that has kindly provided the data in a codified form for maintaining the confidentially. After confirming the similitude in the approaches through a comparative statistical analysis of the databases, both sets of data have been compiled in the re-calibration exercise, producing new effect estimation (risk-response) curves. This approach was needed as the IC database did not included sufficient information for the Mediterranean ecoregion. Table ES-1 summarises the available information.

Table ES-1. Summary description of the JRC and INIA Databases

JRC IC-WFD Database					
Ecoregion	**Northern**		**Central/Baltic**	**Atlantic**	**Mediterranean**
Status	*Chlor a*	*Macrophytes*	*Chlor a*	*Chlor a*	*Chlor a*
No. total	484	769	990	44	34
No. Good	402	516	549	19	31
No. Less than good	82	253	441	25	3
INIA-Green Planet Database					
Ecoregion	**Northern/Central/Atlantic**				**Mediterranean**
No. total	185				75
No. Good	83				37
No. Less than good	102				38

The field data are distributed in two main categories, water bodies fulfilling the good status conditions, or “G+”; and those with less than good status, or “G-“. Probability distributions of the TP concentrations in each of the two groups “G+” and “G-“ are estimated. The obtained probability distributions represent the best estimation for the conditional probabilities p(TP | G+) and p(TP | G-). The conditional probability is the probability of some event A occurring, given that some other event B is known to have occurred. In this case, p(TP | G+) represents the probability of a water body having a certain total phosphorus concentration, TP, given that the water body is in good status conditions, G+. Similarly, p(TP | G-) represents the probability of a water body having a certain total phosphorus concentration, TP, given that the water body is not in good status conditions, G-.

The statistical evaluation included a screening assessment using the data description tools and the distribution fitting module; the selected computational tool allows the selection of the best parametric distribution that fits the input data. The goodness-of-fit tests that were used for screening the selected distribution were the Kolgomorov-Smirnov and the Anderson-Darling tests. The Kolmogorov-Smirnov D statistic calculates the maximum distance between the cumulative distribution of the data and the cumulative distribution function of the fitted distribution. This calculation is a nonparametric method that tests the overall goodness of fit between the distribution of the data and the selected distribution. The Anderson-Darling statistic is a general test for complete datasets (without censored observations) that compares the fit of an observed cumulative distribution function with an expected cumulative distribution function; this test is mainly focussing on the goodness-of-fit in the tails of the distribution. The data were considered to fit the distribution if the p value obtained in the goodness-of-fit test was lower than 0.05. When none of the available distributions provide an acceptable fitting, the raw data where used for establishing the conditional probability distributions p(TP | G-) and p(TP | G+).

These conditional probabilities will be used in the risk characterization for quantifying the eutrophication risk associated to a given TP concentration. TP is a continuous variable, and all frequency and probability distributions are presented as cumulative distributions; therefore, for a certain TP value “x” the associated likelihood (expressed as frequency, probability or risk estimation) “y” must be understood as following: if the TP concentration value does not exceed x ($TP \leq x$) the expected likelihood will not exceed y ($Likelihood \leq y$).

The combined database allowed the estimation of conditional probability distributions for four main ecoregions offering a Pan-European coverage:

- Central/Baltic
- Northern
- Atlantic
- Mediterranean

The IC WFD datasets where classified using the chlorophyll a boundaries. In addition, a complementary set of data using the macrophytes boundary for establishing the status condition was available for the Northern ecoregion. The IC-WFD database also allocated each water body to a selected ecotype. Statistically significant differences among ecotypes were observed for the Central/Baltic and Northern ecoregions. Thus additional conditional probability distributions were developed for three ecotypes, representing the maximum, medium and minimum sensitivity, within each of these ecoregions.

Risk characterization: The combination of the exposure estimations and the effect assessment offers a quantitative estimation of the expected risk.

It was very clear from the literature review that the INIA data set cannot be considered a random sample of water bodies. The same is true for the IC WFD database. As a consequence the conditional probability of a water body to be in less than good status given a certain TP concentration, p(G- | TP) cannot be directly estimated from the data base. The data subsamples for G+ and G- are, however, considered a good representation of each subpopulation (sites in good status and sites in less than good status), as a consequence, it is possible to obtain the cumulative frequency distributions of total phosphorous concentration in each subsample, and to assume that these distributions offer a proper estimation of the cumulative conditional probability distributions of TP in each subpopulation: the conditional probabilities p(TP | G+) and p(TP | G-), representing the cumulative distribution of TP concentrations in sites in good status and in sites in less than good status, respectively. Thus, an alternative approach was developed.

For each total phosphorous concentration, the eutrophication risk is defined as the likelihood of a sensitive site, susceptible to eutrophication, to be in less-than-good eutrophication status. The eutrophication risk is expressed as a relative value, ranging from 0 to 1 (or 0% to 100% when expressed as percentage). The correction is associated to the maximum expected value, and therefore, it is related to the likelihood expected when the percentage of sites in less than good eutrophication status reach the maximum value for each TP level.

As mentioned above all probability distributions are presented as cumulative distributions; therefore, for a certain TP value "x" the associated eutrophication risk "y" must be understood as following: if the TP concentration value does not exceed x ($TP \leq x$) the expected eutrophication risk will not exceed y (Eutrophication risk ≤ y).

The information does not allow calculating the eutrophication risk as a number, but according to the definition, the risk value must be within the range defined by the cumulative conditional probability distributions: (TP|G-) ≤ Eutrophication risk ≤ (TP|G+). Thus the risk is presented as a range.

Risk communication and comparative risk assessment: Due to the complexity of the proposed methodology a specific expert consultation was conducted to obtain information on the understanding, comprehension, perception and preferences of different alternatives for presenting the results. The preferences from the experts were for receiving as much information as possible on the risk characterization output and its associated uncertainty.

The updated information on P-based detergent consumption provided by the European detergent industry association (AISE) includes information on laundry and dishwashing detergents. Therefore, the risk communication options have been adapted in order to present information for each type of detergents and for the combination of phosphorous emissions associated to both kinds of detergents.

For the deterministic examples, the risk is presented in a tabular form, which also includes the basic input values employed for that particular estimation, and by graphics comparing the different risk estimations.

The main improvements in terms of risk communication have been done for the probabilistic estimations. The contribution of P-based detergents (laundry and/or dishwashing) to the eutrophication risk is presented by risk exceedence curves, presenting the likelihood for having a risk contribution higher than that indicated in the figure. Three complementary methods have been selected for this representation: Estimated risk contribution for each source, comparative assessment of total versus reduced risks, and trends in the estimated risk reduction, presenting the certainty bands for the 10th, 25th, 50th and 90th percentiles, representing the certainty ranges into which the actual values of the forecasts fall. For example, the band which represents the 90th certainty percentile shows the range of values into which a forecast has a 90% chance of falling. The bands are centred on the median of each forecast.

Estimated risk contributions.

Deterministic and probabilistic estimations have been conducted for each ecoregion. The results are summarised in the following figures and tables. The deterministic estimations were conducted for average European values at three phosphorous concentration levels. The results for the lowest selected concentration, 50 µgP/l, which represents the highest estimated detergents` contribution for each ecoregion, are shown in Figures ES-1 to ES-4.

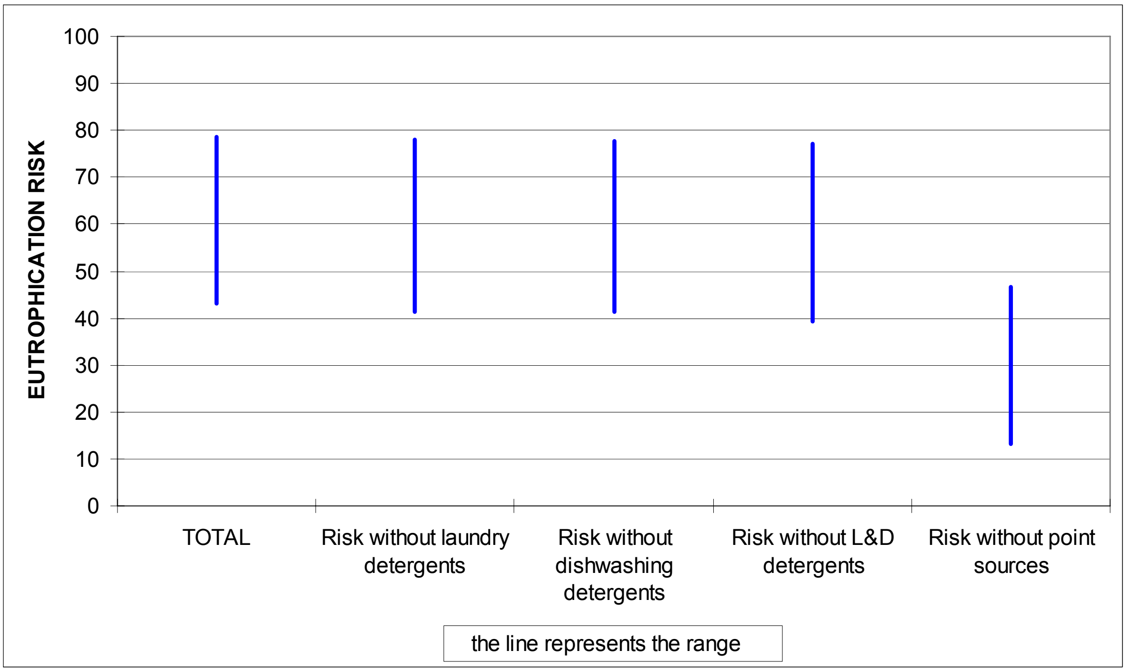

Figure ES-1. Graphic representation of the contribution of P-based detergents to the eutrophication risk estimated for the Atlantic ecoregion using averaged values and a TP concentration of 50 µgP/l.

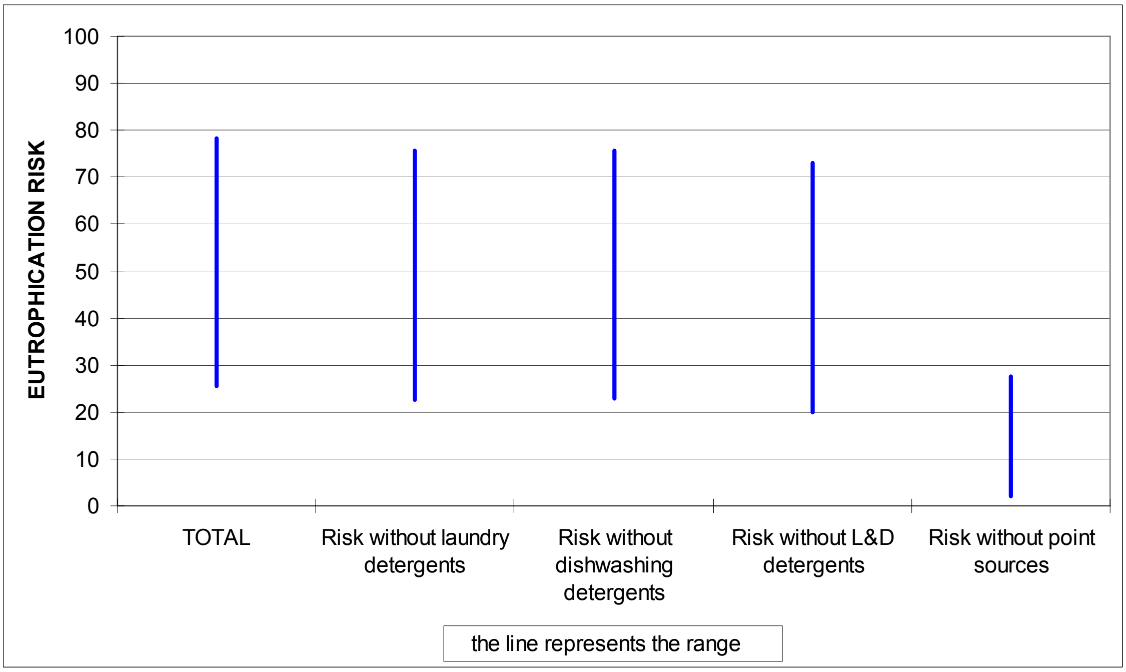

Figure ES-2. Graphic representation of the contribution of P-based detergents to the eutrophication risk estimated for the Central/Baltic ecoregion using averaged values and a TP concentration of 50 µgP/l.

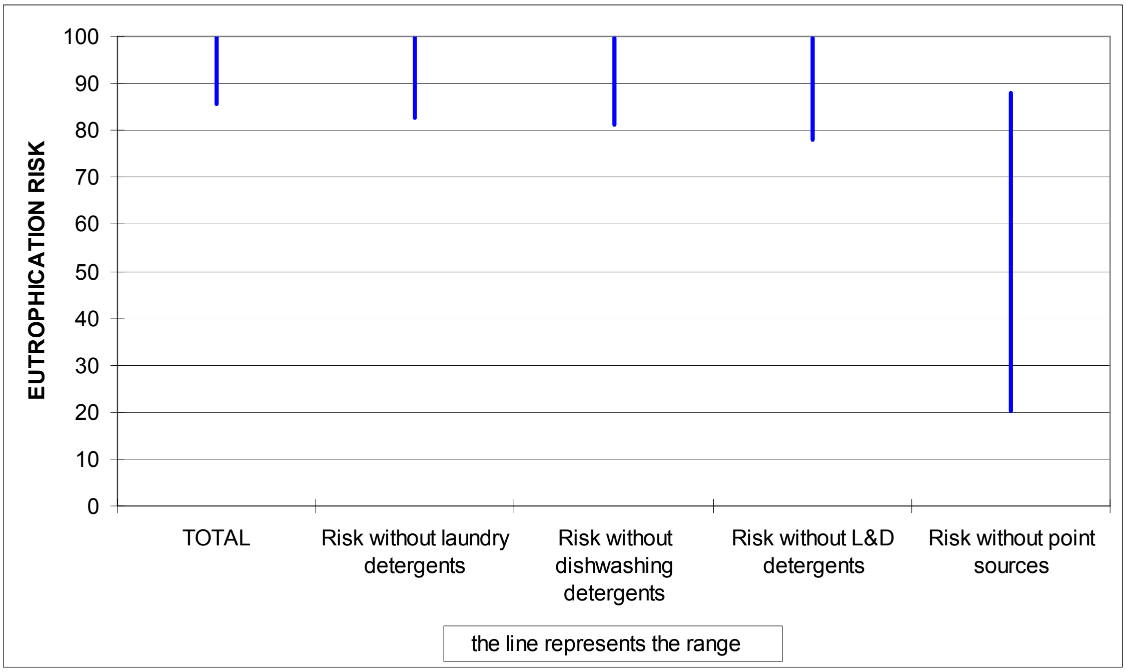

Figure ES-3. Graphic representation of the contribution of P-based detergents to the eutrophication risk estimated for the Northern ecoregion using averaged values and a TP concentration of 50 µgP/l.

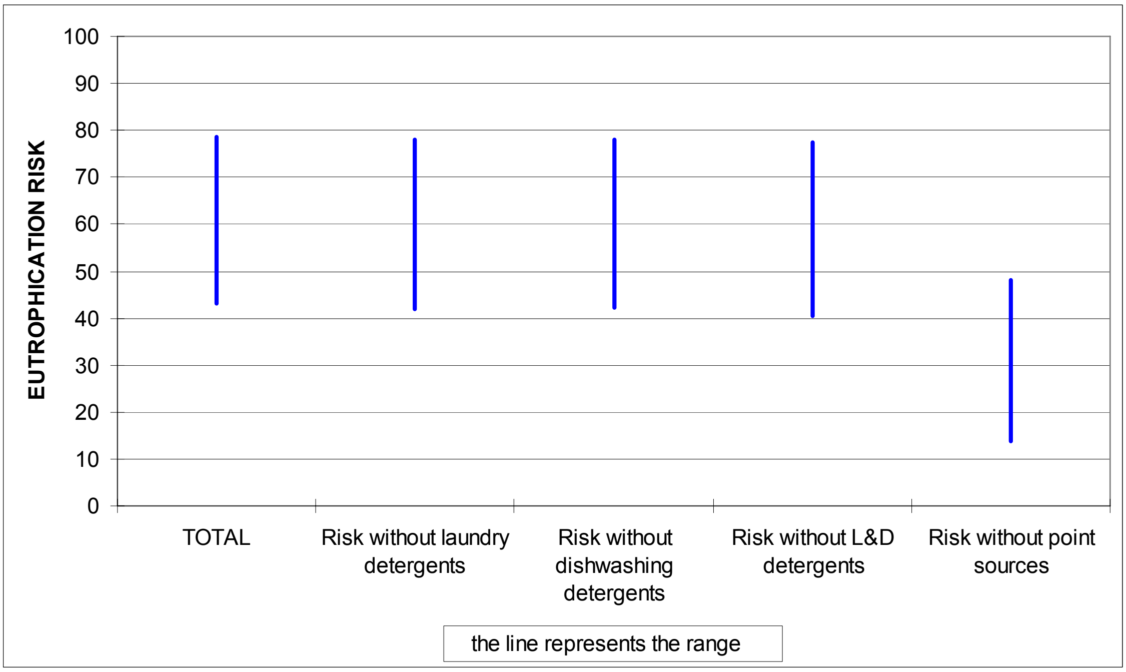

Figure ES-4. Graphic representation of the contribution of P-based detergents to the eutrophication risk estimated for the Mediterranean ecoregion using averaged values and a TP concentration of 50 µgP/l.

A summary of the results obtained for the twelve selected scenarios, which represent average conditions, is presented in Table ES-2.

Table ES-2. Results obtained for the different generic scenarios. The table shows the detergent contribution, in percentage, to the total P load in the catchment; the three selected levels of annual average total P concentration, and the difference between the total risk and the risk without P-based detergents. *(This difference is presented for the upper and lower bounds of the risk range).*

Example	**Ecoregion**	**Detergent contribution**		**TP conc.**	**Risk contribution from detergents**		
		Laundry	Dishwash		Laundry	Dishwash	Both
		%	%	µg/l	%	%	%
1	Atlantic	5.8	6.4	50	0.7-1.8	0.8-1.9	1.5-3.8
2	Atlantic	5.8	6.4	150	0.4-1.8	0.5-1.9	0.9-3.8
3	Atlantic	5.8	6.4	300	0.4-1.2	0.5-1.3	0.9-2.5
4	Central/Baltic	6.3	6.7	50	3.0-3.1	3.2-3.3	6.4-6.6
5	Central/Baltic	6.3	6.7	150	0.4-3.1	0.4-3.3	0.9-6.6
6	Central/Baltic	6.3	6.7	300	0.1-1.0	0.1-1.1	0.3-2.2
7	Northern	4.9	6.7	50	0.0-3.2	0.0-4.5	0.1-7.9
8	Northern	4.9	6.7	100	0.0-0.1	0.0-0.2	0.0-0.5
9	Northern	4.9	6.7	150	0.0-0.1	0.0-0.2	0.0-0.3
10	Mediterranean	4.8	3.8	50	0.6-1.6	0.4-1.1	1.1-2.8
11	Mediterranean	4.8	3.8	150	0.4-1.6	0.3-1.1	0.7-2.8
12	Mediterranean	4.8	3.8	300	0.4-1.0	0.3-0.8	0.7-1.8

Complementary results are obtained through the probabilistic assessments conducted for each ecoregion. The results are summarised in Table ES-3. For facilitating the comparison of the results obtained for each ecoregion, the table presents the outcome of the estimations conducted for the concentration-risk curves obtained for the whole ecoregion using the chlorophyll a boundaries for establishing the ecological status. Minor differences are observed when using the available alternative concentration-risk curves: the ecotype specific curves for the Central/Baltic and Northern ecoregions and the curve obtained using the macrophytes boundary for the Northern ecoregion. These differences do not modify the proposed conclusions. The comparison of the estimations obtained for the different ecotype concentration-risk curves obtained for each ecoregion offers an estimation of the expected uncertainty of the results associated to the fitting of raw data to the conditional distributions. As the concentration-risk curves have an "*S*" shape, with the slope increasing and then decreasing along the phosphorous concentration gradient, the use of a more or less sensitive risk-response curve may either increase or decrease the relative contribution of detergents to the eutrophication risk, depending on the TP concentration for which the risk contribution is estimated. For example, in the case of the Northern ecoregion, the use of the ecotype concentration-risk curves slightly increases the detergents contribution, while the use of the macrophytes risk-response curve slightly decreases this contribution. For the central estimations, for which the uncertainty reaches minimum values, all estimations are close, with maximum differences of about 1 unit in the percentage of the eutrophication risk associated with the detergent contribution.

Table ES-3. Summary results for the contribution of detergents to the eutrophication risk in the four ecoregions. Values are presented as percentages of the eutrophication risk.

ATLANTIC ECOREGION				
Risk Contribution	**Mean**	**Median**	**10th Percentile**	**90th Percentile**
Laundry	1.5	1.6	0.5	2.3
Dishwashing	1.6	1.8	0.6	2.5
Laundry & Dishwash	3.2	3.5	1.2	4.9
CENTRAL/BALTIC ECOREGION				
Risk Contribution	**Mean**	**Median**	**10th Percentile**	**90th Percentile**
Laundry	3.1	0.8	0.0	9.6
Dishwashing	2.7	3.1	0.6	4.8
Laundry & Dishwash	5.8	4.5	2.0	10.4
NORTHERN ECOREGION (Chlorophyll a boundaries)				
Risk Contribution	**Mean**	**Median**	**10th Percentile**	**90th Percentile**
Laundry	2.0	1.9	0.3	3.2
Dishwashing	3.3	3.6	0.6	4.9
Laundry & Dishwash	5.3	5.7	1.0	8.0
MEDITERRANEAN ECOREGION (Excluding Cyprus and Malta)				
Risk Contribution	**Mean**	**Median**	**10th Percentile**	**90th Percentile**
Laundry	1.2	0.9	0.0	3.2
Dishwashing	1.1	1.1	0.0	1.9
Laundry & Dishwash	2.3	1.7	0.5	4.5

The combination of the deterministic and probabilistic approaches, and the estimations for the Tajo, Ebro and Danube Rivers, offer a coherent assessment of the expected contribution of P-based detergents on the eutrophication risk at the Pan-European Level. The general averaged contribution to the eutrophication risk from each type of detergent (laundry or dishwashing) is estimated to be below 5%; and the combined contribution around 4-6%. Only under extreme conditions, the contribution of detergents to the eutrophication risk may exceed the 10%, using realistic worst case assumptions in terms of point versus diffuse emissions, these extreme conditions could occur rarely at the Pan-European level: about one case every tenth (combining spatial and temporal variability) in the Central/Baltic and Northern ecoregions; and with an even lower frequency in the Atlantic and Mediterranean ecoregions.

This model, validated and re-calibrated using the WFD IC data, can be applied for identifying these extreme circumstances, and for estimating the expected outcome of different risk management options.

The report also presents some preliminary results regarding the possibilities for expanding the model for covering the Baltic Sea. The preliminary results suggest that the conceptual model can be adapted and expanded for a simultaneous assessment of phosphorous and nitrogen. These results should be confirmed with additional estimations.

SECTION 1:
INTRODUCTION AND STUDY BACKGROUND

Polyphosphates are widely used as builder in household cleaning products. In conjunction with surfactants, they allow detergents to perform efficiently in all washing conditions. They are widely used in laundry detergents, dishwasher detergents, industrial and institutional detergents. Phosphates are widely used in the form of sodium tripolyphosphate Na5P3O10 (STPP) with CAS-No 7758-29-4 (pentasodium triphosphate, or Triphosphoric acid, pentasodium salt; EINECS No. 231-838-7). Through the voluntarily programme HERA, industry has conducted an environmental and human risk assessment of STPP (HERA, 2003). Household cleaning applications are estimated by industry to account for 90-95% of STPP use in Europe.

As an ingredient of household cleaning products, STPP included in domestic waste waters is mainly discharged to the aquatic compartment, directly, via sewage treatment plants (STP), via septic tanks, infiltration or other autonomous wastewater elimination systems. As STPP is an inorganic substance, biodegradation studies are not applicable. However, STPP can be hydrolysed, finally to orthophosphate, which can be assimilated by algae and/or by microorganisms. STPP thus ends up being assimilated into the natural phosphorus cycle. Reliable published studies confirm biochemical understanding, showing that STPP is progressively hydrolysed by biochemical activity in contact with wastewaters (in sewerage pipes and within sewage works) and also in the natural aquatic environment (HERA, 2003).

However, the HERA (2003) report does not address the eutrophication risk associated to the emission of phosphorus into the aquatic environment due to the hydrolysis of STPP. The report states that "*The eutrophication of surface waters due to nutrient enrichment is not addressed in this document because a PNEC cannot be defined for such effects, which depend on many factors varying spatially and temporally (temperature, light, concentrations of phosphates and of other nutrients, activity of grazer population …*)". As a consequence, the Environmental risk of STPP in the HERA report covers exclusively the toxicity of STPP but not its potential contribution to eutrophication.

The Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE) of the European Union considered that the argument was not acceptable. The committee recognised that a PNEC for eutrophication cannot be defined as a single number applicable to all ecosystems; but considered that the basic rules for environmental risk assessment are applicable, although a higher tier assessment should be required, e.g. a landscape evaluation with probabilistic outcomes for each landscape scenario (CSTEE, 2003)

Obviously, the CSTEE recognised the complexity of the eutrophication phenomena, and the limited role of anthropogenic phosphorus loads:

"The risk of eutrophication related to anthropogenic phosphate loads plays a role when the following key factors appear simultaneously in the spatial and temporal scales:

- *The ecosystem can respond to the additional nutrient load with an increase in algal productivity resulting in structural and functional changes*
- *Phosphorus is the limiting nutrient*

Increase in phosphorus loads will result in eutrophication problems only in those locations and points in time which these conditions are fulfilled." (CSTEE, 2003) .

In addition, the committee suggested that a quantitative assessment of the extent of eutrophication in EU water bodies in relation to phosphorus load from different sources, and in particular in relation to STPP contribution, could be performed on the basis of a literature review on existing experimental and modelling information, produced on the evolution of the eutrophication problem and on the recovery of eutrophic water bodies.

The Phosphate CEFIC Sector, CEEP, contracted a team composed by the technological based spin-off company Green Planet in cooperation with the Research Spanish National Institute for Agriculture and Food Research and Technology (INIA), for conducting a research project that would explore the CSTEE proposal and develop a quantitative eutrophication risk model.

The study finished in 2007 with the development of an innovative approach, designed for quantifying the risk associated to the additional input of phosphorus associated to the use of STPP in detergents. The report was submitted to the D.G. Enterprise, European Commission, and presented at the Detergents Working Group. The whole study is available at the Commission's D.G. Enterprise web page: http://ec.europa.eu/enterprise/chemicals/legislation/detergents/studies/ceep_final_study_april_2007.pdf

D.G. Enterprise submitted the model report and results for scientific assessment by the Scientific Committee on Health and Environmental Risks (SCHER), the full opinion of the Scientific Committee is available at the Commission's D.G. SANCO web page: http://ec.europa.eu/health/ph_risk/committees/04_scher/docs/scher_o_066.pdf

This report describes the validation and re-calibration exercise, conducted as a follow up of the SCHER opinion.

BRIEF DESCRIPTION OF THE DEVELOPED EUTROPHICATION RISK ASSESSMENT MODEL

DEFINITIONS

The EC Urban Waste Water Treatment Directive (91/271/CEE) defines Eutrophication as:

"the enrichment of water by nutrients especially compounds of nitrogen and phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms and the quality of the water concerned”.

This definition was combined with the definition of risk as “the likelihood and magnitude for the occurrence of adverse effects”; associating the identification of “adverse effects” to “undesirable disturbance”. The model development followed the recommendations adopted for the implementation of criteria for defining eutrophication related effects in the Common Implementation Strategy of Water Framework Directive (CIS-WFD). Ecosystem responses resulting in deviations from the “Good Status definition” are assumed to be unacceptable, and modifications in the algae and plant growth not resulting in deviations from the “Good Status definition” are considered acceptable in terms of negative ecosystems consequences.

Following the principles of the CIS-WFD, two definitions for “Significant Undesirable Disturbances” were used to define negative ecosystem consequences. The first definition covers the significant increases in algal growth and biomass production; the second covers changes in taxonomic diversity not necessarily associated to significant increase in overall primary production.

Both definitions follow the first proposal from the ECOSTAT Eutrophication Activity group. The work started with the ECOSTAT draft definitions from 2004 and 2005; and was revised after the new adopted definitions, presented in the final report of the CIS of the WFD Eutrophication Activity, “Towards a Guidance Document on Eutrophication Assessment in the context of European Water Policies”, March 2006.

In addition, there were many other documents developed around the CIS process that were considered in order to clarify the criteria to use in the effect assessment. The idea was the collect as much validated information as possible on the biological elements that are expected to be affected in the eutrophication process. In this sense, a number of draft and final reports have been considered:

- CIS-WFD. Guidance document No. 6. “Towards a guidance on establishment of the intercalibration network and the process on the intercalibration exercise”. 2000.
- CIS-WFD. Guidance document No. 7. “Monitoring under the Water Framework Directive”. 2000.
- CIS-WFD. Guidance document No. 10. “River and lakes – Typology, reference conditions and classification systems”. 2000.
- Finnish Environment Institute. “Monitoring and Assessment of the Ecological Status of Lakes A pilot procedure developed and tested in the Life Vuoksi Project”. 2004.
- CEH, UK Environment Agency and Scottish Environment Protection Agency. “Risk Assessment Methodology for Determining Nutrient Impacts in Surface Freshwater Bodies”. Science Report SC020029/SR. NUPHAR Project.

The project focused on field studies to integer the natural variability using the most realistic situations. The analysis and interpretation of the reviewed information and the application of risk assessment concepts has allowed the development of a specific proposal for assessing the eutrophication risk associated to nutrients and in particular to P emissions.

The model is presented here using the typical elements of environmental risk assessment protocols: exposure assessment; effect assessment, risk characterization and risk communication.

EXPOSURE ASSESSMENT

A river basin scenario was considered the best approach for a quantitative pan-European risk assessment. The key elements of the exposure estimations are briefly presented below.

Point Phosphorous sources: Contribution from STPP in detergent formulations.

P loads from diffuse and point sources were considered, where STPP from detergent formulation was considered an additional point source of P. The contribution of this source depends on the use of P-based detergents. Country data, provided by the industry (CEEP and AISE) were used for the calculations.

The International Association for Soaps, Detergents and Maintenance Products (AISE, www.aise-net.org) provided data for the quantities of phosphates used in detergents sold in the European Union (25 states; figures in tonnes P per year (tP/year)) for the year 2004, broken down by country detergent sales. The AISE figures were used as the basis for the average European (EU-25) consumption equivalent to 0.36 gP/person/day; and the highest national value in the EU, 1.02 gP/person/day for the Slovak Republic.

Point Phosphorous sources: Contribution from Human Metabolism

Other P sources include point and diffuse loads. The additional main point source contribution of P emissions is human metabolism. Emissions from human metabolism are obviously associated to the population. Using the literature review done by Lasevils and Berrux (2000) an average value of 1.5 gP per inhabitant and day was selected. Values of 1.5 to 1.62 gP per inhabitant and day had been proposed by other authors for the Danube River basin (Schreiber et al., 2003; Zessner and Lindtner, 2005).

Point Phosphorous sources: P removal at Sewage Treatment Plants

The P loads form point sources are related to discharges from the municipal sewer systems. In the EU, Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment, amended by Commission Directive 98/15/EC of 27 February 1998, established requirements for treating urban waste waters. The Directive establishes a time-table with dead-lines for the implementation of collecting and treatment systems for urban waste water in agglomerations which meet the criteria laid down in the Directive.

If the collected municipal sewages are treated in a Sewage Treatment Plant (STP) before being discharged into receiving water bodies, the treatment will reduce P emissions. The reduction in P emissions obviously depends on the type of treatment. Jiang et al. (2004) published a summary of expected P removal for several types of sewage treatment plants. The removal of P at a conventional secondary treatment plant is of about 20-25%. The implementation of tertiary treatment with specific P removal may achieve reductions close to 90% and even over 99% for very specific treatments.

Based on the data in the EU 2004 report on levels of sewage treatment in place (completed with expert estimates for France, Spain, and the 10 new EU states for which this report does not provide data), and on literature information concerning phosphate removal in sewage works indicated above, CEEP conducted an expert estimation of the overall figures for P removal (as TP) from sewage for each European country. The European average figure selected for current P-reduction at STP is 20%. This figure corresponds to the mean value of CEEP estimations weighted by the population of the countries of EU-15. This figure was also supported by the expert judgement at the Workshop of November 2005. Specifically they recommended to use a 20% of P-removal as an average European value where there is not a specific implementation of nutrient removal in treatment of sewage. For comparison of the expected results in the future, a highest expected reduction of 60% (3x estimated current P reduction at STP) was also considered.

The TP emissions from point sources were calculated as follow:

Point emissions = (Human metabolism + Detergents)x(100- % Removal at STP)/100

Diffuse Phosphorous sources:

The contribution of P and other nutrients from diffuses sources was estimated through the export coefficients approach. Generic export coefficients for four general land use categories: arable land, forest, pastures and "other" land uses were obtained from a literature review. Table 1 presents the export coefficients selected after the update of the literature review conducted by Lasevils and Berrux (2000).

Table 1.1. Selected Export Coefficients.

Land use	Units	Coefficient	Range	References
Arable Land	kg ha^{-1} $year^{-1}$	0.66	0.02 - 123	Lasevils and Berrux, 2000 Hilton et al., 2002 Hanrahan et al., 2001 De Wit and Bendoricchio, 2001
Pasture	kg ha^{-1} $year^{-1}$	0.4	0.002 – 5.8	
Forest	kg ha^{-1} $year^{-1}$	0.02	0.01 – 0.51	
Other	kg ha^{-1} $year^{-1}$	0.2	0.02 - 3	

The reported ranges for the export coefficients are highly variable, mostly due to the inclusion of very extreme values far away from the average. Due to the differences in the reporting format, it was not possible to produce a fully-harmonized set of coefficients. Thus, expert judgment in addition to statistical analyses where employed for the selection of the most likely value. The values selected for arable land, pasture and forests were those mostly used by other authors and basically correspond to the median value of the reported range. The hardest difficulty appeared for the "Other" category, as it covers very different situations; an averaged value was selected.

These values represent expected averages for large river basins; and should not be used for relatively small river basins, which require the inclusion of additional factors (see Vighi et al., 1991).

The literature review did not provide a sufficient database for performing a probabilistic implementation of the export coefficients based on a statistical evaluation of reported data; consequently, the probabilistic implementation of the export coefficients was done by expert judgement.

River basin hydrology

For this simplistic generic scenario, the required information on river hydrology is the Annual Average River Flow (RF) at the end of the selected part of the catchment area. This RF depends on the characteristics of the catchment area, particularly size, climatic conditions, topography and water management.

The European Rivers Network (ERN) website (ERN, 2006) compiles information that was completed and confirmed from published reports of some European river basin authorities. The data base included 32 European rivers with catchment areas larger than 12000 km^2.

A positive correlation between catchment area and river flow was found; but also significant variations for some rivers due to topography and climatic conditions (Figure 1.1).

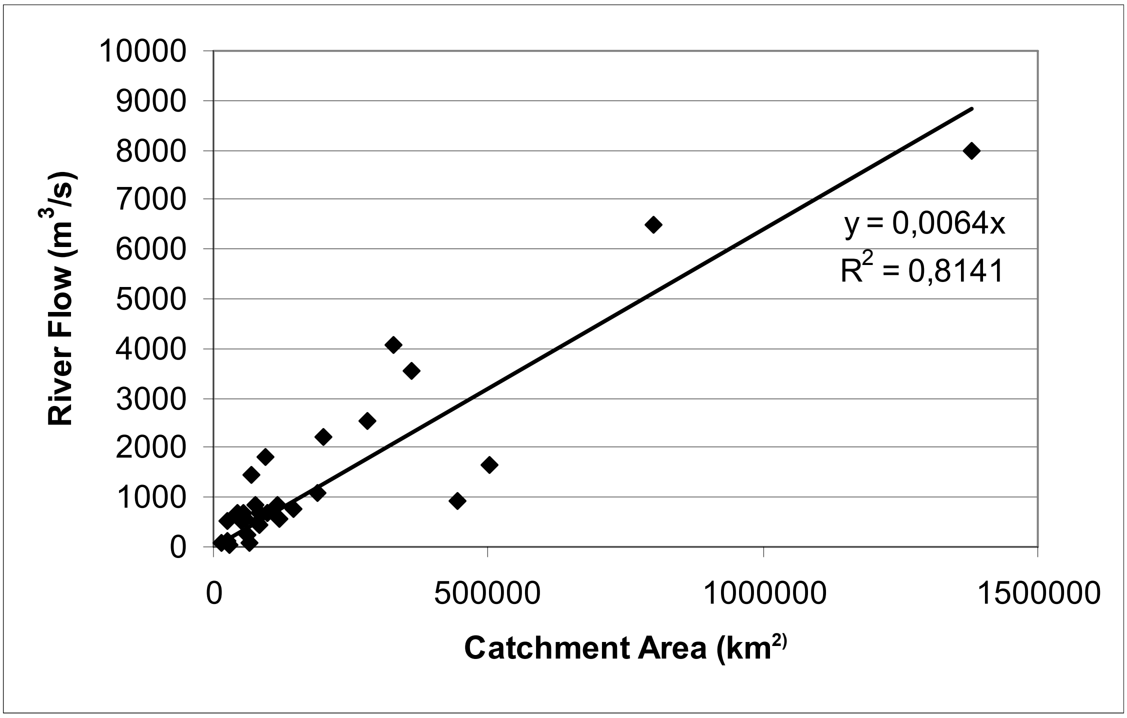

Figure 1.1. Relationship between Catchment Area and Annual Average River Flow at the mouth of several European rivers.

The equation presented in Figure 1 was used for setting the average relationship between catchment area and river flow for the generic deterministic assessment:

River Flow (m^3/s) = 0.0064 Catchment Area (km^2)

The whole data set was used for the probabilistic refinement; the statistical analysis indicated that the data distribution does not offer a proper fitting to any of the most commonly used probability distributions. Thus a customized distribution was created using Crystal Ball. This customized distribution is shown in Figure 1.2, data are presented as deviations per unit of the actual RF from that predicted by the regression slope. The range covers from 0.16 to 3.24 indicating that the actual RF can be between about one sixth and three times (16% and 324%) the predicted RF.

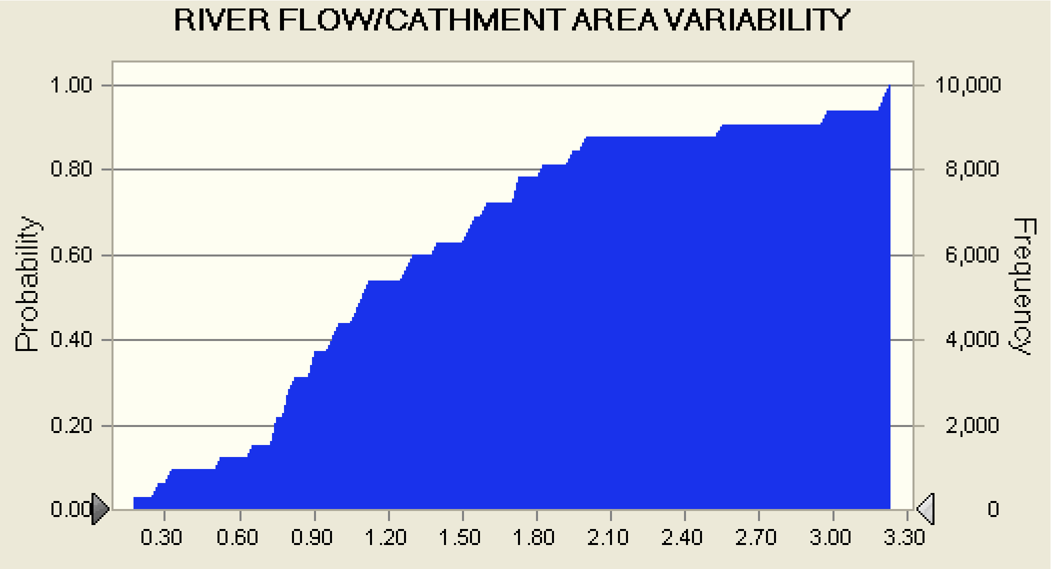

Figure 1.2: Distribution of the variability in the River Flow/Catchment Area relationship observed for 32 large European rivers. Data are presented as deviations (per unit) from the regression slope shown in Figure 1.

PEC estimations

Based on the total phosphorous emissions and the river flow associated to each catchment area, the model estimates the annual average TP concentration at any point of the river. The contribution of each phosphorous source is also estimated. Several values for the same river basin can be estimated provided that the information is available (Figure 1.3).

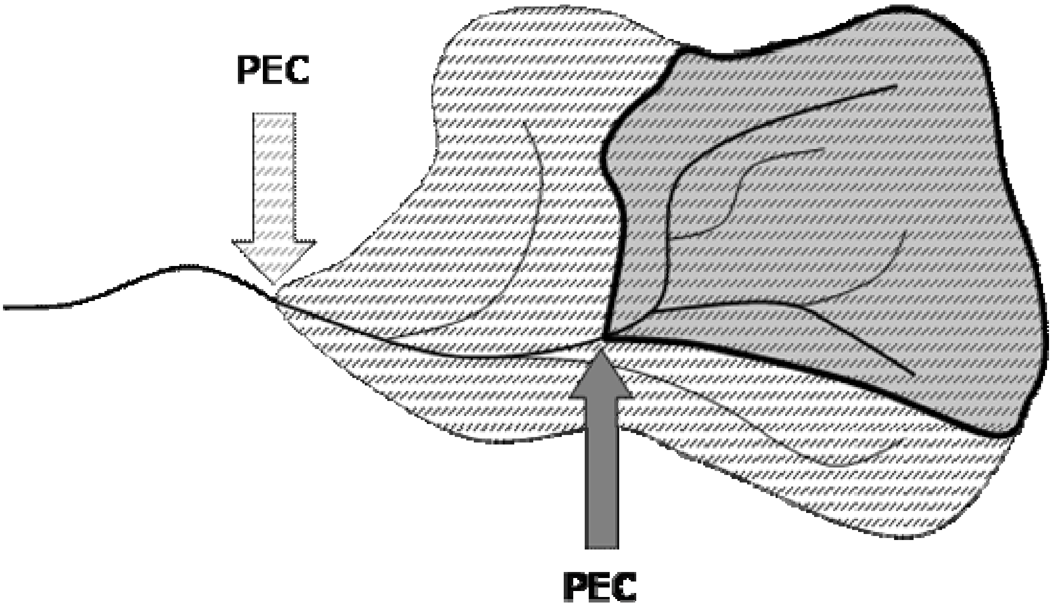

Figure 1.3: The exposure assessment scenario. The annual average Predicted Environmental Concentration (PEC) for selected points in the river basin is estimated on the basis of direct and indirect nutrient loads in the upstream catchment and the river flow.

Mathematical implementation

The mathematical implementation of the model was conducted with Excel data sheets. The probabilistic implementation for covering the variability and uncertainty was conducted by using Monte Carlo analysis based on Crystal Ball software.

The relevant model parameters related to the Exposure estimations where included in an input interface. These parameters are summarised in Table 1.2.

Table 1.2. Parameters employed for the Exposure estimation.

MODEL PARAMETER	UNITS
Population Density	person/ha
Catchment Area	ha
River Flow	m^3/s
Land use: Arable Land area	%
Land use: Pasture area	%
Land use: Forest area	%
Land use: Other uses area	%
Arable Land coefficient	kg/ha/year
Pasture coefficient	kg/ha/year
Forest coefficient	kg/ha/year
Other land uses coefficient	kg/ha/year
P emission from Population	g/person/day
P emission from Domestic Detergents	g/person/day
Current P reduction at STP	% (relative to P inflow entering STP)

The final estimation of the exposure level was determined using simplistic mass balance equations. The exposure is determined through the TP concentration determined as:

$$\boxed{TP = (DLa+PLa-STPRa)/WRa}$$

Where:
TP = TP concentration at the point of estimation;
DLa = upstream TP loads from diffuse sources;
PLa = upstream TP loads from population including P-based detergent consumption;
STPRa = TP amount retained/recovered at the STP, which if relevant should also incorporate any additional reductions in P emissions from population, such as e.g. people not connected to sewage collection systems;
WRa = annual cumulative amount of water at the point of estimation.

For allowing the identification of independent contributions, PLa is determined as the sum of the individual major P contributions: from human metabolism and domestic detergents. It should be noted that minor contributions are not included and, therefore, if relevant for some scenarios, must be transformed into population equivalents and included as a component of the population emissions.

Water management should also be considered in certain cases. If the amount of water employed for irrigation and/or transferred to other river basins is significant, an expert judgement is required for considering whether the WRa should be calculated from the measured RF or from the annual amount of available surface water resources obtained through a water mass balance of precipitation, evapotranspiration and groundwater recharge in the catchment area.

The model estimates the TP concentration at the selected point of estimation. However, TP annual variability may be very large, as point emissions are not related to rainfall events. Therefore, any comparison between monitored and predicted values requires the use of monitoring designs able to estimate an accurate annual average concentration. The use of generic coefficients assumes the homogeneous distribution of pollution sources along the catchment area.

P sedimentation and uptake by algae/plants within the river basin was not considered in the 2006-2007 model. These processes are particularly significant in lentic waters, e.g. lakes and reservoirs. Therefore, the model predicts the concentration in the lotic waters, i.e. waters (streams and watercourses) entering a lake or reservoir; while the in-lake concentration is expected to be lower than the estimation due to the buffer capacity of these lentic systems (dilution, P sedimentation, algae/plants P consumption, etc.). All these issues should be considered when using the model output.

The information produced by the ICPDR (International Commission for the Protection of the Danube River) was used for a screening analysis. The capability of the model for estimating the contribution from diffuse sources was checked out through the comparison of model estimations -based on land use distribution- (relative proportion of diffuse sources, which also gives the proportion of point sources) and the point sources contributions, estimated from the MONERIS model. And point sources contribution was also checked out through the comparison of TP estimated by our model *versus* monitoring data (year 2001 and 2002) reported in the TNMN reports. This information is presented in Figure 1.4.

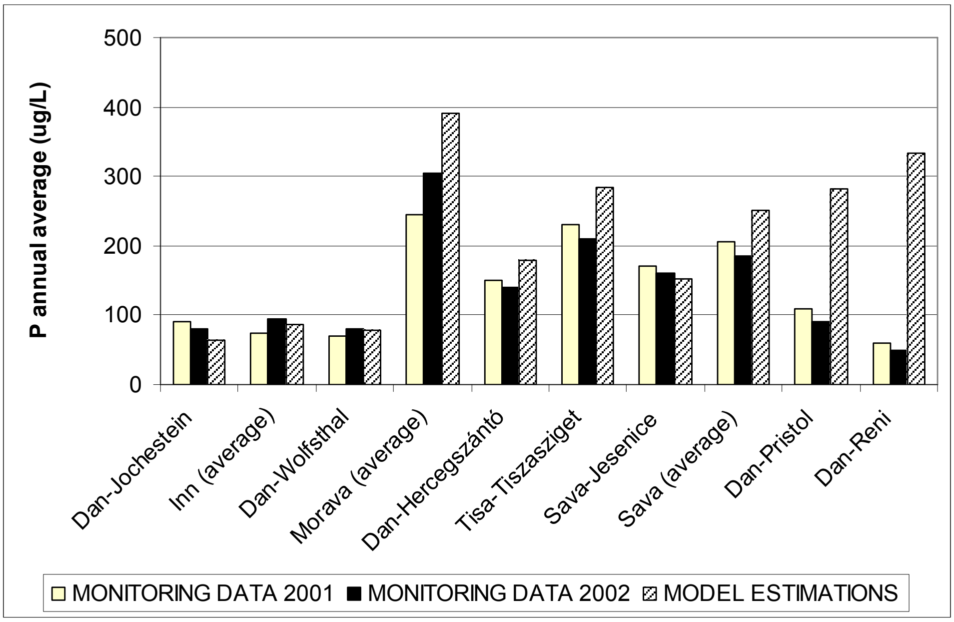

Figure 1.4. Comparison of monitoring 2001 and 2002 TP concentrations, for the Danube River and some tributaries, with model estimations.

The comparison suggests that model estimations are generally in good agreement with monitoring data for catchment areas where phosphorous sedimentation is of limited relevance. Largest over-predictions are expected for areas where sedimentation plays a significant role.

In general, the model offered “worst case” estimations, suitable for generic assessments of relatively large catchment areas (the estimations have been done for catchment areas above 25000 km^2). Due to the geographical variability in sedimentation processes, this aspect was not included in the pan-European assessment. However, at the river basin level; this aspect can be covered using monitoring TP data when available; then, the simplified model can be used for quantifying the relative contribution of the different sources if this information is not available from catchment specific models.

EFFECT ASSESSMENT

The effect to be quantified in the original model was man-made accelerated eutrophication[1] of inland freshwaters resulting in a deterioration of water quality, which interferes with the normal development of aquatic communities. The hazard identification was based on the potential of algal growth to result in undesirable disturbances.

For the definition of undesirable effects, the recommendations adopted for the implementation of eutrophication effects in the Water Framework Directive have been used. The proposal from the ECOSTAT Eutrophication group, developed in 2004 and revised in 2005, were considered (ECOSTAT, 2004; 2005). Ecosystem responses resulting in deviations from the "Good Status definition" are assumed to be adverse effects, and modifications in the ecosystem balance not resulting in deviations from the "Good Status definition" are considered acceptable in terms of negative ecosystem consequences.

Two definitions for *Significant Undesirable Disturbances* have been used for defining negative ecosystem consequences. The first definition covers significant increases in algal growth and biomass production; the second covers changes in taxonomic diversity not necessarily associated to significant increase in overall primary production.

For adverse effects associated to the increase in primary production the following definition was proposed:

"*A significant undesirable disturbance is a direct or indirect anthropogenic impact on an aquatic ecosystem that appreciably degrades the health or threatens the sustainable human use of that ecosystem".*

Up to ten different types of "significant undesirable disturbances" that may result from accelerated growth of phytoplankton, macroalgae, phytobenthos, macrophytes or angiosperms were identified.

For structural changes in the primary producers communities not necessarily resulting in overall increase of production rate, the following definition was proposed:

The condition of phytoplankton, phytobenthos, macrophytes, macroalgae or angiosperms would not be consistent with good ecological status where, as a result of anthropogenic nutrient

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[1] Phosphorus is an essential element which can be found in several biological macromolecules. The environmental hazards associated to the emission of P to the aquatic environment are related to its role as algae and plant nutrient. When P is the limiting factor and the environmental conditions favour the process, the algal growth rate increase associated to the P emissions may provoke an excessive development of algal populations (or some opportunist species within the algal community) leading to structural and functional changes in the ecosystem and, in some cases, extraordinary algal blooms resulting in fish kills, invertebrates impairment and macrophytes mortality due to anoxic conditions derived from that. The phenomenon is known as Eutrophication and P is just one of the factors involved in the process. Eutrophication compromises the beneficial uses of waters and can generally be perceived as an undesirable degradation of the environment; causing, in many cases, significant economic losses.

enrichment, changes in the balance of taxa had occurred that are likely to adversely affect the functioning of the ecosystem"

Four main categories were identified, distinguishing between moderate and poor-bad status conditions.

The conceptual model developed by ECOSTAT was adapted for assessing the increase in phosphorous concentration as the primary impact source. The modified model is presented in Figure 1.5.

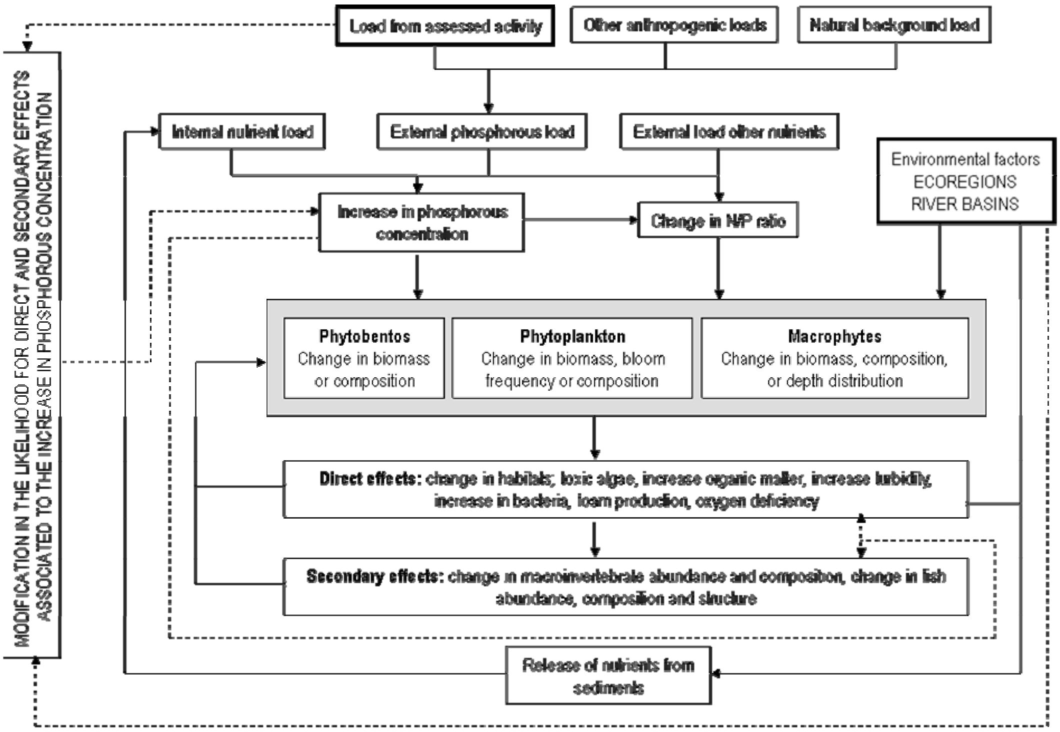


Figure 1.5: Conceptual framework for assessing the eutrophication risk associated to specific activities provoking nutrient emissions. Adapted and modified from the general ECOSTAT framework (ECOSTAT, 2004) developed under the Eutrophication Activity for the implementation of WFD.

The dose(concentration)/response assessment is even more complex as the response would depend on the conditions of the water body receiving the discharge. The review of available information confirmed the difficulty for establishing dose/response relationships even for controlled experimental conditions in mesocosms or semifield studies. Therefore, an innovative alternative is proposed, based on a probabilistic interpretation of field observations.

Field data analysis and criteria application

Over 500 individual field cases were reviewed from literature. After a quality assessment, 303 individual cases were validated, assessed case by case. Data included different water bodies monitored around Europe, and the same water bodies monitored in different years. The approach is similar to that employed at the OECD study, and offered a combination of spatial and temporal variability.

Table 1.3 summarises the main characteristics of the field studies database. Nutrient concentrations were reported in all cases as annual averages as this is the parameter estimated by the model. Other characteristics, such as conductivity, temperature, dissolved oxygen or pH, were included as described in the original paper. The effects database was presented in electronic form as an Appendix of the final report, with all the details collected for the assessment.

Table 1.3. Description of the selected field information used for the effect assessment. Validated set of 303 data items collected from European inland water bodies.

Characteristics	Descriptors	Units and endpoints
Geographical identification	European Ecological Region River Basin Waterbody Name	name name name
Morphological and physico-chemical description	Waterbody Type Area Mean Depth Depth Classification Conductivity Temperature Dissolved Oxygen Secchi disk pH TP & TN annual average conc.	name ha m Deep/Shallow µS/cm ºC mg/L m - µg/L
Ecological variables	Trophic Status Dominant Species Ecosystem structure	OECD (1982) Most relevant Number of species and structure (per taxa group)
Effect endpoints	Chlorophyll a Algal blooms Shifts in Species Composition, Abundance, Structure: Phytoplankton, Invertebrates, Other aquatic flora, Other fauna Sediment organic matter Change in water quality Oxygenation conditions at hypolimnion Other specific local effects	µg/L yes / no yes / no Relevant changes Relevant changes yes / no yes / no Oxygenated, hypoxia, anoxia yes / no

Using the definitions of "significant undesiderable disturbances" presented above the status condition of each water body in each monitoring year was assessed.

The fundamental assessment was based on deviations from the "Good Status conditions" as described for the Water Framework Directive:

Qualitative approach: The information available for each water body is compared with the criteria established for good quality conditions. When the water body has remained in good ecological conditions through the whole year, the water body is classified as in "Good Status" (G+). When deviations from the good quality conditions have been observed (reported) during the whole or part of the assessed year, the water body is classified as in "Less than Good Status" (G-). The classification is based on the observations and evidences of negative ecological consequences when reported, and also on the information on physical-chemical conditions (water transparency, hypolimnetic oxygenation conditions, excessive organic matter in sediments, P-release from sediments, etc.) and biological elements (Chlorophyll-a concentrations; phytoplankton, invertebrates and fish density and dominance, presence of algal blooms and species involved in the bloom, sifts in ecosystem structure and function, trophic status, presence of tolerant/pollution sensitive species, toxic species, etc.). Although the in-lake P concentration was noted in the database (TP annual average concentration), it was not considered for adopting the decision on classification levels. More information on exact parameters considered for the assessment will be presented in next section of Data analysis.

It is important to reiterate that this assessment was exclusively based on the limnological/biological/ecological observations, without considering the phosphorous concentration.

Two complementary screening/confirmation assessment methods were employed. The objective of these methods was to identify potential discrepancies in individual water bodies between the assigned status and that expected from some selected characteristics, including phosphorous levels, which could be associated to errors in the assignment of the Good or Less-than-Good status condition. These methods were used for confirming that observed trends between classification and key relevant parameters were in line with those expected; in addition, each data point showing divergences from the observed trends was revisited case-by-case for confirming that the initially assigned classification. Those methods are briefly described below:

Semi-quantitative approach: an integer value between -3 and +3 is given to each body and time period combination, according to the following classification criteria; the overall intention was to maintain the following equivalences:

- -3 high conditions = REFERENCE CONDITIONS
- -2 very good conditions = HIGH STATUS
- -1 good conditions = GOOD STATUS
- 0 limit situation = LIMIT BETWEEN GOOD AND MODERATE STATUS
- +1 possibly negative effects = MODERATE STATUS
- +2 clear negative effects = POOR STATUS
- +3 dramatic consequences = BAD STATUS

This semi-quantitative approach was used for producing scattered graphics presenting trends between the semi-quantitative classification and relevant parameters, including chlorophyll-a, Secchi disk turbidity and total phosphorous concentration. Data points deviating from the general tendency were identified, and the status classification was rechecked for each of these data points, using the criteria presented for the qualitative classification.

Morphoedaphic index (MEI) method: The natural trophic conditions of stagnant water bodies in Europe vary from Ultraoligotrophic to Hypereutrophic classes, and obviously this variability creates some difficulties when assessing anthropogenic deviations from the "good status" conditions. The Morphoedaphic index or MEI method (Vighi and Chiaudiani, 1985) was used for confirming the anthropogenic origin of the observed conditions. Whenever possible (about one half of the cases) the measured TP concentration was compared with the natural background TP estimated from the MEI. The comparison allowed the identification of potential divergences between the ecological assessment and the expected anthropogenic contribution. These potential divergences (less-than-good conditions with low anthropogenic contribution and good conditions with a high anthropogenic contribution) were revised case-by-case.

Table 1.4. Summary of the status allocation processes for each water body.

Initial Eutrophication	Application of ECOSAR criteria: Direct & indirect effects	Initial allocation as G+ or G- status

Assessment		
Complementary confirmation	Semi-quantitative classification Trends versus key parameters	from -3 to +3 Identification of data points deviating from the trend
	MorphoEdaphic Index (MEI based on conductivity) following Vighi, and Chiaudani, 1985.	Identification of data points deviating from the expected result
Confirmation of the initial assesment	Deviating data are re-checked case-by-case	Final allocation as G+ or G- status

Conditional probabilities and selection of the effect assessment distributions

The collected data cannot be considered a random sample of water bodies, and as a consequence, the conditional probability of a water body to be in less than good status given a certain TP concentration, p(G- | TP) cannot be directly estimated from the data base.

Instead, the conditional probabilities p(TP | G-) and p(TP | G+), representing the distribution of TP concentrations in the sites with good and with less-than-good status respectively, were considered.

The process included a statistical assessment, checking if the data could be fitted to a log-normal or other parametric distribution, and the potential differences among ecoregions within Europe and ecotypes within each ecoregion. The recommendations expressed by the expert at the first Madrid Workshop were of great value in this process.

Finally, considering the characteristics of the database it was decided to develop conditional probability distributions p(TP | G+) and p(TP | G-) splitting the information in two ecoregion groups, one covering Atlantic, Northern and Central European water bodies and the other for those located in the Mediterranean area; and to further split the Atlantic, Northern and Central European group in two ecotypes, deep lakes and shallow water bodies. However, no enough information for the deep lakes was available and thus the following eco-region&type classes were finally considered:

- Atlantic, Northern and Central European shallow lakes
- Mediterranean water bodies.

The distributions are presented in Figures 1.6 and 1.7.

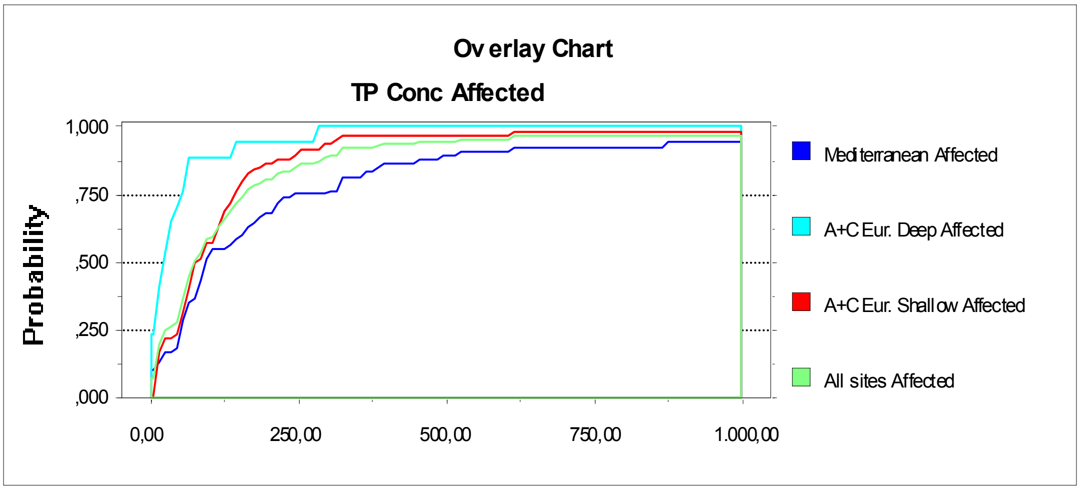


Figure 1.6. Cumulative conditional distributions p(TP | G-) for all sites and those of each eco-region&type-class. The legend indicates “Affected” for G- sites.

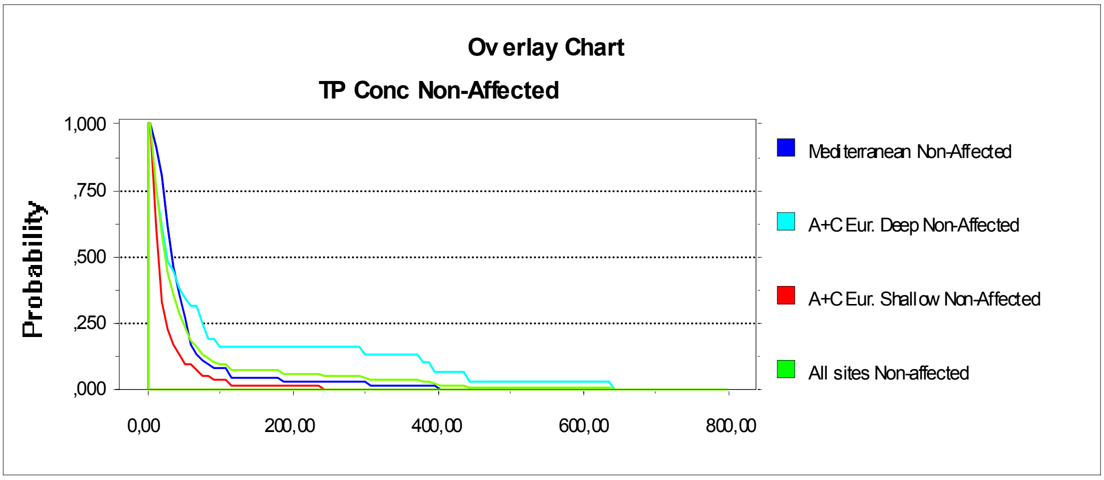


Figure 1.7. Reverse cumulative conditional distributions p(TP | G+) for all sites and those of each eco-region&type-class. The legend indicates “Non-Affected” for G+ sites.

QUANTITATIVE CHARACTERIZATION OF THE EUTROPHICATION RISK.

The eutrophication risk has been characterised through the estimation of a probability of a water body to be in less than good status. As eutrophication is a problem primarily associated to specific types of water bodies, such as lakes, reservoirs, stagnant water bodies and river areas with slow-moving conditions, it was considered that, within an area or river basin, the risk should be expressed taking into account exclusively those water bodies which could be sensitive to eutrophication. Thus, for each exposure assessment estimation, TP, the eutrophication risk associated to that concentration is defined as the likelihood of a sensitive site, susceptible to eutrophication, to be in less-than-good eutrophication status. This value is represented by the joint probability for having a certain TP concentration and being in less-than-good status corrected by the percentage of sites in the area with potential for suffering eutrophication problems if enough amounts of nutrients are provided. This likelihood value can be represented as p(TP ∩ G-)/(p(G-)max). The correction by the maximum value of p(G-) provides a risk value ranging from 0 to 1 (or 0% to 100% when expressed as percentage).

This value is delineated by the range defined by the conditional probability distributions p(TP | G-) and 1- p(TP | G+).

It should be noted that TP is a continuous distribution and all probabilities are presented as cumulative or reverse accumulative probabilities. As observed in Figures 6 and 7, in the 2006-2007 model the conditional distribution for sites in less than good status, p(TP | G-), was presented as a cumulative distribution, therefore, for a certain TP value "x" the associated probability must be understood as the probability for having a TP concentration value that does not exceed x (TP ≤ x). On the other hand, the conditional distribution for sites in good status, p(TP | G+), was presented as a reverse cumulative distribution, therefore, for a certain TP value "x" the associated probability must be understood as the probability for having a TP concentration value that exceed x (TP > x). As the eutrophication risk is defined by the conditional probability distributions p(TP | G-) and 1- p(TP | G+); the risk distributions are presented as cumulative distributions; therefore, for a certain TP value "x" the associated risk "y" must be understood as following: if the TP concentration value does not exceed x (TP ≤ x) the expected eutrophication risk will not exceed y (Eutrophication risk ≤ y).

A "Most Likely Probability" value, mlp, was estimated in the previous report; however, due to the uncertainty of this estimation; this approach has not been longer considered; and the risk is only expressed as a range.

The quantitative characterizations of the eutrophication risk are presented in Figures 1.8 and 1.9 for Atlantic, Northern and Central European shallow lakes, and Mediterranean water bodies respectively. As explained above, in the case of Atlantic, Northern and Central European deep lakes, the lack of good fitting and the insufficient amount of data did not allow producing a correct risk characterization. Therefore this ecoregions&type class was not longer considered in the risk characterization.

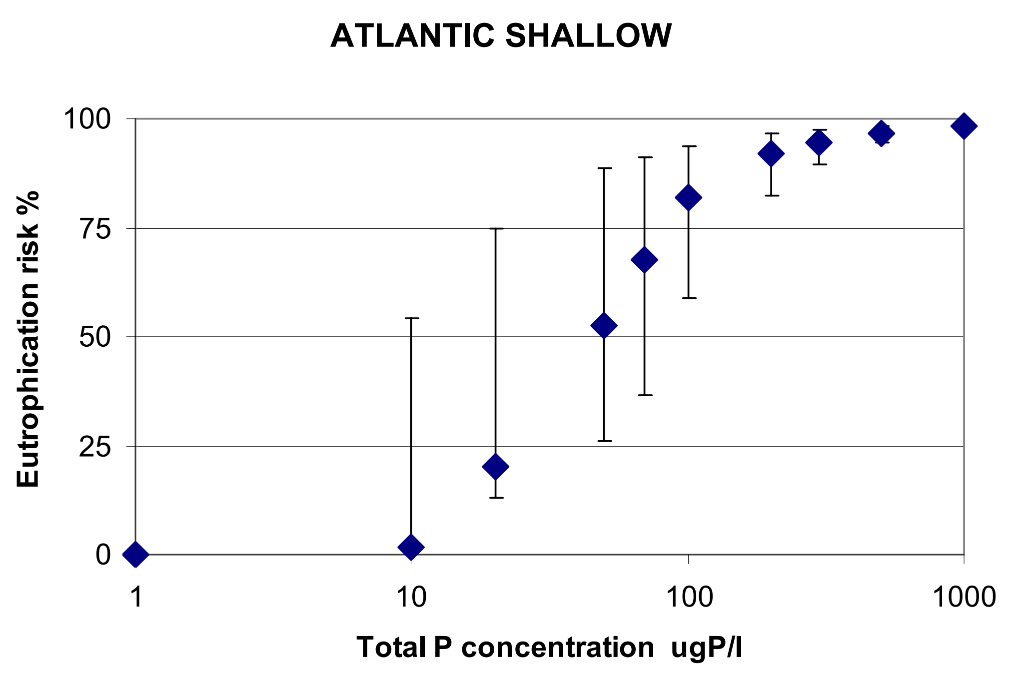


Figure 1.8. The eutrophication risk of Atlantic, Northern and Central European shallow lakes as a function of the TP concentration. The lines indicate the range between p(TP | G-) and 1- p(TP | G+); the rhombus is the mlp(G-) value estimated for the assumption that 33% of the sensitive water bodies in the area are in less-than-good status.

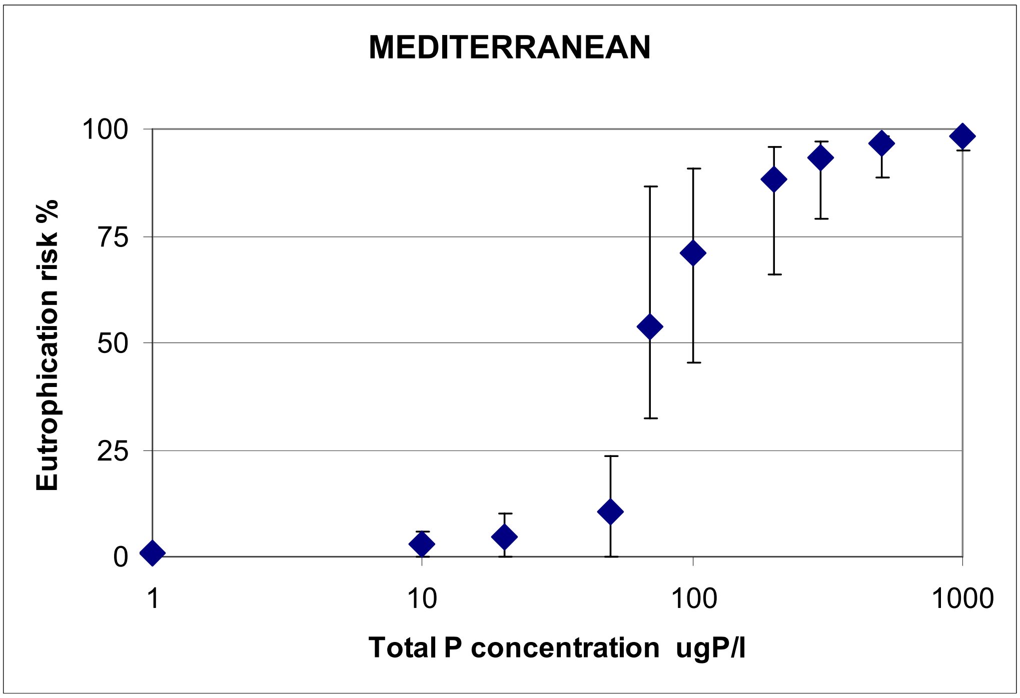


Figure 1.9. The eutrophication risk of Mediterranean water bodies as a function of the TP concentration. The lines indicate the range between p(TP | G-) and 1- p(TP | G+); the rhombus is the mlp(G-) value estimated for the assumption that 33% of the sensitive water bodies in the area are in less-than-good status.

COMPARATIVE RISK ASSESSMENT AND RISK COMMUNICATION OPTIONS.

As for other complex and higher tier ecological risk assessments, the alternatives for communicating the results of the risk characterization become a crucial issue. A survey among environmental experts was conducted using a questionnaire specifically developed for this project. The participants were 38 persons with university degrees in environmental sciences. Participants were selected from the INIA Department of the Environment and from the participants at a SETAC Europe Annual Meeting. The sample covered persons with very different levels of expertise, from PhD students to high level experts and it was well balanced in terms of gender and education level (graduated and PhD). Participants covered a wide range of education backgrounds (mostly chemistry and biological sciences), age, and sector (academic, business, government).

The best approaches for presenting results from probabilistic risk assessments, the opinions from the experts can be summarised as follows:

- Results should be presented using graphic approaches offering as much information as possible, including information on the uncertainty of the assessment, even if these graphic forms require a more complex interpretation. However, if a high level of risk is identified, requiring urgent risk management measures, simplified graphics presenting the risk in a clear way are preferred.
- For avoiding misinterpretations, probabilistic graphics should always be presented with additional information allowing a proper interpretation of the data by the users.
- There is a tendency for considering that the same graphics should be used for presenting the results to risk assessors and risk managers.
- Most experts considered that the complexity of probabilistic graphic representations is not an inconvenient if the interpretation of the results is done by experts.

These results were presented at the expert workshop and it was agreed to follow the preferences; presenting the results as individual distributions.

When using in consumers detergent formulations, phosphates represent an additional source to the point emissions of P associated to municipal sewers, to be added to the contribution from human metabolisms and other minor sources. This contribution can be quantified as the different between the eutrophication risk with and without the detergents` contribution. As expected, the relationship between TP and the eutrophication risk is not linear. For comparative purposes it was decided to also present the overall contribution of all point sources and all diffuse sources, again this contribution can be quantified as the difference in the eutrophication risk with and without point/diffuse sources. An example of the risk characterization outcome is presented in Figure 1.10.

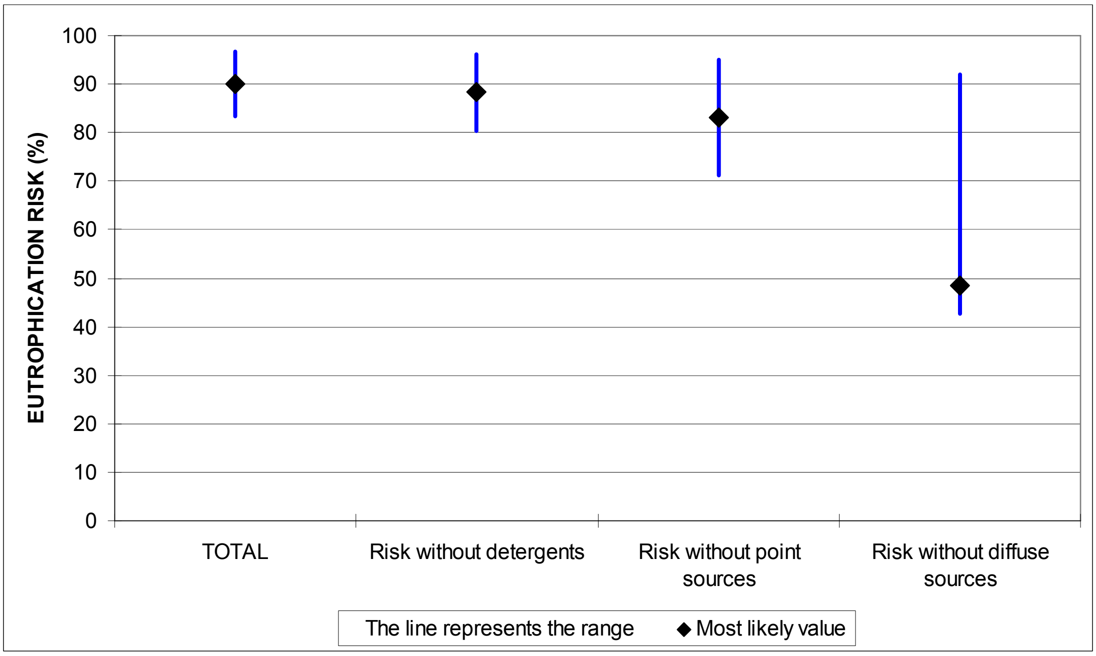


Figure 1.10. Example of the presentation of the risk characterization output. For risks (range and most likely probability value) are presented covering the total (overall) risk, the predicted risk eliminating the contribution of detergents, the predicted risk eliminating the contribution of point sources and the predicted risk eliminating the contribution of diffuse sources.

MODEL IMPLEMENTATION

The exposure scenarios, effects estimation and risk characterization approach was initially implemented in an Excel datasheet providing deterministic exposure estimations based on default values, and probabilistic risk estimations combining the exposure estimations and the effect assessment distributions.

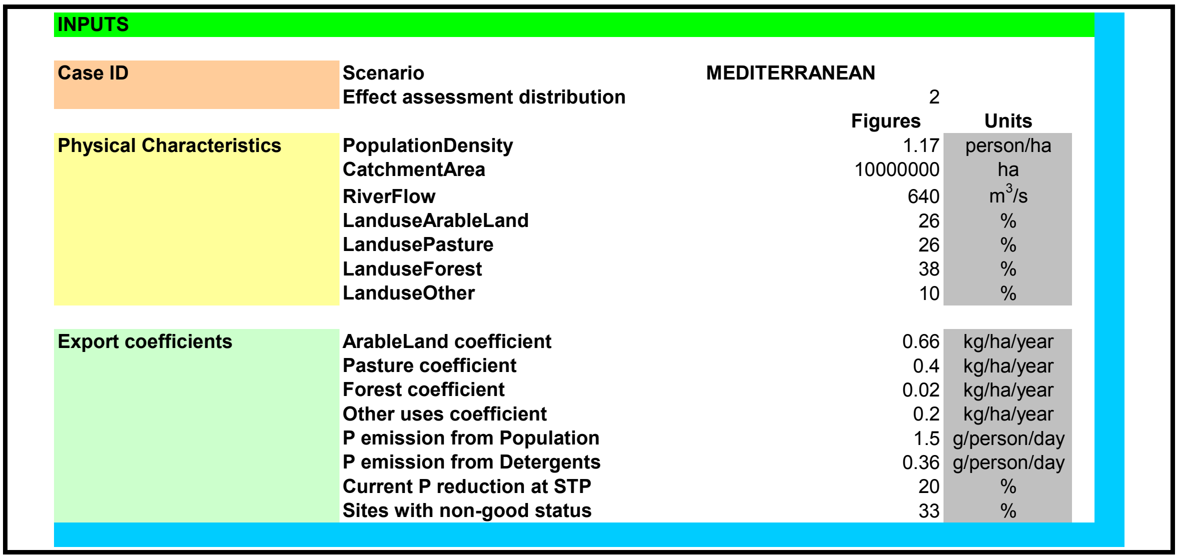
Three main information blocks were required, the selected eco-region&type-classes; the characteristics of the river basin (population density, catchment area, river flow, land use pattern) and the P export coefficients (for diffuse and point sources including the specific contributions of detergents, the capability of the sewage treatment plant, and the selected value for p(G-)max).

The model results included:

- the predicted exposure concentrations (TP concentration in µg/l),
- the specific contribution of domestic detergents (in µgP/l and in percentage of the total TP contribution), after the removal of P at the sewage treatment plant for the estimation of loads from point sources.
- the contribution of other point sources, excluding detergents, (in µg/l and in percentage of the total P contribution), after the removal of P at the sewage treatment plant for the estimation of loads from point sources.

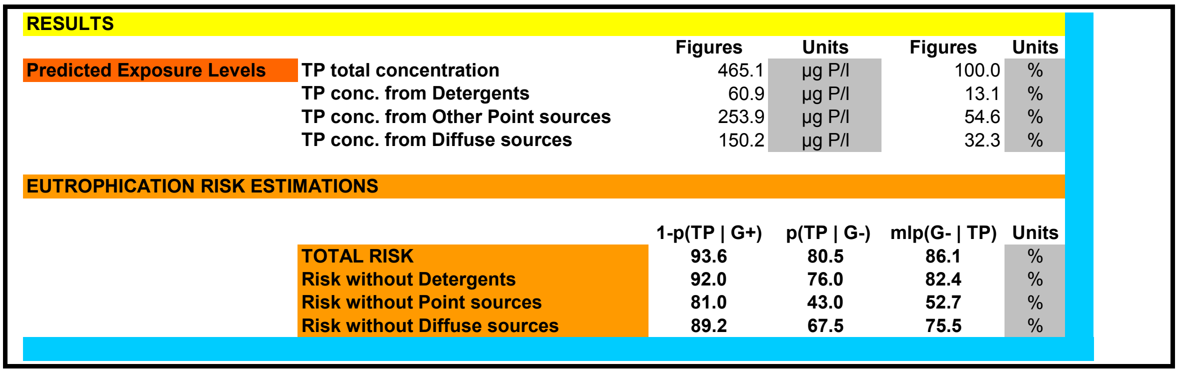
- the contribution of diffuse sources (in µg/l and in percentage of the total P contribution),
- the eutrophication risk estimations (in percentage of total probability) showing the maximum (p(TP | G-), and minimum (1- p(TP | G+)) of the range, and the most likely value (mlp(G-| TP)).

Figures 1.11 and 1.12 present examples of the input requirements and the obtained model results, respectively.



INPUTS			
Case ID	**Scenario**	**MEDITERRANEAN**	
	Effect assessment distribution	2	
		Figures	**Units**
Physical Characteristics	**PopulationDensity**	1.17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m^3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	**ArableLand coefficient**	0.66	kg/ha/year
	Pasture coefficient	0.4	kg/ha/year
	Forest coefficient	0.02	kg/ha/year
	Other uses coefficient	0.2	kg/ha/year
	P emission from Population	1.5	g/person/day
	P emission from Detergents	0.36	g/person/day
	Current P reduction at STP	20	%
	Sites with non-good status	33	%

Figure 1.11. Example of the Input module of the risk assessment calculator.



RESULTS					
		Figures	**Units**	**Figures**	**Units**
Predicted Exposure Levels	**TP total concentration**	465.1	µg P/l	100.0	%
	TP conc. from Detergents	60.9	µg P/l	13.1	%
	TP conc. from Other Point sources	253.9	µg P/l	54.6	%
	TP conc. from Diffuse sources	150.2	µg P/l	32.3	%
EUTROPHICATION RISK ESTIMATIONS					
		1-p(TP | G+)	**p(TP | G-)**	**mlp(G- | TP)**	**Units**
	TOTAL RISK	**93.6**	**80.5**	**86.1**	%
	Risk without Detergents	**92.0**	**76.0**	**82.4**	%
	Risk without Point sources	**81.0**	**43.0**	**52.7**	%
	Risk without Diffuse sources	**89.2**	**67.5**	**75.5**	%

Figure 1.12. Example of the Output module of the risk assessment calculator.

In addition, the risk characterization was presented in a graphic form. These estimations cover the total risk based on the estimation of total phosphorus concentration, the risk from all sources excluding detergents (zero contribution of detergents), the risk excluding point sources (zero contribution from point sources) and the risk excluding diffuse sources (zero contribution from diffuse sources).

A number of examples of the potentiality of the implemented model were assessed by showing different combinations of parameters that define several generic scenarios covering a range of total P concentration and point and diffuse sources contributions, and two levels of detergent contribution and implementation of P-removal at the sewage treatment plant. A summary of the main inputs considered for the selected generic scenarios is presented below.

Examples 1a, 1b, 1c, 1d:

- European average consumption of P-based detergents (1a, 1b);
- European highest national consumption of P-based detergents (1c, 1d);
- Mediterranean effect assessment (1a, 1c);
- Atlantic shallow lakes effect assessment (1b, 1d);
- Average European values for Population density, River flow, Agricultural intensity and current P reduction at STP.

Examples 2a, 2b, 2c, 2d:

- European average consumption of P-based detergents (2a, 2b);
- European highest national consumption of P-based detergents (2c, 2d);
- Mediterranean effect assessment (2a, 2c);
- Atlantic shallow lakes effect assessment (2b, 2d);
- Average European values for Population density, Agricultural intensity and Current P reduction at STP;
- 2x European average River flow.

Examples 3a, 3b, 3c, 3d:

- European average consumption of P-based detergents (3a, 3b);
- European highest national consumption of P-based detergents (3c, 3d);
- Mediterranean effect assessment (3a, 3c);
- Atlantic shallow lakes effect assessment (3b, 3d);
- Average European values for River flow, Agricultural intensity and current P reduction at STP;
- 1/3 x European average Population density.

Examples 4a, 4b, 4c, 4d:

- European average consumption of P-based detergents (4a, 4b);
- European highest national consumption of P-based detergents (4c, 4d);
- Mediterranean effect assessment (4a, 4c);
- Atlantic shallow lakes effect assessment (4b, 4d);
- Average European values for River flow and Current P reduction at STP;
- 1/3 x European average Population density
- Low Agricultural intensity.

Examples 5a, 5b, 5c, 5d:

- European average consumption of P-based detergents (5a, 5b);
- European highest national consumption of P-based detergents (5c, 5d);
- Mediterranean effect assessment (5a, 5c);
- Atlantic shallow lakes effect assessment (5b, 5d);
- Average European values for Population density and Agricultural intensity;
- 2x European average River flow.
- 3 x current P reduction at STP.

Further examples, using real river basin or generic data were developed for two river basins in Spain, a national generic scenario Poland, and Danube international basin.

Probabilistic implementation

The probabilistic model implementation was done by using Crystal Ball software for conducting a Monte Carlo analysis. The following input values were transformed into distributions:

- Population density: triangular distribution based on minimum (Finland), EU average and maximum (The Netherlands, Malta has been excluded).
- River flow: triangular distribution of the flow to area ratio based on minimum, average and maximum
- P contribution from P metabolism: normal distribution
- P contribution from domestic detergents: triangular distribution based on zero use of P-base detergents, the EU average, and the national maximum contribution (Slovak Republic figure).
- P reduction at STP: The employed distribution: triangular distribution based on minimum (Greece), EU average, and maximum for countries allowing P-based detergents (Denmark).

For each assessment, the risk was presented as a distribution range with a mlp estimation; showing the total risk and the risk without P-based detergents as cumulative probability distributions.

SECTION 2:
DESCRIPTION OF THE VALIDATION PROCESS

The validation process has tried to cover as much as possible all the concerns and recommendations included in the SCHER opinion, additional improvements have been incorporated following presentations and discussions at different scientific meetings.

SCHER recognised that the developed model presented a novel tool to assess, in a quantitative manner, the risks of eutrophication due to phosphorus release. However SCHER concluded that the scientific quality of the report has been diminished due to a number of key points which were not adequately addressed, such as: (1) a limited data base to develop the model which may not be representative of the European lakes, (2) the limited data used for the validation of the developed approach and the current proposal.

SCHER underlined that further work was required to enhance the specific relevance of the INIA model to the WFD and proposed that "Overall, prior to the application of the model and the use of the results, the science presented in this INIA report should be further developed".

Following extensive discussion in the meetings of the Commission WG on detergents, (December 2007, July, 2008) it was concluded that the Commission will continue to work in collaboration with Member States to improve the knowledge base through the scientific improvement of the INIA model.

Therefore in line with the SCHER remarks to consider the Inter-Calibration data of the WFD and available information from other EU eutrophication studies, the Commission attempted to facilitate the contact of INIA, with (a) JRC: a meeting at ISPRA (June 2008) explored possibilities to use the IC data for the development of the INIA model and established a collaboration between the responsible scientists; (b) Baltic scientists: a workshop organised in Stockholm (September 2008) defined modes of cooperation and implementation of the INIA methodology into existing Baltic (marine water) models and research projects; (c) Danube River Basin (DRB) projects: In a meeting in Vienna (December 2009), INIA discuss ways of cooperation with DRB which would allow to compare risk model predictions based on actual measured data and the observed biological response.

In a workshop organised in Madrid (March 2009) with the participation of European eutrophication and environmental risk assessment experts, INIA presented the outcome of this validation and re-calibration exercise of the model, in particular concerning the effect assessment and risk characterisation tools. The comments have been incorporated in this report.

CONCEPTUAL AND METHODOLOGICAL DEVELOPMENTS

Conceptual description of the eutrophication risk model

In the Madrid workshop (2009) the experts suggested the inclusion of a conceptual description of the proposed eutrophication risk model. This description is presented here. It should be noted that to facilitate the comprehension of the approach, in this report both conditional probability distributions p(TP|G+) and p(TP|G-) are presented as cumulative distributions (in the previous report p(TP|G+) was presented as a reverse cumulative distribution) the consequence, as presented below is that the risk is defined within the range established by p(TP|G+) and p(TP|G-), while in the previous report, the upper limit was 1-p(TP|G+) as this distribution was presented as a reverse cumulative distribution.

Risk definition

For each exposure assessment estimation, TP, the eutrophication risk is defined as the likelihood of a sensitive site, susceptible to eutrophication, to be in less-than-good eutrophication status. The eutrophication risk is expressed as a relative value, ranging from 0 to 1 (or 0% to 100% when expressed as percentage). The correction is associated to the maximum expected value, and therefore, it is related to the likelihood expected when the percentage of sites in less than good eutrophication status reach the maximum value for each TP level.

TP is a continuous variable, and all probability distributions are presented as cumulative distributions; therefore, for a certain TP value "x" the associated risk "y" must be understood as following: if the TP concentration value does not exceed x (TP ≤ x) the expected eutrophication risk will not exceed y (Eutrophication risk ≤ y).

This value is represented by the joint probability for having a certain TP concentration and being in less-than-good status corrected by a function which, for each TP concentration, is associated to the percentage of sites with potential for suffering eutrophication problems if enough amounts of nutrients are provided.

This conceptual description is presented in Figure 2.1.

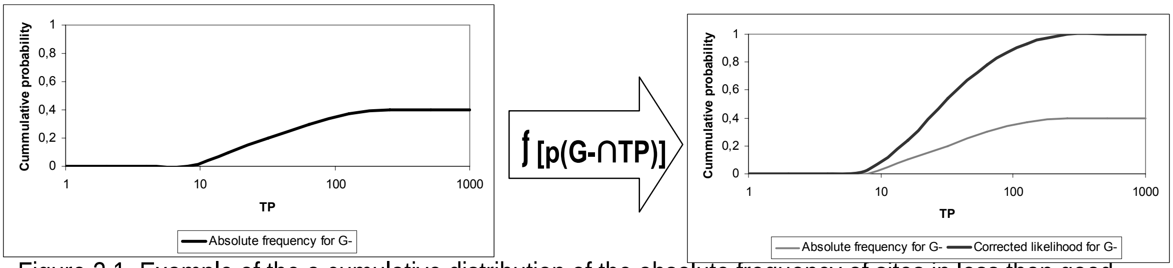


Figure 2.1. Example of the a cumulative distribution of the absolute frequency of sites in less than good status, assuming that 40% of the waterbodies are in this situation, and example of correction of this distribution for obtaining a risk range covering from 0 to 1 (0 to 100%)

The information in the INIA and the JRC databases were obtained following specific criteria for the selection of the number of water bodies representing both, good and less than good conditions. The data cannot be considered a random sample, and therefore, it is not possible to estimate the absolute frequency for the sites in good and in less than good status conditions. In particular, the percentage of sites in good and in less than good status in the databases, as a whole, for each ecoregion and ecotype, and for each TP value, does not necessarily represent the real expected percentages.

The data subsamples for G+ and G- are, however, considered a good representation of each subpopulation (sites in good status and sites in less than good status), as a consequence, it is possible to obtain the cumulative frequency distributions of total phosphorous concentration in each subsample, and to assume that these distributions offer a proper estimation of the cumulative conditional probability distributions of TP in each subpopulation: the conditional probabilities p(TP | G+) and p(TP | G-), representing the cumulative distribution of TP concentrations in sites in good status and in sites in less than good status respectively.

Empirical observations for the conditional probabilities p(TP | G+) and p(TP | G-)

The analysis of the initial data set, confirmed by the assessment conducted using the WFD intercalibration data provided by the JRC, demonstrated that for any TP value, the cumulative conditional probability of TP for sites in good status, p(TP|G+), is equal to or higher than the cumulative conditional probability of TP for sites in less than good status, p(TP|G-).

This empirical observation is fully in line with the expected association between the concentration of phosphorous and the eutrophication risk. It indicates that given two different TP concentrations, the frequency of sites in less than good status at the higher concentration cannot be lower than that for the sites with the lower TP concentration; or in other words, that an increase in the phosphorous concentration is expected to result in an increase in the likelihood of a site to be in less than good status.

This observation has been used for developing the quantitative eutrophication risk model. Figure 2.2 offers an example of the relationships among the different distributions:

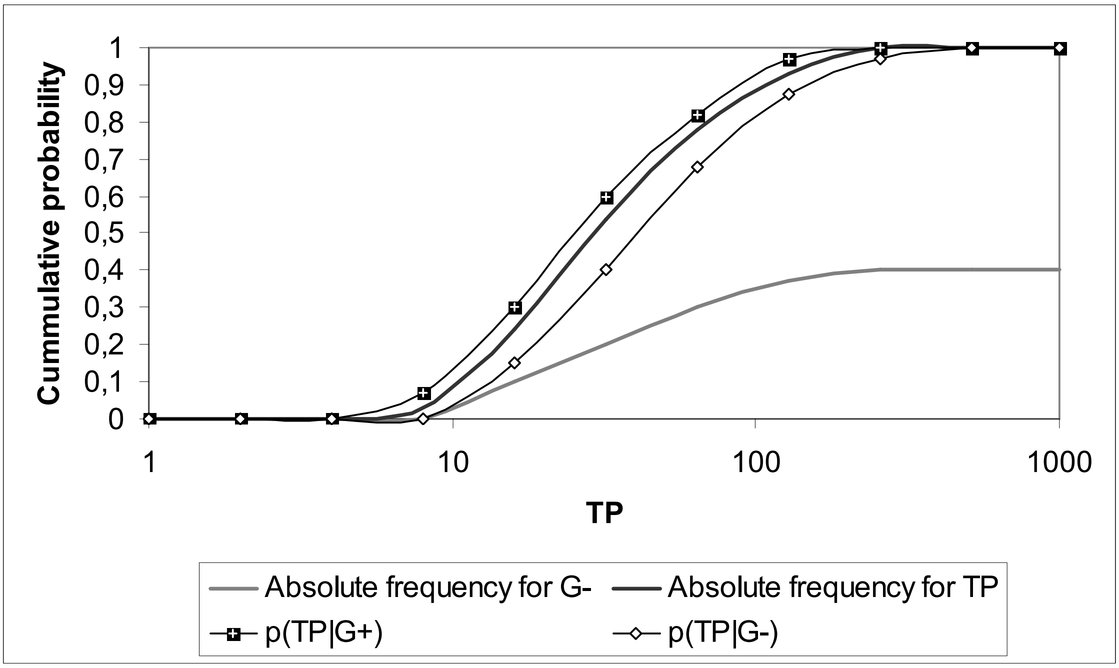


Figure 2.2. Cumulative conditional TP probability distributions for G+ and G-, and cumulative frequencies for TP in sites with less than good status (G-) and in all sites.

The distributions presented in the figure as conditional probabilities can be obtained from the databases; however, as the percentage of sites in good and less than good status in the databases does not represent the percentage expected for the real population, the distributions presented as absolute frequencies cannot be assumed to represent the real cumulative distributions for the population.

Quantitative estimation of the eutrophication risk associated to a certain cumulative TP concentration.

As a direct quantification is not feasible, an alternative approach has been developed. The approach follows the conceptual principles defined above: the eutrophication risk is obtained though a transformation of the cumulative distribution of the absolute frequency of sites in less than good status, the correction considers the maximum possible frequency for sites in less than good status, and the value ranges from 0 to 1 (0 to 100%).

The alternative uses the following principles:

1. A site can be either in good or in less than good status (i.e., the conditions of being or not in good status exclude each other and cover the whole spectrum, p(G+) + p(G-) = 1 and p(G+ ∩ G-) = 0).
2. For any TP value, the cumulative probability for (TP|G+) is equal to or higher than the cumulative probability for (TP|G-)
3. As a consequence the cumulative distribution for TP (covering all sites) should be equal to or lower than the cumulative probability for (TP|G+); and equal to or higher than the cumulative probability for (TP|G-)
4. If a population is dominated by sites in good status, the cumulative distribution for TP (covering all sites) will be in close proximity to the cumulative probability for (TP|G+)
5. If a population is dominated by sites in less than good status, the cumulative distribution for TP (covering all sites) will be in close proximity to the cumulative probability for (TP|G-)
6. The cumulative distribution of TP expected when the frequency of sites in less than good status reach the maximum possible value for each TP concentration offers a proper correction factor, satisfying the conditions for the correction function established in the risk definition.

The alternative calculates the eutrophication risk as a relative value obtained from the cumulative conditional probability for (TP|G-), multiplied by the ratio between the actual cumulative distribution for TP (covering all sites) and the expected cumulative distribution for TP assuming that the maximum possible number of sites in less than good status is reached for each TP concentration. As observed in Figure 2.3, the expected cumulative distribution for TP assuming that the maximum possible number of sites in less than good status is reached for each TP concentration, must be equal to or higher than p(TP|G-) and equal to or lower than the actual cumulative distribution for TP.

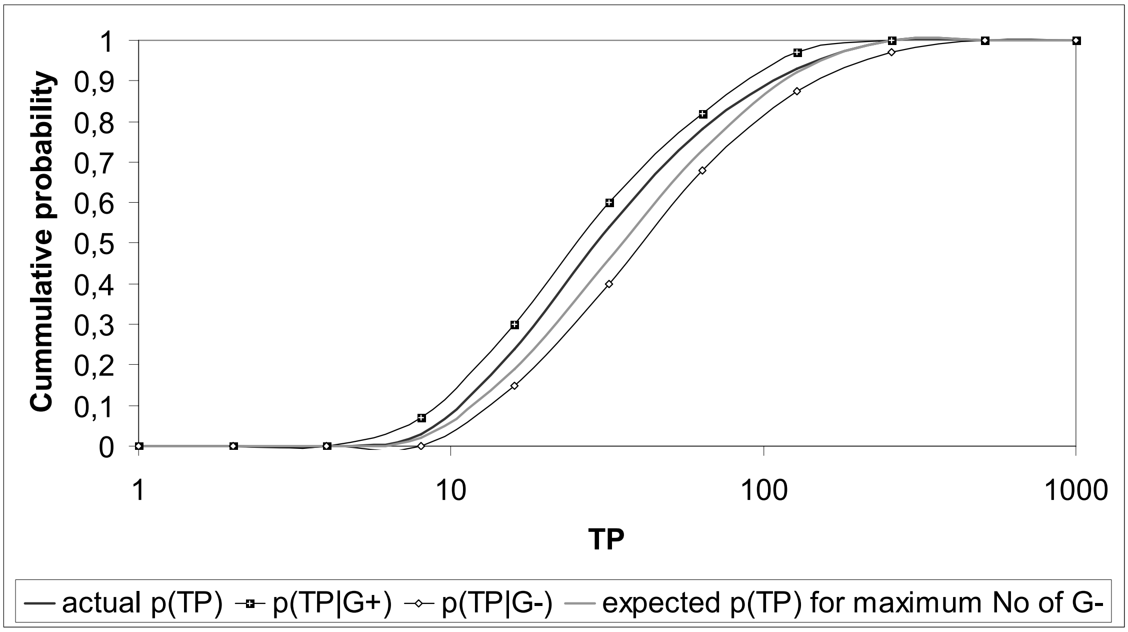


Figure 2.3. Conditional distributions and examples of the actual and G-maximized cumulative distributions for TP in all sites.

Unfortunately, the available information does not allow to estimate proper values for both TP distributions, However, it is obvious from the figure and the rationale above, that the ratio (actual/G-maximized cumulative distributions for TP) ranges between 1 (when the actual situation already contains the maximum possible frequency of sites in less than good status for each TP concentration) and a theoretical maximum of p(TP|G+)/p(TP|G-) (when the actual situations contains the minimum possible frequency of sites in less than good status for each TP concentration) as the maximum potential value for the actual cumulative distribution for TP (covering all sites) is p(TP|G+) and the minimum potential value for the expected cumulative distribution for TP assuming that the maximum possible number of sites in less than good status is reached is p(TP|G-), as

If $p(TP|G-) \leq p(TPactual) \leq p(TP|G+)$, and
$p(TP|G-) \leq p(TPmaxG-) \leq p(TPactual)$

Then, $1 \leq [p(TPactual)/ p(TPmaxG-)] \leq p(TP|G+)/ p(TP|G-)$

As a consequence, the eutrophication risk cannot be calculated as a single number, but it is clear that it should range between the values provided by the cumulative conditional distributions p(TP|G+) and p(TP|G-), as

If $1 \leq [p(TPactual)/p(TPmaxG-)] \leq p(TP|G+)/ p(TP|G-)$

Then, $p(TP|G-) \leq p(TP|G-)[p(TPactual)/p(TPmaxG-)] \leq p(TP|G+)$,

Both cumulative conditional distributions cover the whole range from 0 to 1, and the Eutrophication Risk, presented as a percentage, ranges from 0 to 100%.

Methodological developments in the updated eutrophication risk model

In addition to the need for expanding the database, the SCHER suggested some methodological changes, in particular, it was considered essential to deal with the sedimentation process, avoiding the use of unrealistically high TP concentrations; the approach adapted in annex of the updated report (De Madariaga et al., 2007), using real monitoring TP data or setting comparisons on the detergents contribution estimated at several pre-established TP concentrations, was considered an improvement. Thus, in this report the simplified exposure model has been used exclusively for estimating the relative contribution of the different sources of phosphorous (detergents, human metabolisms and diffuse sources).

Regarding TP concentrations, the approaches selected in the 2007 updated report have been also used here. The deterministic scenarios have been repeated at three TP levels, low, medium and high. For the probabilistic estimations, the measured TP concentrations of the database of measurements for each ecoregion have been fitted to a lognormal distribution (this distribution presented the best fit in all cases). As mentioned above, the simplified exposure model has been used to identify the relative contribution of detergents (laundry and dishwashing), human metabolisms and diffuse sources.

The SCHER also expressed concerns on the use of triangular distributions for simplifying the probabilistic calculations. Thus these distributions have not been used in the updated report.

The experts at the Madrid meeting suggested that the data for each ecoregion should be presented independently. The options for merging the ecoregion estimations in a single pan-European assessment would require selecting weighting coefficients, combining different variables such as population density, land use, P-based consumption patterns, etc., and therefore would increase the uncertainty in the assessment. The four selected ecoregions offer a proper pan-European coverage, and where considered the best approach for presenting the model outcome.

Regarding the P-based consumption pattern, the detergents industry association AISE kindly provided an updated set of consumption estimations, based on figures for 2007. The provided information is presented in Annex 1. The figures provided by AISE and the national population data provided by EUROSTAT for the year 2007, have been used to estimate the averaged P-based detergents laundry and dishwashing detergent contributions in the different EU Member States. These figures are presented in Table 2.1 it should be noted that the authors of this study cannot accept responsibility on the figures provided by AISE.

The table also includes the average values obtained for each ecoregion. The values correspond to population weighted averages, excluding from the calculations the countries for which information has not been provided by AISE. The allocation to the countries to each ecoregion is presented in Table 4.3. The estimation of the weighted average for the Northern ecoregion, considers that one fourth of UK and Ireland populations are located in this ecoregion.

Table 2.1 P-based detergent contributions in the different EU countries estimated from the consumption figures kindly provided by AISE (see Annex 1).

COUNTRY	POPULATION	DETERGENT CONTRIBUTION	
		g P per person and day	
	2007	laundry	dishwashing
Austria	8298923	0.00	0.28
Belgium	10584534	0.00	0.19
Bulgaria	7679290	0.45	
Cyprus	778684	2.15	0.25
Czech Republic	10287189	0.00	0.11
Denmark	5447084	0.20	
Estonia	1342409	0.84	
Finland	5276955	0.10	0.24
France	63392140	0.05	0.18
Germany	82314906	0.00	0.26
Greece	11171740	0.13	0.08
Hungary	10066158	0.72	0.06
Ireland	4312526	0.08	0.18
Italy	59131287	0.00	0.09
Latvia	2281305	0.77	
Lithuania	3384879	0.91	
Luxembourg	476187		
Malta	407810		
Netherlands	16357992	0.00	0.29
Poland	38125479	0.53	0.04
Portugal	10599095	0.14	0.13
Romania	21565119	0.39	
Slovakia	5393637	0.52	0.04
Slovenia	2010377	1.06	
Spain	44474631	0.16	0.16
Sweden	9113257	0.10	0.16
United Kingdom	60816701	0.16	0.17
POPULATION WEIGHTED ECOREGION AVERAGES			
Central/ Baltic		0.172	0.183
Atlantic		0.158	0.173
Mediterranean		0.125	0.100
Northern		0.131	0.181

It should be noted that the figure estimated for Cyprus is two times higher than the next highest figure, and is considered an outlier. Possible explanations for this high value are estimation errors, that the detergent formulations have not been improved for minimizing the amount of polyphosphates yet, or that the AISE data includes amount formulated in the country and then exported outside.

Nevertheless, the generic model is not considered suitable for covering areas with very specific conditions such as Cyprus or Malta, which would require a site specific assessment. Therefore, the figure from Cyprus has not been used for the assessment. If Cyprus, Malta or any other country is interested in having country specific assessments and provide the required exposure information, country specific assessments would be conducted for those countries.

INTRODUCTION TO THE WFD INTERCALIBRATION DATA

The JRC compiled the information available regarding the WFD Inter Calibration exercise, the description of the datasets, was prepared by the JRC experts and is copied below.

Descrition of IC datasets prepared by the JRC Experts

Altogether data for ca. 1300 lakes and 2700 lake years were pooled from national datasets into GIG databases (see Table 2.2). These databases contained both basic data (altitude, surface area, mean depth, alkalinity), quality data (chl-*a*, nutrients, Secchi depth) and pressure data (land use, population density, other impacts).

Table 2. 2. Description of Lake GIG datasets

GIG	Lakes	Lake years	Countries participating
Alpine	86	557	AT, DE, IT, FR, SI
Atlantic	28	39	IE, UK
Central/Baltic	434	1143	BE, DE, DK, EE, FR, GB, HU, LT, LV, NL, PL
Mediterranean	48	48	CY, ES, FR, GR, PT, RO
	210*	330*	ES, PT, IT
Northern	500	552	FI, IE, NO, SE, UK

* only for validation of the boundaries

Data was collected from different sources – mainly environment agencies and ministries, as well as scientific institutes and universities, using the data from national monitoring programs, but also from several research projects.

One of the problems was the heterogeneity of the data: due to different data origin different sampling and analyses methods were used (except Mediterranean GIG who carried out sampling in summer 2005 using agreed and unified strategy). Despite the large heterogeneity of the data, some common patterns can be defined (See Table 2.3):

- Mostly samples from the vegetation season, Alpine GIG included also winter/spring season;
- Ca. 4 sampling dates per season (from 1-2 to 10);
- Mostly samples from epilimnion/surface layer, Med GIG - euphotic zone defined as 2.5 Secchi depth;
- Spectrophotometry with ethanol/acetone extraction used for chl-a detection, high performance liquid chromatography (HPLC) used additionally in the Alpine region

Table 2.3. Characteristics of chlorophyll-a sampling and analyses methods in the Geographical Intercalibration Groups

(ALP-Alpine, ATL- Atlantic, CB – Central/Baltic, MED – Mediterranean, NOR – Northern GIG)

GIG	Chlorophyll-a metric	The time period of sampling	Frequency of sampling	Sampling depth	Lab analyses method
ALP	Annual mean	The whole year: winter/spring included, for GE boundaries winter/spring excluded	Ca 4 times /year, mostly 3-6 time/year, range 1-25 times/year	Euphotic zone, epilimnion, fixed depth	Spectrophotometry with ethanol/acetone extraction or HPLC
ATL	Vegetation season mean	Vegetation season: April – September (October)	2-9 times/year	Pre 2005 integrated samples, 2005 subsurface	Spectrophotometry with methanol extraction
C/B	Vegetation season mean	Vegetation season: in most case April (May) – October (September)	2-20 times per season, mostly 5-8 times/season	Surface samples, some integrated	Spectrophotometry with ethanol/acetone extraction
MED	Summer mean, euphotic zone	Summer period (June-September)	4 sampling dates (in some cases 2-3) per year	Euphotic layer defined as 2.5 Secchi depth	Spectrophotometry with acetone extraction
NOR	Vegetation season mean	Vegetation season - varying because of the length of the growth season; April – September used in analysis	1-6 times a year, data checked to cover evenly the vegetation period April – Sept	Mostly integrated samples (0-2 m Finland /epilimnion Norway), also surface samples and outlet samples	Spectrophotometry with ethanol/acetone extraction

The results of the first Lake Intercalibration exercise are the setting of reference conditions and class boundaries for chlorophyll a values for all lake intercalibration types and all geographical regions of the EU.

The Lake Intercalibration exercise is carried out within five Geographical Intercalibration Groups (GIGs) – Alpine, Atlantic, Central/Baltic, Mediterranean and Northern GIG.

1. Alpine (Austria, France, Germany, Italy, Slovenia);
2. Atlantic (Ireland, UK);
3. Central/Baltic (Belgium, Czech Republic, Denmark, Estonia, France, Germany, Hungary, Latvia, Lithuania, Netherlands, Poland, Slovakia, UK);
4. Mediterranean (Cyprus, France, Greece, Italy, Malta, Portugal, Romania, Spain);
5. Northern (Finland, Ireland, Norway, Sweden, UK).

Fifteen common Intercalibration types shared by Member states with similar hydromorphological and chemical features were defined for the Intercalibration exercise. The main purpose of typology was to enable the type-specific approach, which is the keystone in the ecological water quality assessment according to WFD (see type description Table 2.4).

Table 2.4. Description of lake types included in the Intercalibration by Geographical Intercalibration Groups. AL -Alpine, A -Atlantic, CB - Central Baltic, N – Northern.

Type code	Lake type characterisation	Altitude (m a.s.l.)	Mean depth (m)	Alkalinity (meq/l)	Additional characteristics
Lake Alpine Geographical Intercalibration Group					
AL3	Lowland or mid-altitude, deep, high alkalinity, large	50 - 800	>15	> 1	Lake size > 50 ha
AL4	Mid-altitude, shallow, high alkalinity, large	200 - 800	3 - 15	>1	Lake size > 50 ha
Lake Atlantic Geographical Intercalibration Group					
A1/2	Lowland, shallow, calcareous	<200	3-15	>1 meq/l	Non-humic
Lake Central Geographical Intercalibration Group					
CB1	Lowland, shallow, calcareous	< 200	3 - 15	> 1	Residence time 1-10 years
CB2	Lowland, very shallow, calcareous,	< 200	< 3	> 1	Residence time 0.1-1 years
CB3	Lowland, shallow , small, moderate alkalinity	< 200	3 - 15	0.2 - 1	Residence time 1-10 years
Lake Mediterranean Geographical Intercalibration Group					
M5/7	Reservoirs, deep, large siliceous, lowland, “wet areas”	0 - 800	> 15	< 1	Lake size > 50 ha Annual mean precipitation > 800 mm
M8	Reservoirs, deep, large, calcareous	0 - 800	> 15	> 1	Lake size > 50 ha
Lake Northern Geographical Intercalibration Group					
N1	Lowland, shallow, moderate alkalinity, clear	< 200 m	3 - 15	0.2 - 1	Colour < 30 mg Pt/l
N2a	Lowland, shallow, low alkalinity, clear	< 200 m	3 - 15	< 0.2	Colour < 30 mg Pt/l
N2b	Lowland, deep, low alkalinity, clear	< 200 m	> 15	< 0.2	Colour < 30 mg Pt/l
N3a	Lowland, shallow, low alkalinity, humic	< 200 m	3 - 15	< 0.2	Colour 30-90 mg Pt/l
N5a	Mid-altitude, shallow, low alkalinity, clear	200-800 m	3 - 15	< 0.2	Colour < 30 mg Pt/l
N6a	Mid-altitude, shallow, low alkalinity, humic	200-800 m	3 - 15	< 0.2	Colour 30-90 mg Pt/l
N8a	Lowland, shallow, moderate alkalinity, humic	< 200 m	3 - 15	0.2 - 1	Colour 30-90 mg Pt/l

The results of the first Intercalibration exercise are the boundary setting for chlorophyll a values for all GIGs (also phytoplankton biomass for Alpine and Mediterranean GIGs, phytoplankton composition metrics for Mediterranean GIG), including three consecutive tasks:

a. Defining of reference criteria and reference lake datasets;
b. Setting of reference conditions and high-good boundaries;
c. Setting of good-moderate boundaries.

Setting of the G/M class boundary was the most critical and difficult procedure in the Intercalibration process and required various approaches by the countries (Table 2.5). Mainly, the secondary effect approach was used for setting and/or validating the G/M boundary, according to which the condition of phytoplankton can be considered good if there is only a negligible probability that :

- Accelerated algal growth would result in a significant undesirable disturbance and/or
- Changes in the composition of taxa would adversely affect the structure or functioning of the ecosystem.

Table 2.5. Approaches used in Geographic Intercalibration Groups to set the "good"/"moderate" class boundary for lakes according to chlorophyll *a* values.

GIG	Approach to set the G/M boundary
Alpine	Defining a 2- to 3-fold increase of phytoplankton biomass of reference conditions as tolerable within the "good" status Based on trophic classification (LAWA 1999) and equal class widths on a logarithmic scale Validating boundaries against the occurrence of undesirable secondary effects related to increased phytoplankton biomass as well as with the decline of the relative biomass proportion of sensitive taxa *Cyclotella*
Central	Several secondary effects to cross-check the validity of the G/M class boundary: - Decrease in maximum depth inhabited by submerged macrophytes; - Shift from macrophytes/benthos-dominated community with clear water to a phytoplankton-dominated community with turbid water; - Increase of the probability of cyanobacterial blooms.
Mediterranean	95th percentile of the distribution of the data from the sites proposed as G/M sites for the IC register Validation of boundaries by secondary effect approach (shift in species composition, depletion of oxygen, decrease of Secchi depth)
Nordic	Phytoplankton composition changes along the chlorophyll a gradient: the G/M boundary at the break point in the curve of impact indicating taxa, i.e. at the threshold beyond which the impact indicating taxa increase more rapidly with the pressure

The final result is the establishment of reference conditions and quality class boundaries for European lakes according to one phytoplankton parameter – the concentration of chlorophyll-a (Table 2.6). For GM boundary setting – as well as for HG and reference conditions - ranges of values rather than fixed values were used (e.g., GM boundary for LCB1 type is range from 8 to 12 µg/l chlorophyll-a, it means that the Member States can set their national boundaries according to the national type characteristics in this range of the values). The main reason for using ranges instead of fixed values is the fact that IC lake types are rather broad and do not reflect all geographical or other typological differences.

The GM boundaries (mean value of the range) established by the Intercalibration process were used to evaluate ecological status of lakes of the IC dataset (only 2 classes were differentiated: above GM boundary and below GM boundary).

Table 2.6. Reference conditions and ecological status class boundary values for chlorophyll *a* (μg/l) set under the Common Implementation Strategy of the European Commission Water Framework Directive (2000).

	Type	**Reference conditions**	**“High”/”Good” boundary**	**“Good”/”Moderate” boundary**
Alpine	AL3	1.5–1.9	2.1-2.7	3.8-4.7
	AL4	2.7-3.3	3.6-4.4	6.6-8.0
Atlantic	A1/2	2.6-3.8	4.6-7.0	8.0-12.0
Central	CB1	2.6-3.8	4.6-7.0	8.0-12.0
	CB2	6.2-7.4	9.9-11.7	21.0-25.0
	CB3	2.5-3.7	4.3-6.5	8.0-12.0
Mediterranean	M5/7	1.4-2.0	*	6.7-9.5
	M8	1.8-2.6	*	4.2-6.0
Northern	N1	2.5-3.5	5.0 – 7.0	7.5 – 10.5
	N2a	1.5-2.5	3.0 – 5.0	5.0 – 8.5
	N2b	1.5-2.5	3.0 – 5.0	4.5 – 7.5
	N3a	2.5-3.5	5.0 – 7.0	8.0 – 12.0
	N5a	1.0-2.0	2.0 – 4.0	3.0 – 6.0
	N6a	2.0-3.0	4.0 – 6.0	6.0 – 9.0
	N8a	3.5-5.0	7.0 – 10.0	10.5 – 15.0

*not assessed because the WFD requires only setting “good” ecological potentials for reservoirs

NORTEHRN MACROPHYTE DATASET

GIG common data set was established for macrophyte taxonomic composition and environmental variables (see Table 2.7) which contained 1068 records. All Northern GIG countries have contributed data.

Table 2.7 . Overview of Northern GIG macrophyte data

Lake Type	FI	IE	NO	SE	UK	Total
Low alkalinity clear (101)	36	18	71	11	91	227
Low alkalinity humic (102)	125	18	20	52	29	244
Mod alkalinity clear (201)	19	12	44	11	92	178
Mod alkalinity humic (202)	55	19	37	36	30	177
High alkalinity clear (301)	-	38	30	4	97	169
High alkalinity humic (302)	-	34	22	-	17	73
All lakes total	235	139	224	114	356	1068

All Northern GIG member states have developed their national macrophyte assessment methods: Table 2.8 gives a short overview on macrophyte assessment methods,

Table 2.8 N-GIG macrophyte assessment methods: metrics and approaches used.

MS	National system	Metric, approach
FI	Finnish preliminary system of macrophyte classification (Leka et al., 2007)	Share of type-specific species in the total number of species: type specific (reference) species are replaced by other species in the course of eutrophication, for example, typical soft water isoetids communities are replaced by nymphaeids or lemnids,
IE	Free Macrophyte Index (Free et al., 2005)	There are 6 components to the Macrophyte Index: Maximum depth of colonisation, Mean depth of presence, RF% (percentage relative frequency) Elodeids, RF% Chara, Plant trophic score, RF% Tolerant taxa. Each of the above metrics were scaled from 0.1 to 1. The average of the assigned metric scores is the Index value.
NO	Norwegian trophic index TI count	Index based on a classification of species as sensitive, tolerant or indifferent to eutrophication, based on their occurrence along eutrophication gradient. The indices subtract the number of tolerant species from the number or abundance of sensitive species. For use in boundary settings, the change in occurrence and abundance of the large isoetids *Isoetes lacustris*, *I. echinospora*, *Littorella uniflora* and *Lobelia dortmanna* in low alkaline lakes and *Chara* spp. in high alkaline lakes were used
SE	Swedish trophic index (Ecke, 2007)	In Sweden, a method which is based on a trophic macrophyte index has been developed (Ecke 2007) and is now incorporated in national regulations (NFS 2008:1).The trophic index is based on the response of macrophytes (Characeae, mosses and vascular plants except helophytes) along a TP gradient. The trophic index is a weighted average of all species' indicator values in a lake. The species used for classification were those showing sudden drops in their occurrence beyond the 75th percentile.
UK	LEAFPACS method	Method is based on a macrophyte nutrient index (LMNI), the number of taxa or functional groups and the relative cover of taxa in the lake. Each metric is expressed as an EQR and the final EQR is based on a weighting because over a natural trophic state gradient (naturally oligotrophic – eutrophic) the relative importance of the above metrics changes.

Each member state then determined **a national EQR** value using national data sets for the lakes that member state had provided to the common data set.

These EQR values and national EQR boundaries (Table 2.9) were used to classify lakes in less than Good or above Good status.

Table 2.9. Agreed national assessment methods with their boundaries for H/G and G/M

Country	**National classification system intercalibrated**	**Type**	**Ecological Quality Ratios**	
			High-Good boundary	**Good-Moderate boundary**
Ireland	Free Macrophyte Index	All types intercalibrated	0.90	0.68
Sweden	Macrophyte Trophic index (Ecke)	Type 101	0.98	0.79
		Type 102	0.98	0.88
		Type 201	0.94	0.83
		Type 202	0.96	0.83
Norway	Macrophyte Trophic Index (Mjelde)	Type 101	0.94	0.61
		Type 102	0.96	0.65
		Type 201	0.91	0.72
		Type 202	0.9	0.77
		Type 301	0.92	0.69
United Kingdom	UK macrophyte assessment system: LEAFPACS	All types intercalibrated	0.80	0.60

SECTION 3: VALIDATION PROCESS

PHASE 1.- INCORPORATION OF THE IC DATA

STATISTICAL ANALYSIS

This section presents the work conducted with the data submitted by the JRC and the comparison with the previous database; the recommendations of SCHER have been followed as much as possible.

The objectives of these statistical comparisons are summarised below:

1. To compare the conditional probability distributions p(TP | G-) and p(TP | G+) obtained from the JRC and the INIA databases,
2. To assess the differences among the different European ecoregions,
3. To assess the differences among the different ecotypes within each ecoregion, and
4. To select the final datasets, and produce the distributions that should be used for updating the effect assessment and risk characterization proposals.

METHODOLOGY

The EU Joint Research Centre (JRC) has provided a database of codified information obtained from the reports of the Water Framework Directive inter-calibration studies. The information has been presented in a form directly prepared for the estimation of the conditional distributions. The data were codified by the JRC for maintaining the confidentiality. Data location was not revealed. For each data point, the information included the JRC code, the ecoregion, the ecotype, the annual average total phosphorous concentration TP, and the eutrophication status, assigned to each water body and year, the assignment split each data point into “Good Status (G+)” or “Less than Good Status (G-)”, according to the information collected during the inter-calibration exercise. Obviously, INIA has accepted the status assignment established by the JRC experts.

The provided database contained five groups of data, two covering the Northern Eco-Region, one with the eutrophication status ecological quality classified according to chlorophyll a measurements, and the other classified according to the macrophyte composition; and three groups covering the Central/Baltic, Atlantic and Mediterranean Ecoregions, with the eutrophication status ecological quality classified according to chlorophyll a measurements.

Each data set contained a JRC code, an ecotype code, the TP annual average concentration, and the classification status. A summary description of the data sets is presented in Table 3.1.

Table 3.1. Sumary description of the JRC and INIA Databases

JRC Database					
Ecoregion	**Northern**		**Central/Baltic**	**Atlantic**	**Mediterranean**
Status	*Chlor a*	*Macrophytes*	*Chlor a*	*Chlor a*	*Chlor a*
No. total	484	769	990	44	34
No. Good	402	516	549	19	31
No. Less than good	82	253	441	25	3
INIA Database					
Ecoregion	**Northern/Central/Atlantic**				**Mediterranean**
No. total	185				75
No. Good	83				37
No. Less than good	102				38

A large set of statistical and probabilistic analysis have been conducted, on the database provided by the JRC and on a combination of the previous INIA-Green Planet database with that provided by the JRC. STATgraphics software for the statistical analysis and Crystal Ball for the Monte Carlo probabilistic implementation have been used.

The statistical analysis has been mostly used for obtaining the conditional probability distributions p(TP | G+) and p(TP | G-), representing the distribution of TP concentrations in the sites with good and with less-than-good status respectively.

The statistical evaluation included a screening assessment using the data description tools and the distribution fitting module; the selected computational tool allows the selection of the best parametric distribution that fits the input data. The goodness-of-fit tests that were used for screening the selected distribution were the Kolgomorov-Smirnov and the Anderson-Darling tests. The Kolmogorov-Smirnov D statistic calculates the maximum distance between the cumulative distribution of the data and the cumulative distribution function of the fitted distribution. This calculation is a nonparametric method that tests the overall goodness of fit between the distribution of the data and the selected distribution. The Anderson-Darling statistic is a general test for complete datasets (without censored observations) that compares the fit of an observed cumulative distribution function with an expected cumulative distribution function; this test is mainly focussing on the goodness-of-fit in the tails of the distribution. The data where considered to fit the distribution if the p value obtained in the goodness-of-fit test was lower than 0.05. When any of the available distributions provide an acceptable fitting, the raw data where used for establishing the conditional probability distributions p(TP | G-) and p(TP | G+).

The Kolgomorov-Smirnov test was also used for the comparisons of two related data sets. This study was applied within and between the INIA and JRC databases for checking similarities and differences among the cumulative distributions of the raw data. The initial assessment compared the distributions obtained from the INIA and from the JRC databases for the same ecoregion. In parallel, differences between the ecoregions within the same database were obtained. The second assessment focused o the ecotypes within the ecoregions. A graphic assessment was combined with the statistical results for selecting which ecoregions and ecotypes should be covered and how to use the whole available data sets. The selection focused on the final consequences for the eutrophication risk assessment, using the statistical results as supporting information for decision making.

The conditional probability distributions p(TP | G-) and p(TP | G+) from the selected ecoregions and ecotypes were used for the mathematical implementation of the model using the

Excel datasheet software for further probabilistic implementation using Crystal Ball. Each log transformed curve was distributed in zones which were quantified by linear interpolation of the log transformed data. The fitted or raw data distributions were used depending on the results of the goodness-of-fit test as mentioned above. The results confirmed that a proper interpolation could be reached using up to eight zones for all distributions.

SUMMARY OF MAIN RESULTS

Comparison of the probabilistic distributions obtained from INIA and JRC databases

The Box-and-Whisker plot (Figures 3.1 and 3.2) has been selected for a graphic representation of the conditional probability distributions obtained from independent and combined sets of data selected from both data bases. It is very clear that the data are not normally distributed; however, the lognormal distribution offers the best fitting in most cases; thus the comparisons are presented for the log-transformed distributions of TP annual average concentrations in water bodies with ‘Good’ or with “Less than Good” status.

The full datasets, obtained by adding the data from both sources, are named INIAJRC and used as initial reference. The other datasets are named according to the source (INIA or JRC databases) and the Ecoregion (Complete means the whole set covering all ecoregions) selected for the analysis.

The original selection in each database was maintained, leading to two datasets for the INIA database (Atlantic/Central/Nordic and Mediterranean) and four datasets for the JRC database (Atlantic, Central/Baltic, Northern, Mediterranean).

The Box-and-Whisker Plot offers a graphical summary of the data including the presence of outliers. This plot was selected as it is particularly useful for comparing parallel batches of data. The graphic representation divides the data into four equal areas of frequency. A box encloses the middle 50 percent, where the median is represented as a vertical line inside the box. The mean was plotted as a point.

Horizontal lines, called whiskers, extend from each end of the box. The lower (left) whisker is drawn from the lower quartile to the smallest point within 1.5 interquartile ranges from the lower quartile. The other whisker is drawn from the upper quartile to the largest point within 1.5 interquartile ranges from the upper quartile.

Values that fall beyond the whiskers, but within 3 interquartile ranges (suspect outliers), are plotted as individual points. Far outside points (outliers) are distinguished by a special character (a point with a + through it). Outliers are points more than 3 interquartile ranges below the lower quartile or above the upper quartile.

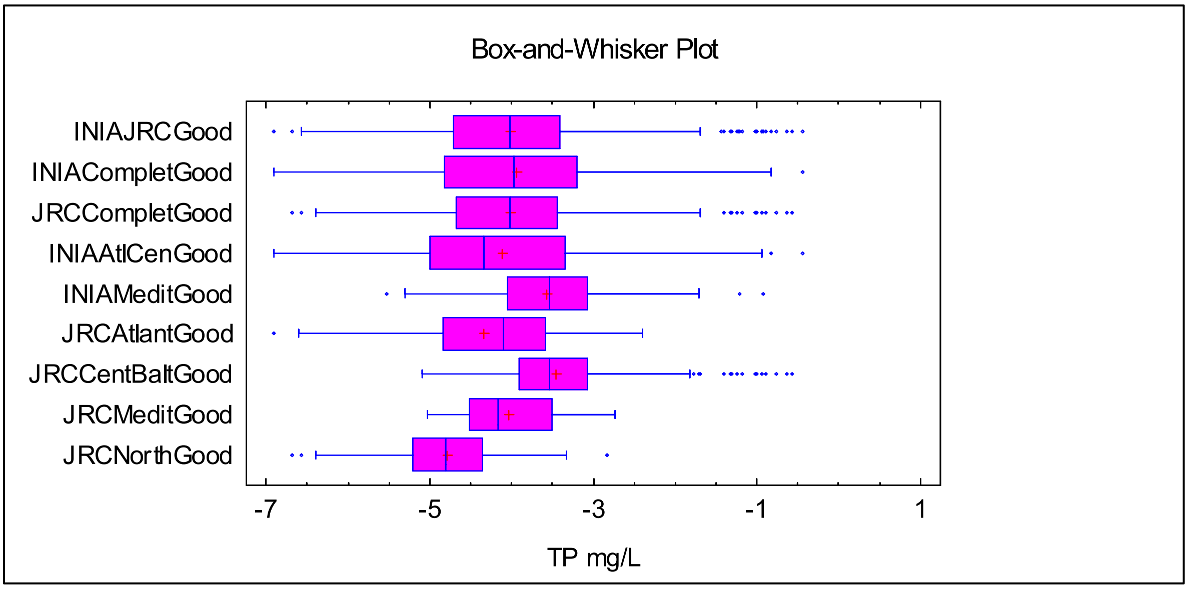


Figure 3.1. Comparison of log-transformed distributions of TP conc. (mg/L) in water bodies with ‘Good’ status: p(TP | G+).

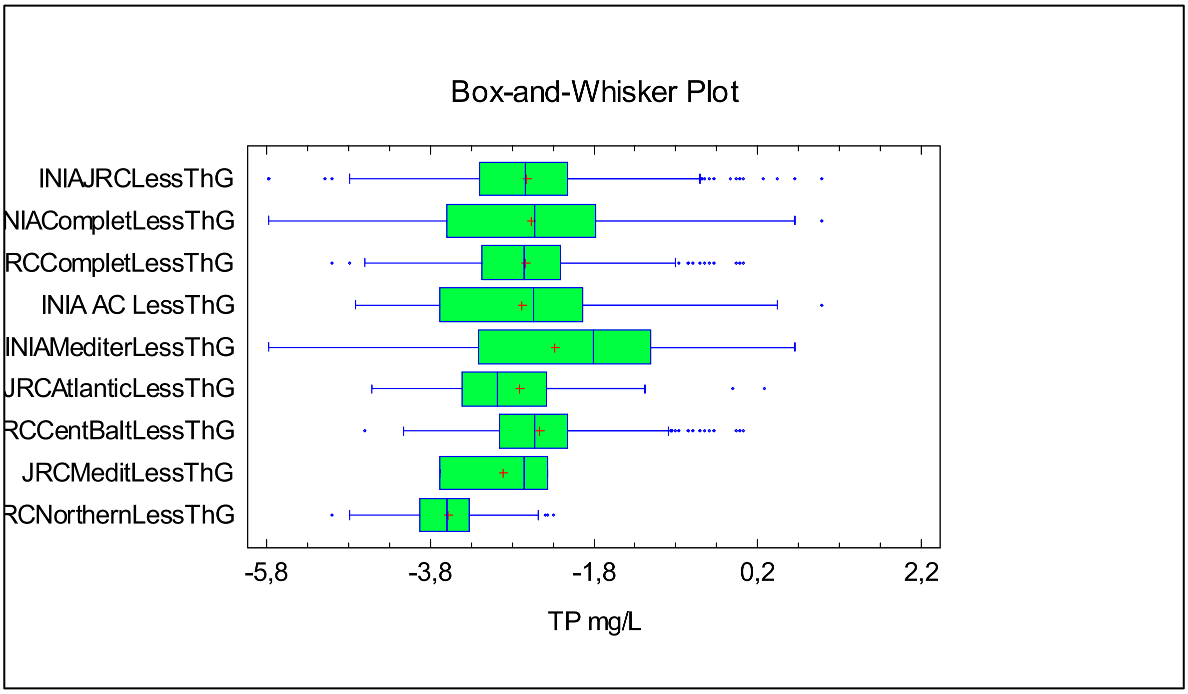


Figure 3.2. Comparison of log-transformed distributions of TP conc. (mg/L) in water bodies with ‘Less than good’ status: p(TP | G-).

As mentioned, the Kolmogorov-Smirnov test was selected for identifying statistically significant differences between the distributions. The Kolmogorov-Smirnov test is non-parametric and distribution free, and has the advantage of making no assumption about the distribution of data. The Kolmogorov-Smirnov test is a robust test that cares only about the relative distribution of the data; it is sensitive to differences in both location and shape of the empirical cumulative distribution functions of the two samples; and therefore was considered the proper method for comparing the data distributions. The results of the independent analysis have been combined and presented in a matrix form in Tables 3.2 and 3.3.

Table 3.2. Matrix of p-values obtained for the distribution comparisons according to the Kolmogorov-Smirnov tests:
Datasets of TP concentrations in waterbodies with 'Good' status.

	INIAJRC	INIAComplete	INIAAtCen	INIAMed	JRCComplete	JRCAtlant	JRCCenBalt	JRCMed	JRCNorth
INIAJRC	-	0.268	0.027*	0.024*	0.957	0.760	0.0*	0.246	0.0*
INIAComplete	-	-	0.335	0.0802	0.181	0.434	0.0*	0.123	0.0*
INIAAtCen	-	-	-	0.008*	0.022*	0.722	0.0*	0.019*	7.5E-8*
INIAMed	-	-	-	-	0.024*	0.077	0.257	0.013*	0.0*
JRCComplete	-	-	-	-	-	0.758	0.0*	0.284	0.0*
JRCAtlant	-	-	-	-	-	-	.0009*	0.673	0.002*
JRCCenBalt	-	-	-	-	-	-	-	$2\ 10^{-6}$*	0.0*
JRCMed	-	-	-	-	-	-	-	-	1.10^{-6}*
JRCNorth	-	-	-	-	-	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (p-value ≤ 0.05)

Table 3.3. Matrix of p-values obtained for the distribution comparisons according to the Kolmogorov-Smirnov tests:
Datasets of TP concentrations in waterbodies with 'Less-than-good' status.

	INIAJRC	INIAComplete	INIAAtCen	INIAMed	JRCComplete	JRCAtlant	JRCCenBalt	JRCMed	JRCNorth
INIAJRC	-	0.004*	0.03*	0.0002*	0.552	0.141	.0003	0.800	0.0*
INIAComplet	-	-	0.510	0.043*	0.0002*	0.046*	.00009*	0.515	0.0*
INIAAtCen	-	-	-	0.0033*	0.0048*	0.092	0.0002*	0.678	0.0*
INIAMed	-	-	-	-	3.10^{-5}*	0.010*	0.0002*	0.217	0.0*
JRCComplete	-	-	-	-	-	0.177	0.0017*	0.871	0.0*
JRCAtlant	-	-	-	-	-	-	0.013*	0.962	0.0001*
JRCCenBalt	-	-	-	-	-	-	-	0.710	0.0*
JRCMed	-	-	-	-	-	-	-	-	0.239
JRCNorth	-	-	-	-	-	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (p-value ≤ 0.05)

As observed in the plots and confirmed by the statistical analysis; in general, there is good agreement between the distributions obtained from the INIA and from the JRC databases. In fact, when the complete databases are compared between the database and with the combined INIAJRC set, no statistically significant differences are observed for the water bodies with Good status. However, statistically significant differences are observed among ecoregions within the same database.

In the case of water bodies with Less than Good status, there are large differences in the contribution of the different ecoregions to the complete data sets; in particular, the Mediterranean ecoregion is almost not represented in the JRC database (three points) but provides a relevant contribution for the INIA database. This situation leads to apparent differences when the complete sets are compared; and statistically significant differences were found. As observed when the comparison is restricted to the ecoregions, the differences are not really related to the databases but to the relative contributions of the different ecoregions within each database; in fact no significant differences are found for the comparison of the INIA-Atlantic/Central and the JRC-Atlantic datasets, or among the Mediterranean sets, although the last comparison is of low value due to the limited number of cases in the JRC database.

The probabilistic distributions obtained from the JRC data in this analysis where compared with those employed in the initial INIA-Green Planet study. The comparison was restricted to the Atlantic/Central/Northern shallow water bodies as the JRC database does not contain enough number of data points with Less than Good status for the Mediterranean ecoregion. The original distribution and its comparison with the revised option are presented in Figures 3.3 and 3.4 respectively.

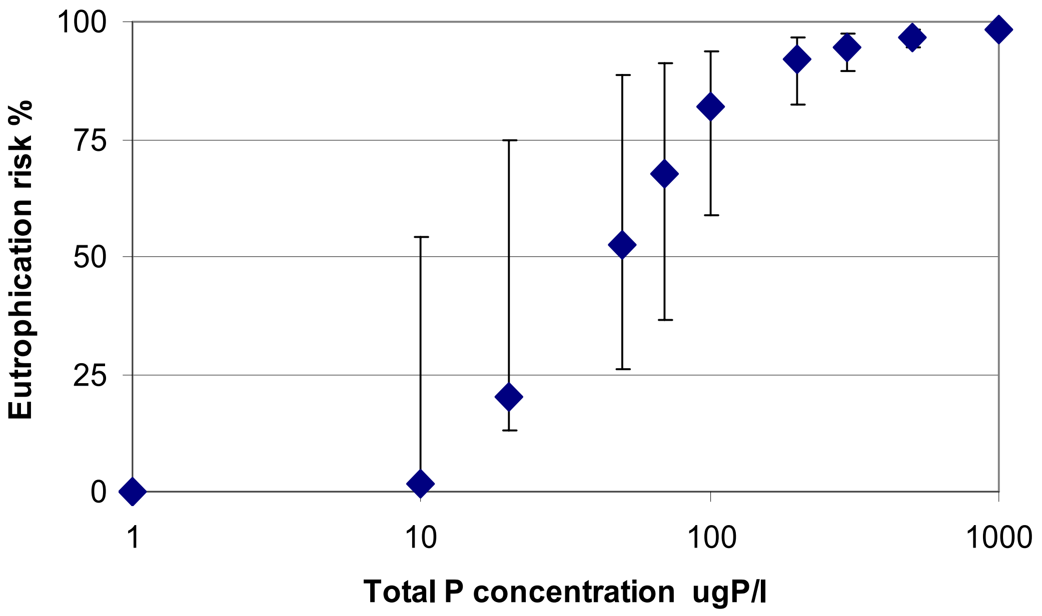


Figure 3.3. Eutrophication risk/concentration response for shallow water bodies located in the Atlantic, Central and Northern ecoregions obtained in the first report.

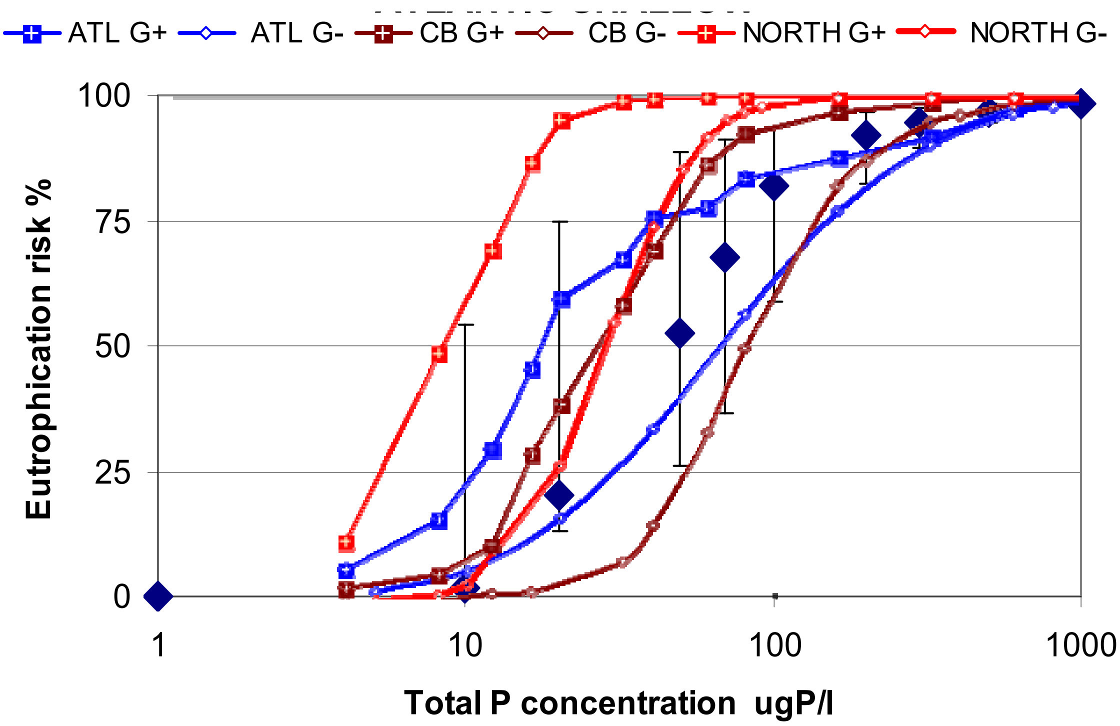


Figure 3.4. Comparison of the eutrophication risk/concentration responses obtained in the initial study with those obtained in this validation exercise.

The results presented in Figure 3.4 clearly confirm that the conditional probability distributions obtained in the first INIA-Green Planet study are in good agreement with those obtained from the JRC data. This agreement is particularly relevant in terms of the validation of the model results, as the eutrophication risk/concentration responses are the key element of the INIA-Green Planet model.

Additional analysis (not shown) demonstrated statistically significant differences among the complete and Ecoregion specific conditional distributions obtained for water bodies with 'Good' and with 'Less than Good' status in the JRC and the INIA databases, confirming the suitability of the data for applying the risk characterization concept proposed by the INIA model.

The observed agreement also confirms that the eutrophication classification applied for constructing the INIA-Green Planet database was sound, and that the criteria where applied in a proper way following the recommendations of the WFD Expert Group. When the amount of available information is analysed, the results indicates that, in reality, both databases should be considered as complementary. In particular, the JRC is essential for a proper distinction among the Atlantic, Central/Baltic, and Northern ecoregions; but does not contain enough information for the Mediterranean ecoregion.

Therefore both databases where combined for creating join data sets for the ecoregions considered in the JRC database:

- Atlantic
- Central/Baltic
- Northern
- Mediterranean

Eutrophication risk/concentration curves for the different European Ecoregions.

The combined datasets were used for developing eutrophication risk/concentration curves for each ecoregion. Figure 3.5 presents an overview of these curves. As mentioned above, when a proper fitting to a parametric distribution was found, the curve was obtained from selected lower tail areas obtained using the critical values tabular option, which calculates the values for the area that fall under the distribution curve. When a proper fitting was not observed, the areas under the curve were obtained directly from the accumulated raw data distribution.

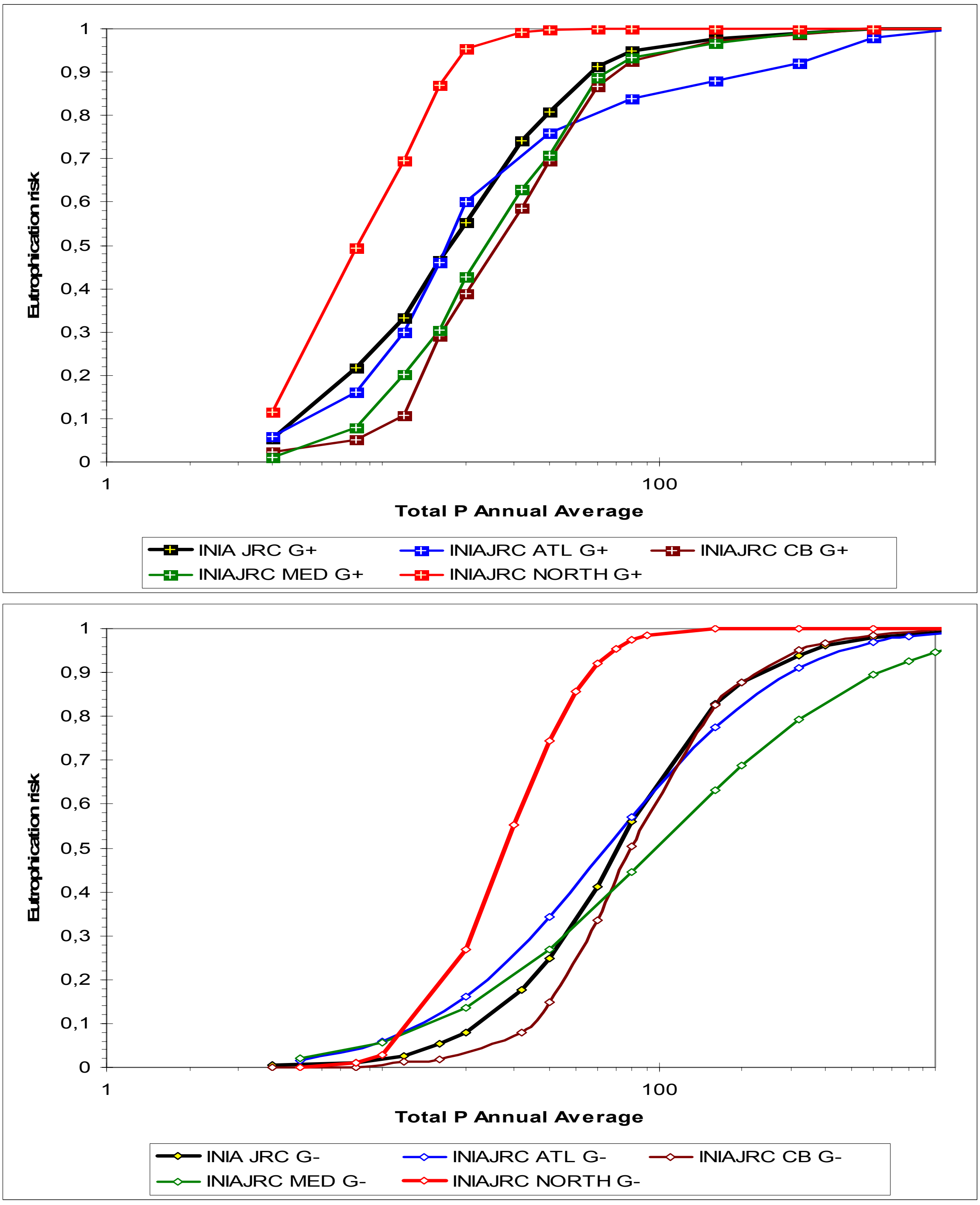


Figure 3.5. Comparison of the eutrophication risk/concentration responses obtained for the whole database, and for each ecoregion.

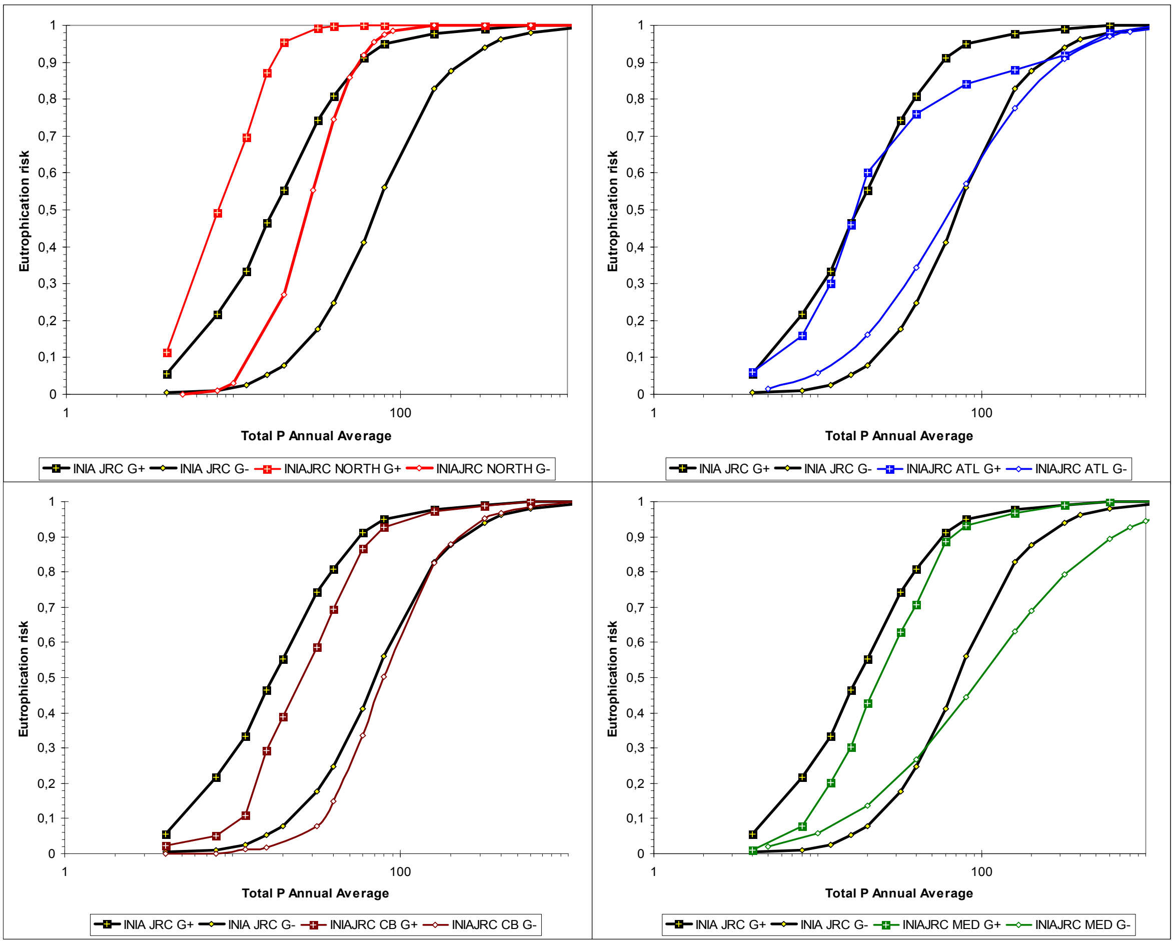


Figure 3.6. Proposed eutrophication risk/concentration responses for the four selected ecoregions and its comparison with the overall distribution.

The benefits obtained by splitting the datasets by ecoregions are observed in Figure 3.6. The results are in agreement with those expected. The Northern ecoregion is most sensitive to the TP level than the average, while the Atlantic and the Central-Baltic ecoregions are mostly included within the overall joint distributions. For the Mediterranean region, the main difference is observed in the curve slopes, which differ from those observed for other curves.

The incorporation of the JRC database allowed to obtain independent distributions for the Northern, the Atlantic and the Central/Baltic ecoregions, which in the initial report where combined due to lack of sufficient data.

The benefits obtained from this splitting-approach are presented in Figure 3.7. Basically, the broad distribution obtained from the joint database is transformed in a set of independent distributions for each region, reducing the variability and offering a less uncertain assessment. As the eutrophication risk is presented as a range, defined by both conditional probability distributions, this improvement is observed as a reduction in the range amplitude. As observed, the Northern and Central-Baltic distributions are basically complementary, the Northern distribution covering the most sensitive part of the whole data set and the Central-Baltic covers the lest-sensitive fraction. The Atlantic distributions occupy a central zone, with significant parts of the area falling within the limits of the other distributions.

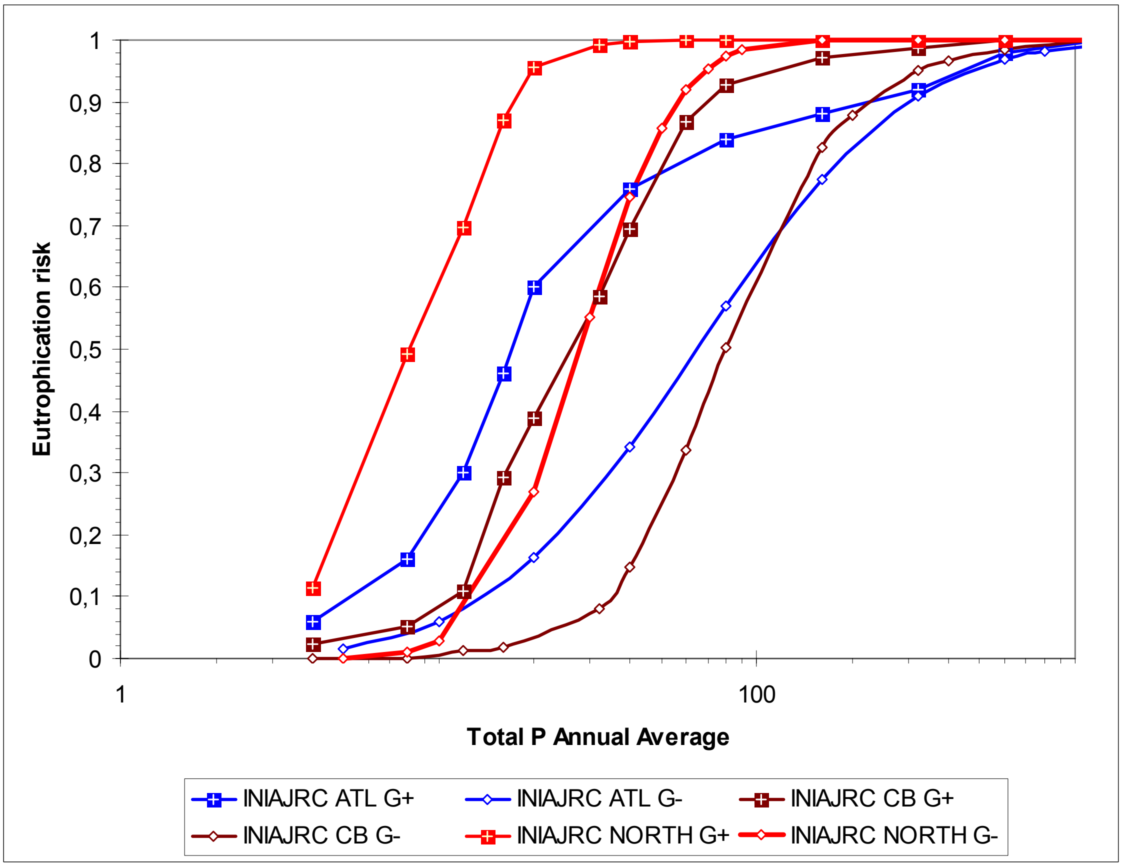


Figure 3.7. Comparison of the proposed eutrophication risk/concentration responses for the three selected ecoregions that will replace the previous Atlantic/Central/Northern distributions.

The comparison of the Mediterranean and Central-Baltic ecoregions is also of particular interests (see Figure 3.8). The conditional probability distributions for sites in Good status conditions are almost identical, and, therefore, the maximum eutrophication risk in both regions is very similar. However, the slopes of the conditional probability distributions obtained for sites in less-than-good status is very different, suggesting that a larger proportion of Mediterranean water bodies can remain at good status at relatively high phosphorous concentrations.

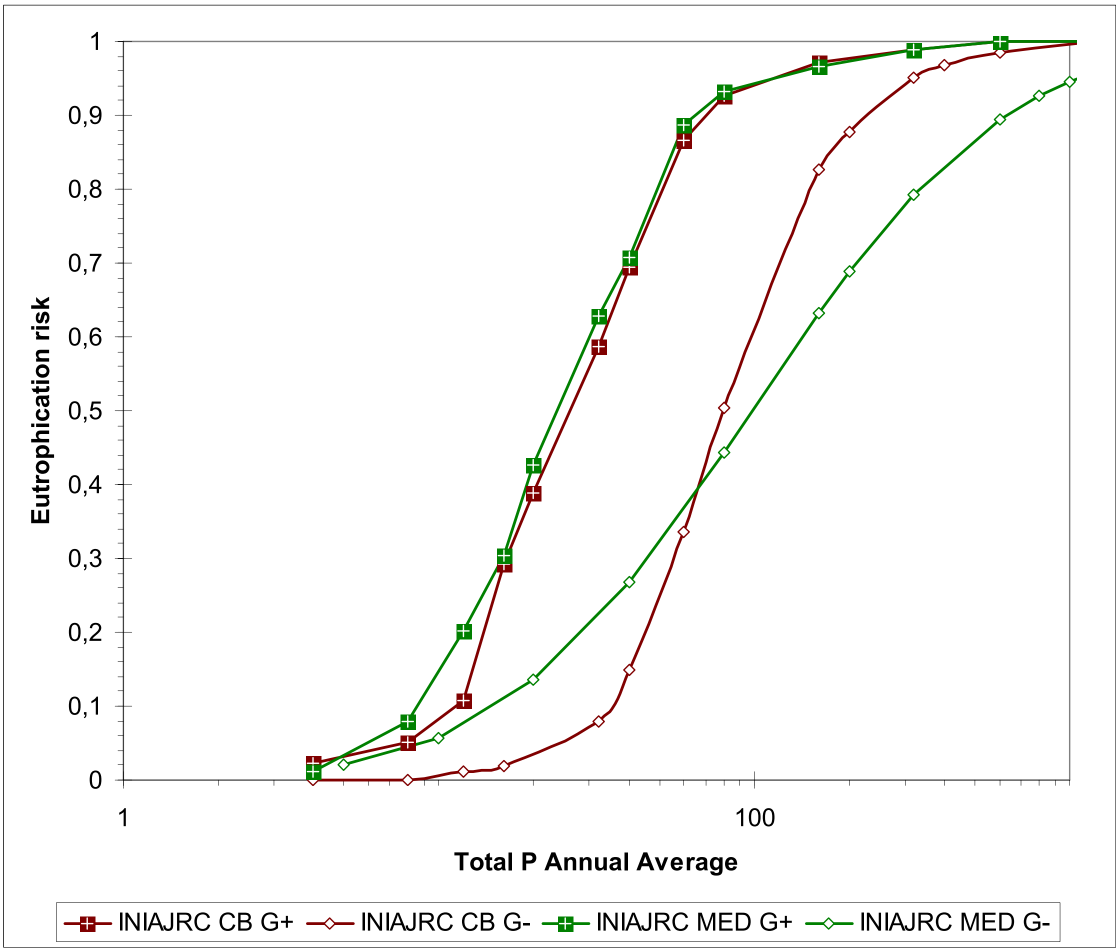


Figure 3.8. Comparison of the proposed eutrophication risk/concentration responses for the Mediterranean and the Central/Baltic ecoregions.

The conditional curves obtained for each of the four selected ecoregions were transformed into mathematical descriptions using corrected loglinear interpolation as described above, and incorporated in a mathematical model constructed in Excel and implemented by Crystal Ball for Monte Carlo Analysis.

Eutrophication risk/concentration curves for the different Ecotypes.

The second step, was to consider the role of the ecotypes within each ecoregion, the approach was similar to that employed for the ecoregion assessment, considering the results of the statistical analysis and the relevance for risk assessment in the final selection.

Tables 3.4 and 3.5 present the results of the statistical evaluation of the ecotypes established for the Northern ecoregion.

Table 3.4. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted among paired ecotype datasets of TP concentrations in waterbodies of Northern ecoregion with 'Good' status.

	JRCComplete	JRCNorth	JRC LN1	JRC LN2a	JRC LN2b	JRC LN3a	JRC LN5	JRC LN6a	JRC LN8a
JRCComplete	-	0.0*	1.9E-8*	0.0*	0.0*	0.0*	0.0*	0.004*	0.013*
JRCNorth	-	-	0.002*	0.0001*	6.7E-9*	1.4E-7*	0.0004*	0.02*	1.8E-8*
JRC LN1	-	-	-	8.8E-8*	0.0*	0.273	1E-6*	0.326	7E-5*
JRC LN2a	-	-	-	-	5E-5*	0.0*	0.171	6E-5*	0.0*
JRC LN2b	-	-	-	-	-	0.0*	0.01*	7.5E-7*	0.0*
JRC LN3a	-	-	-	-	-	-	0.0*	0.186	0.0003*
JRC LN5	-	-	-	-	-	-	-	1E-5*	0.0*
JRC LN6a	-	-	-	-	-	-	-	-	0.001*
JRC LN8a	-	-	-	-	-	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05)

Table 3.5. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted among paired ecotype datasets of TP concentrations in waterbodies of Northern ecoregion with 'Less-than-good' status.

	JRCComplete	JRCNorth	JRC LN1	JRC LN2a	JRC LN2b	JRC LN3a	JRC LN5	JRC LN6a	JRC LN8a
JRCComplete	-	0.0*	7E-7*	4E-7*	0.05	1.2E-8*	0.061	0.066	7.3E-7*
JRCNorth	-	-	0.816	0.0037*	0.185	0.008*	0.912	0.992	0.003*
JRC LN1	-	-	-	0.005*	0.141	0.009*	0.789	0.943	0.057
JRC LN2a	-	-	-	-	0.995	0.015*	0.301	0.165	0.0001*
JRC LN2b	-	-	-	-	-	0.141	0.448	0.181	0.073
JRC LN3a	-	-	-	-	-	-	0.789	0.331	1E-5*
JRC LN5	-	-	-	-	-	-	-	0.927	0.093
JRC LN6a	-	-	-	-	-	-	-	-	0.727
JRC LN8a	-	-	-	-	-	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05)

The tables confirm statistically significant differences among some ecotypes, the relevance of these differences in terms of the eutrophication risk assessment was assessed using graphic representations and comparisons. The overall results are presented in Figure 3.9. It is clear that although most of the ecotypes distributions fall within the limits of the overall ecoregion distribution, splitting the datasets into ecotypes has the benefit of reducing the internal variability/uncertainty in the risk estimation.

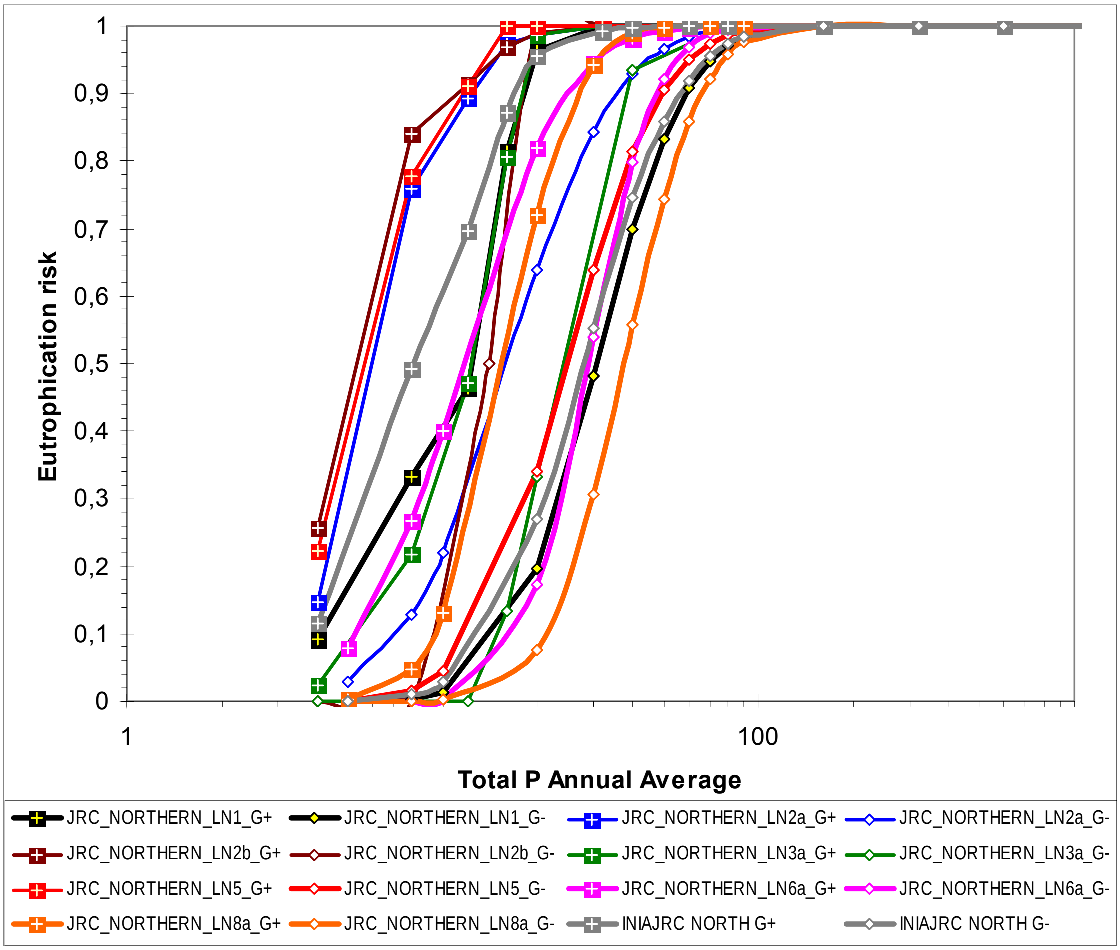


Figure 3.9. Eutrophication risk/concentration responses for the different ecotypes of the Northern ecoregion.

The results suggest that the overall assessment can be achieved by selecting three specific ecotypes, NORTHERN_LN2b; NORTHERN_LN1, and NORTHERN_LN8a, representing the highest, medium and lowest sensitivity, respectively. Figure 3.10 demonstrate that this selection covers all Northern ecotypes, and the final proposed conditional probability distributions are presented in Figure 3.11.

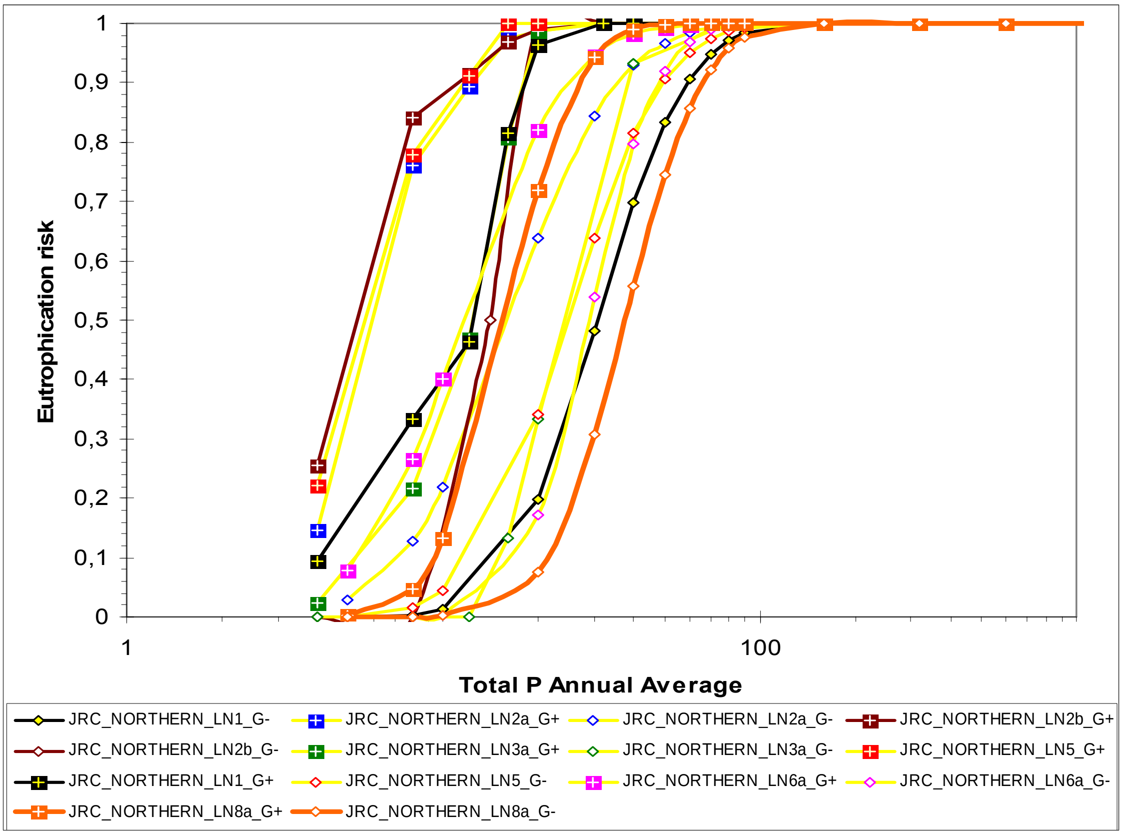


Figure 3.10. Eutrophication risk/concentration responses for the selected and non-selected (yellow lines) ecotypes of the Northern ecoregion.

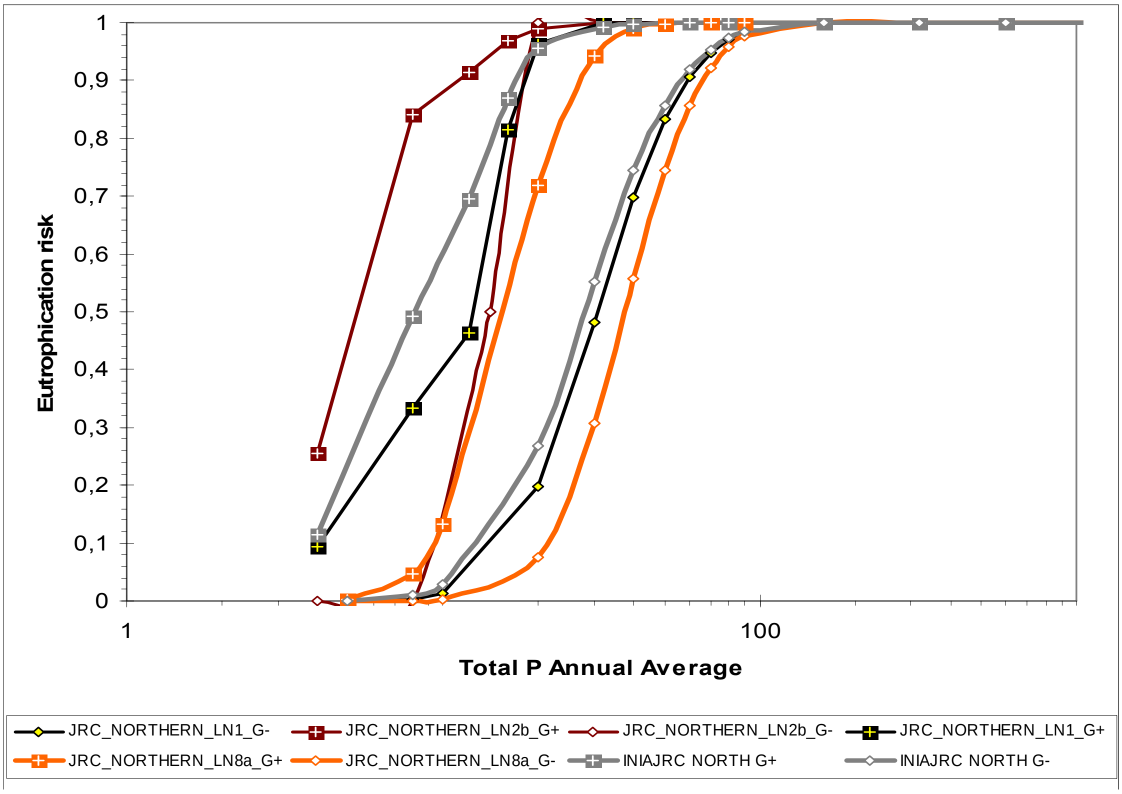


Figure 3.11. Comparison of the eutrophication risk/concentration responses for the overall Northern ecoregion and the three selected ecotypes.

Tables 3.6 and 3.7 present the results of the statistical evaluation of the ecotypes established for the Central/Baltic ecoregion.

Table 3.6. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted among paired ecotype datasets of TP concentrations in waterbodies of Central and Baltic European ecoregion with 'Good' status.

	JRCComplete	JRCCentBalt	JRC CB1	JRC CB2	JRC CB3
JRCComplete	-	0.0*	0.0*	0.0*	0.0059*
JRCCentBalt	-	-	0.045*	1E-6*	0.0004*
JRC CB1	-	-	-	0.0*	0.0*
JRC CB2	-	-	-	-	1.1E-7*
JRC CB3	-	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05)

Table 3.7. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted among paired ecotype datasets of TP concentrations in waterbodies of Central and Baltic European ecoregion with 'Less-than-good' status.

	JRCComplete	JRCCentBalt	JRC CB1	JRC CB2	JRC CB3
JRCComplete	-	0.0017*	0.452	0.0*	0.0008*
JRCCentBalt	-	-	0.0504	0.00008*	2E-5*
JRC CB1	-	-	-	8.7E-8*	0.0017*
JRC CB2	-	-	-	-	0.0*
JRC CB3	-	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05)

Statistically significant differences where observed among all three ecotypes. As observed in Figure 3.12, the situation is similar to that observed for the Northern ecotypes. Most of the ecotype distributions fall within or close to the ecoregion distribution. In this case, the sensitivity to the eutrophication risk increases from ecotype CENTRAL/BALTIC_CB2, to CB3 and CB1, and the variability in the assessment is substantially reduced by splitting the overall dataset into independent ecotypes.

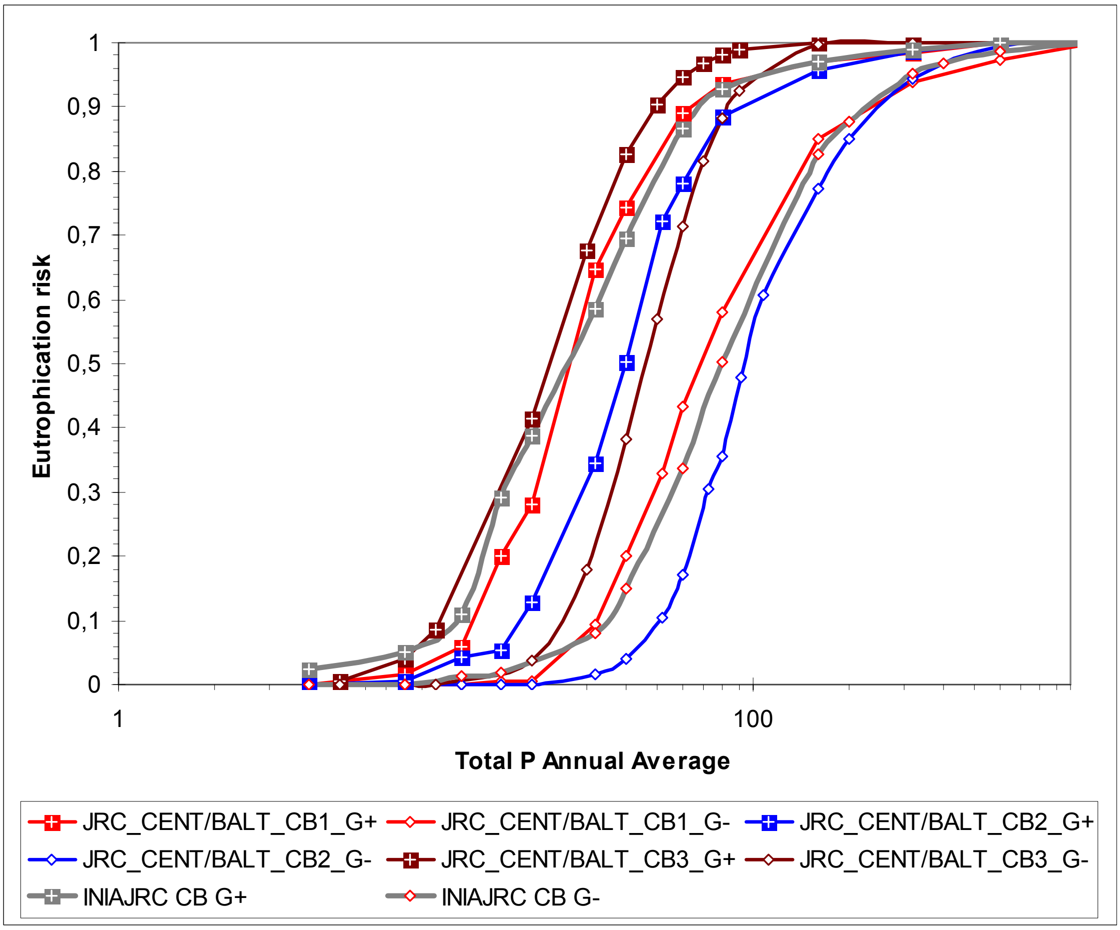


Figure 3.12. Comparison of the eutrophication risk/concentration responses for the overall Central/Baltic ecoregion and the three selected ecotypes.

Tables 3.8 to 3.11 summarised the statistical results obtained for the ecotype assessment of the Mediterranean and Atlantic ecoregions. Basically, no statistically significant differences where found, thus the overall distribution, without further considerations of the potential role of ecotypes, will be used for this ecoregions.

Table 3.8. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted among paired ecotype datasets of TP concentrations in waterbodies of Mediterranean ecoregion with 'Good' status.

	JRCComplete	JRCMediterr	JRC Med_C	JRC Med_SW
JRCComplete	-	0.284	0.361	0.384
JRCMediterr	-	-	0.842	0.756
JRC Med_C	-	-	-	0.635
JRC Med_SW	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05)

Table 3.9. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted among paired ecotype datasets of TP concentrations in waterbodies of Mediterranean ecoregion with 'Less-than-good' status.

	JRCComplete	JRCMediterr	JRC Med_C	JRC Med_SW
JRCComplete	-	0.871	0.679	Error
JRCMediterr	-	-	0.660	Error
JRC Med_C	-	-	-	Error
JRC Med_SW	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05). Error: no output due to data error

Table 3.10. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted among paired ecotype datasets of TP concentrations in waterbodies of Atlantic ecoregion with 'Good' status.

	JRCComplete	JRC Atlantic	JRC Atl_LA1	JRC Atl_LA2
JRCComplete	-	0.758	0.116	0.082
JRC Atlantic	-	-	0.055	0.503
JRC Atl_LA1	-	-	-	0.017*
JRC Atl_LA2	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05)

Table 3.11. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted among paired ecotype datasets of TP concentrations in waterbodies of Atlantic ecoregion with 'Less-than-good' status.

	JRCComplete	JRC Atlantic	JRC Atl_LA1	JRC Atl_LA2
JRCComplete	-	0.177	0.801	0.031*
JRC Atlantic	-	-	0.562	0.947
JRC Atl_LA1	-	-	-	0.271
JRC Atl_LA2	-	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05)

Comparison of chlorophyll-a and macrophytes data bases for the Northern ecoregion

The IC database provided by the JRC contained two complementary datasets for the Northern region, one with the status assessed as a function of chlorophyll a, as for the other ecoregions, as a second set assessed on the basis of macrophyte communities.

The statistical analysis (Tables 3.12 and 3.13) confirms that there are statistically significant differences, in the conditional probability distributions obtained from the Northern data bases created using chlorophyll-a or macrophytes for setting the eutrophication status.

Table 3.12. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted between two datasets of TP concentrations (mg/L) in waterbodies of Northern ecoregion with 'Good' status. Comparison of complete dataset and Northern datasets, obtained with two different assessment criteria (Chlorophyll-a and macrophytes).

	JRCComplete	JRCNorth_Chl-a	JRCNorth_Macrop
JRCComplete	-	0.0*	0.0*
JRCNorth_Chl-a	-	-	0.0*
JRCNorth_Macrop	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05)

Table 3.13. Matrix of p-values obtained with Kolmogorov-Smirnov tests conducted between two datasets of TP concentrations (mg/L) in waterbodies of Northern ecoregion with 'Less-than-good' status. Comparison of complete dataset and Northern datasets, obtained with two different assessment criteria (Chlorophyll-a and macrophytes).

	JRCComplete	JRCNorth_Chl-a	JRCNorth_Macrop
JRCComplete	-	0.0*	0.0*
JRCNorth_Chl-a	-	-	2E-6*
JRCNorth_Macrop	-	-	-

* = statistically significant difference between the two distributions at the 95% confidence level (P-value ≤ 0.05)

The assessment based on macrophytes is less sensitive to phosphorous that the assessment based on chlorophyll-a, as observed in Figure 3.13.

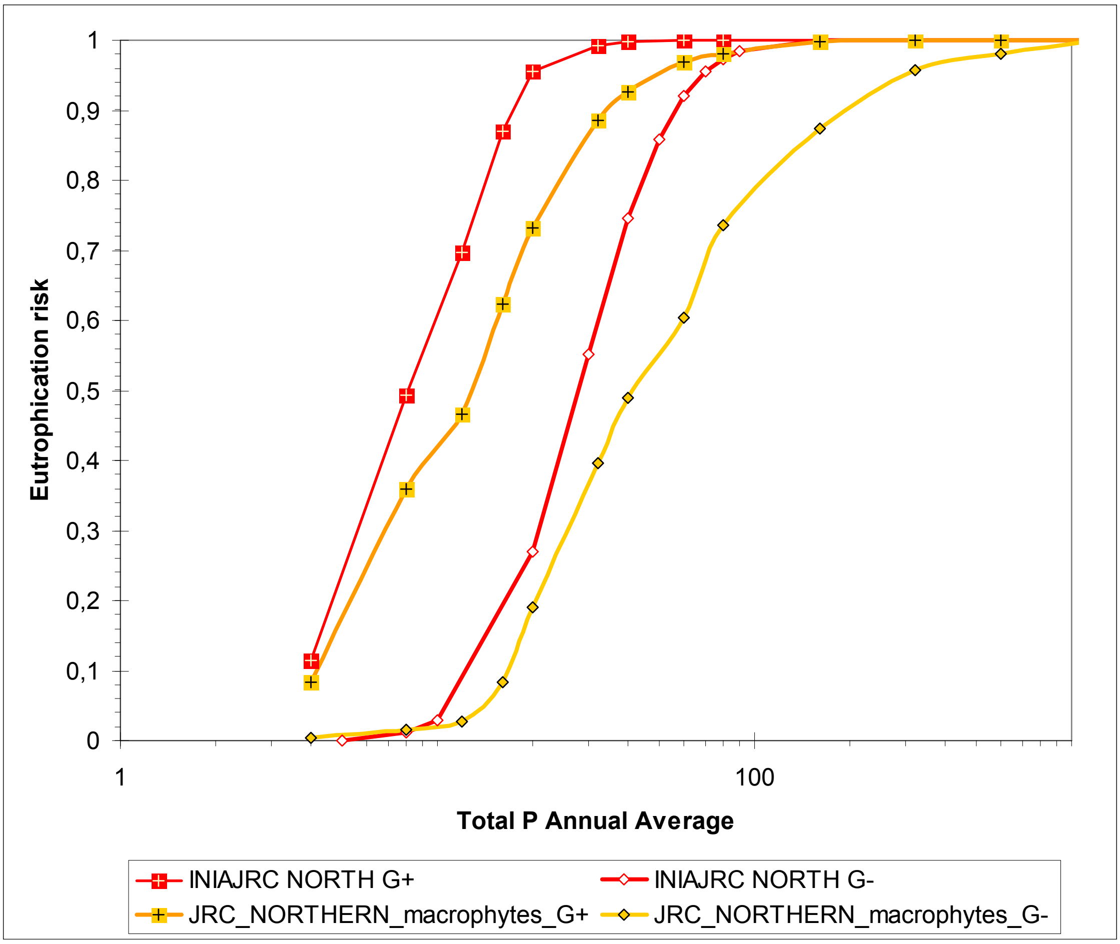


Figure 3.13. Comparison of the eutrophication risk/concentration responses obtained for the two Northern databases.

Nevertheless, in the interregional comparison, the Northern water bodies are still the most sensitive (higher eutrophication risk at the same TP concentration), although the difference is lower for the assessment based on macrophytes than for the assessment based on chlorophyll-a, as observed in Figure 3.14.

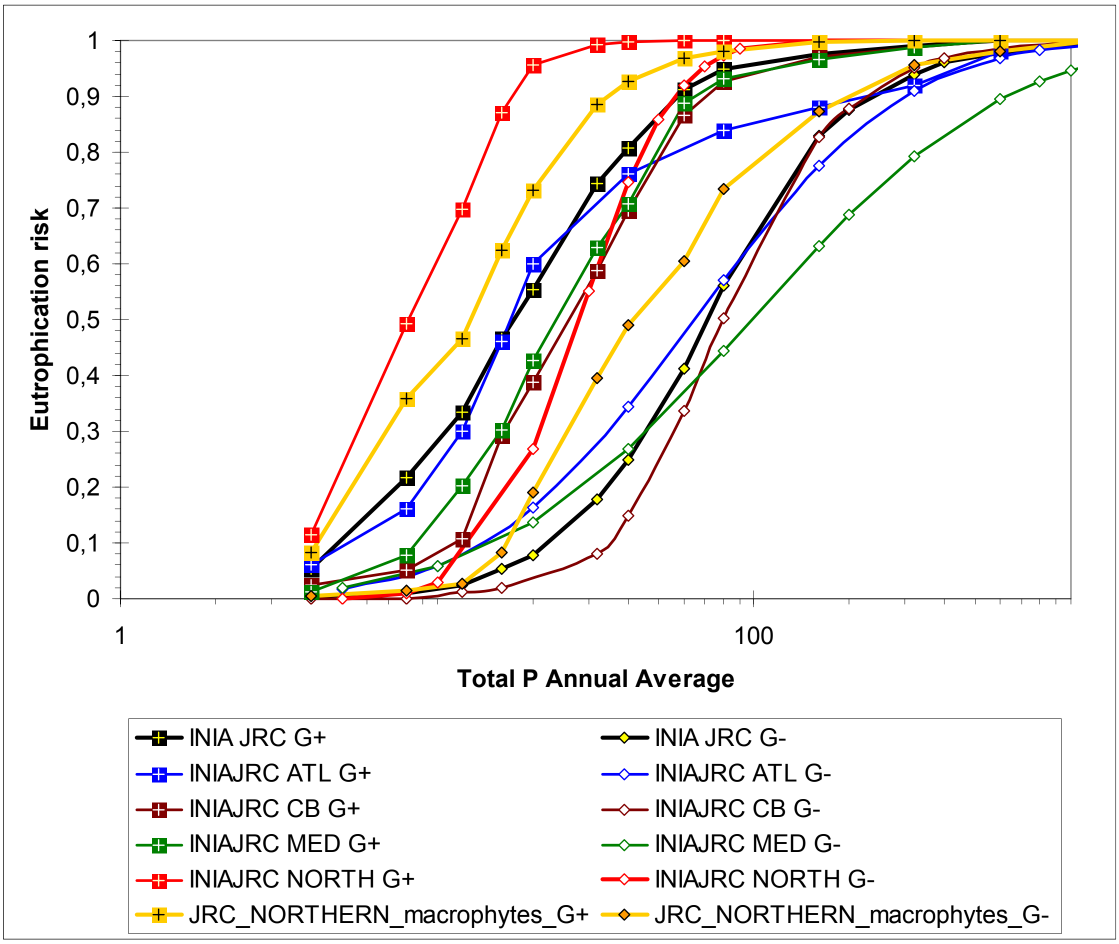


Figure 3.14. Comparison of the eutrophication risk/concentration responses obtained for each ecoregion.

CONCLUSIONS FROM THE STATISTICAL ANALYSIS OF THE JRC DATABASES

The databases from JRC and INIA are complementary in terms of the ecoregion coverage. In particular, the INIA database was essential for a proper coverage of the Mediterranean ecoregion. The experts at the second Madrid workshop suggested the use of the additional Mediterranean set employed for the validation of the boundaries. Unfortunately, this dataset was not available for the JRC; access to this data has been requested to the Spanish CA, but no response has been obtained until now. Thus the fusion of both databases is currently the only possible option for covering the Mediterranean ecoregion.

The statistically analysis indicate no relevant differences among both databases; in fact, no statistically significant differences are observed for the water bodies with Good Status and the apparent differences observed for the water bodies with Less than Good status should be attributed to the different weight of the Ecoregions in the data sets. Significant differences among ecoregions within the same database are observed.

These results confirm that for the proposed use, setting the conditional probability distributions, the combination of both databases is acceptable and posses clear benefits in terms of expanding the regional coverage and reducing the uncertainty.

Thus, the datasets have been combined and the conditional distributions, representing the range of the eutrophication risk/concentration response, were obtained for the four ecoregions determined in the JRC database: Northern, Central/Baltic, Atlantic and Mediterranean.

Statistically significant differences among the datasets established by the chlorophyll a and the macrophytes status boundaries have been observed for the Northern ecoregion. Thus two complementary assessments will be produced for this ecoregion.

An additional assessment of the role of the different ecotypes within each ecoregion has been also conducted. Three ecotypes, representing the higher, medium and lower sensitivity have been selected for the Northern and the Central/Baltic ecoregions. No statistically significant differences were observed for the Atlantic and the Mediterranean ecoregions; thus the overall distribution has been used in this case.

These distributions have been used for refining the eutrophication risk estimations associated to the use of polyphosphate in detergent formulations.

MODEL RE-CALIBRATION AND PROPOSED RISK CURVES

The conditional distributions, representing the range of the eutrophication risk/concentration response, have been implemented into the mathematical model by adapted log-linear interpolation.

The model has been implemented using Excel, allowing the further probabilistic implementation by Monte Carlo Analysis using Crystal Ball.

Following the SCHER opinion and the recommendations received from the experts in the different meetings and workshops, the simplified exposure estimation was modified, and restricted to be used for quantifying the proportional contribution of each of the following phosphorous sources:

- Point emissions:
    - Human metabolisms. Using the default value of 1.5 g P per person and day
    - Laundry and dishwashing detergents. Using the country values provided by AISE
- Diffuse emissions:
    - Using land use patterns for four categories and the default emission coefficients

The following eutrophication concentration-risk curves have been implemented in the risk eutrophication model.

CENTRAL BALTIC ECOREGION

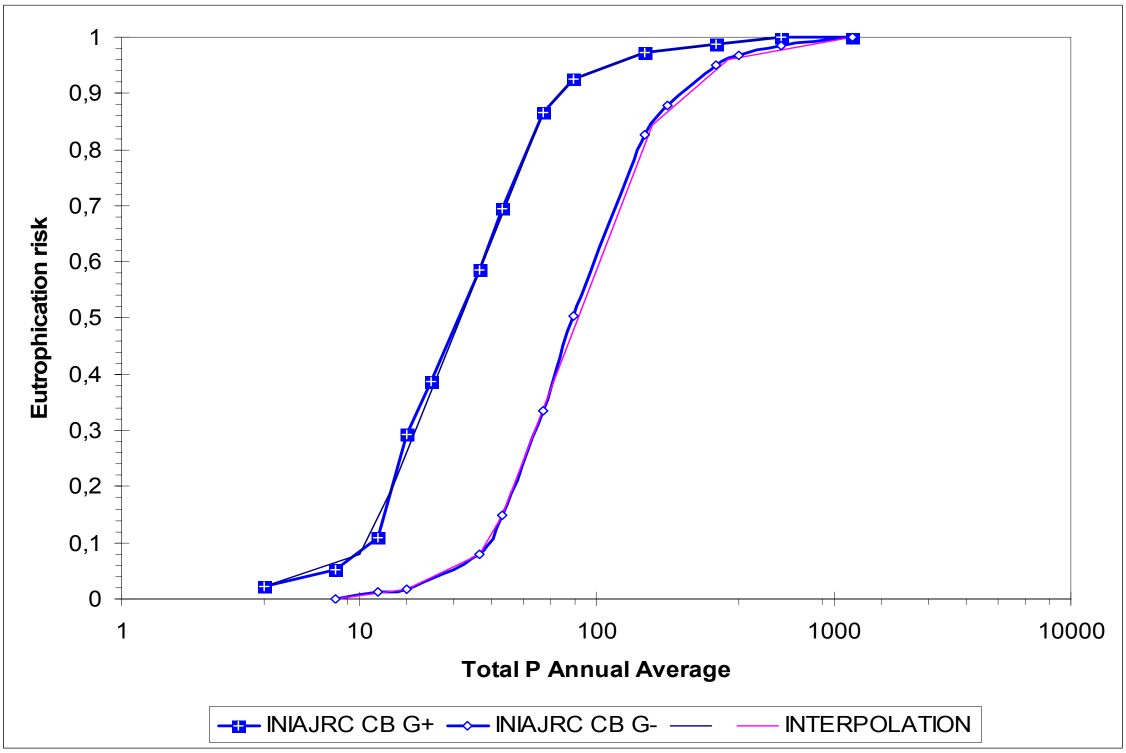


Figure 3.15. Interpolated risk curve proposed for the Central/Baltic ecoregion.

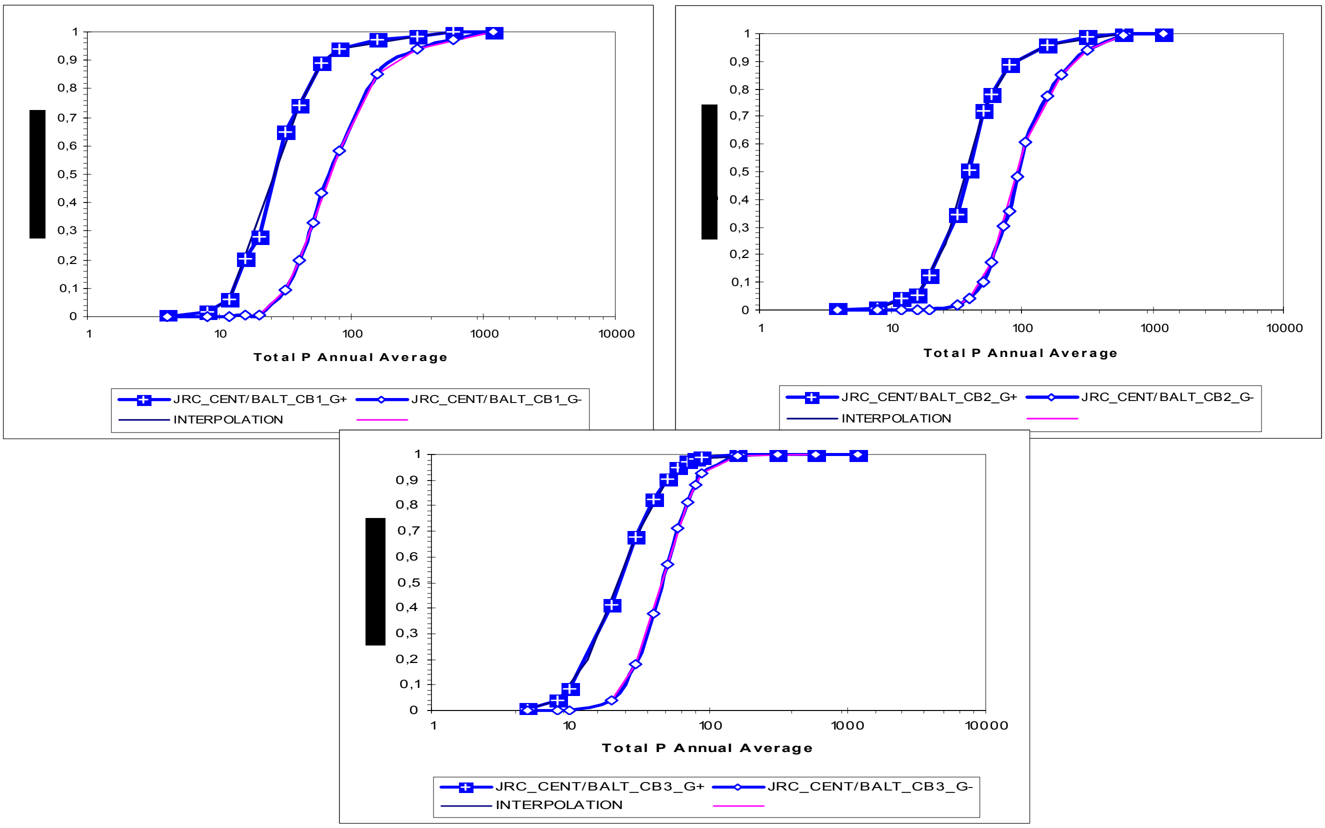


Figure 3.16. Interpolated risk curve proposed for the Central/Baltic ecotypes.

NORTHERN ECOREGION

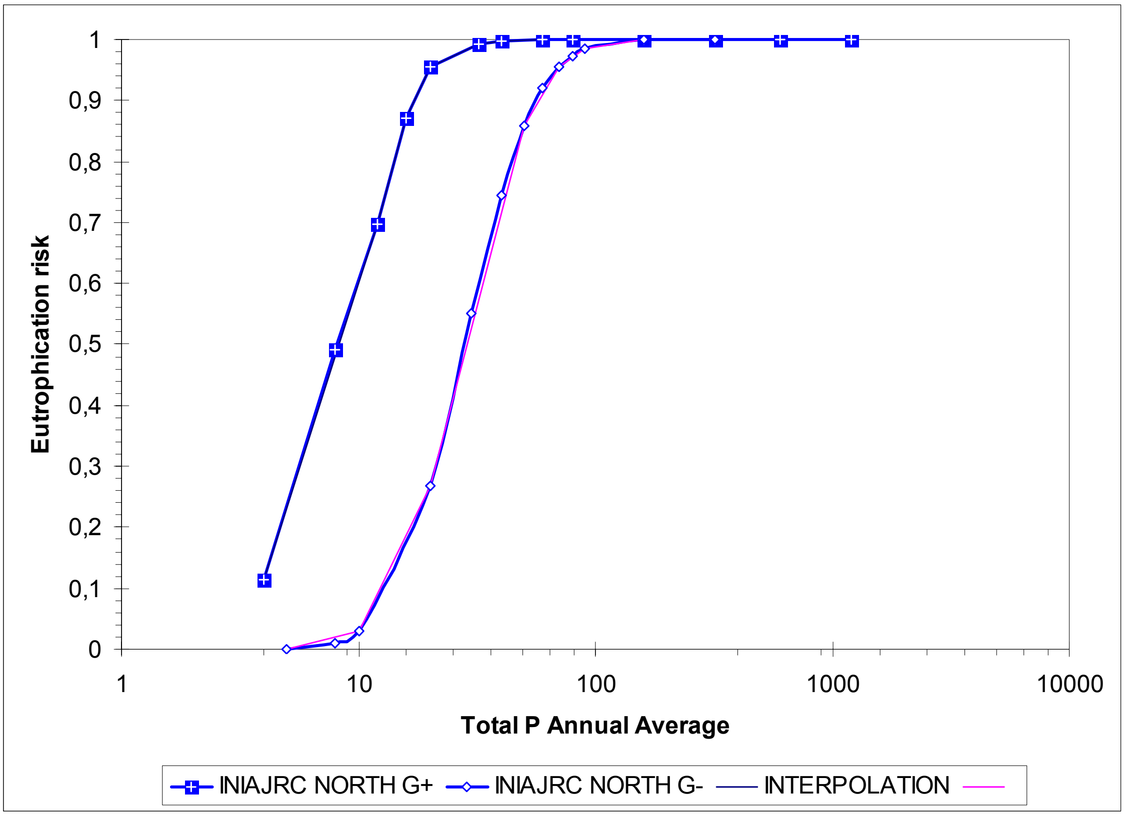


Figure 3.17. Interpolated risk curve proposed for the Northern ecoregion based on chlorophyll a.

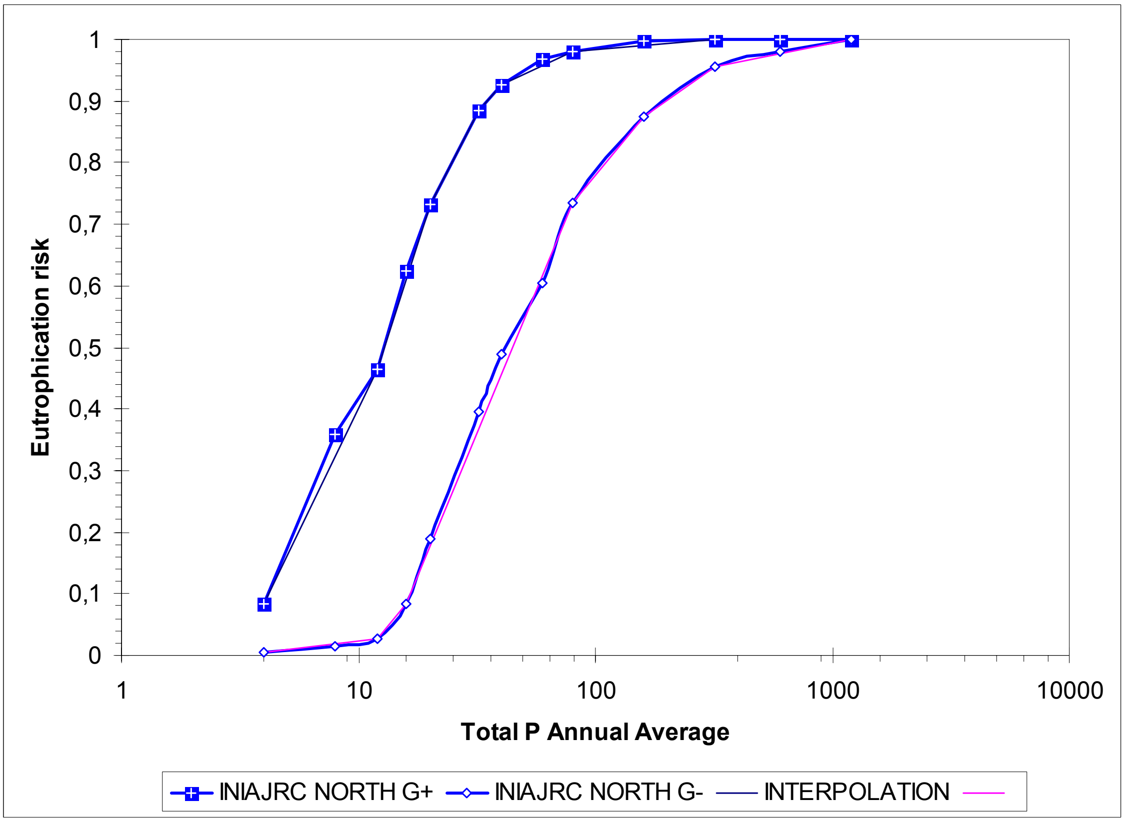


Figure 3.18. Interpolated risk curve proposed for the Northern ecoregion based on macrophytes.

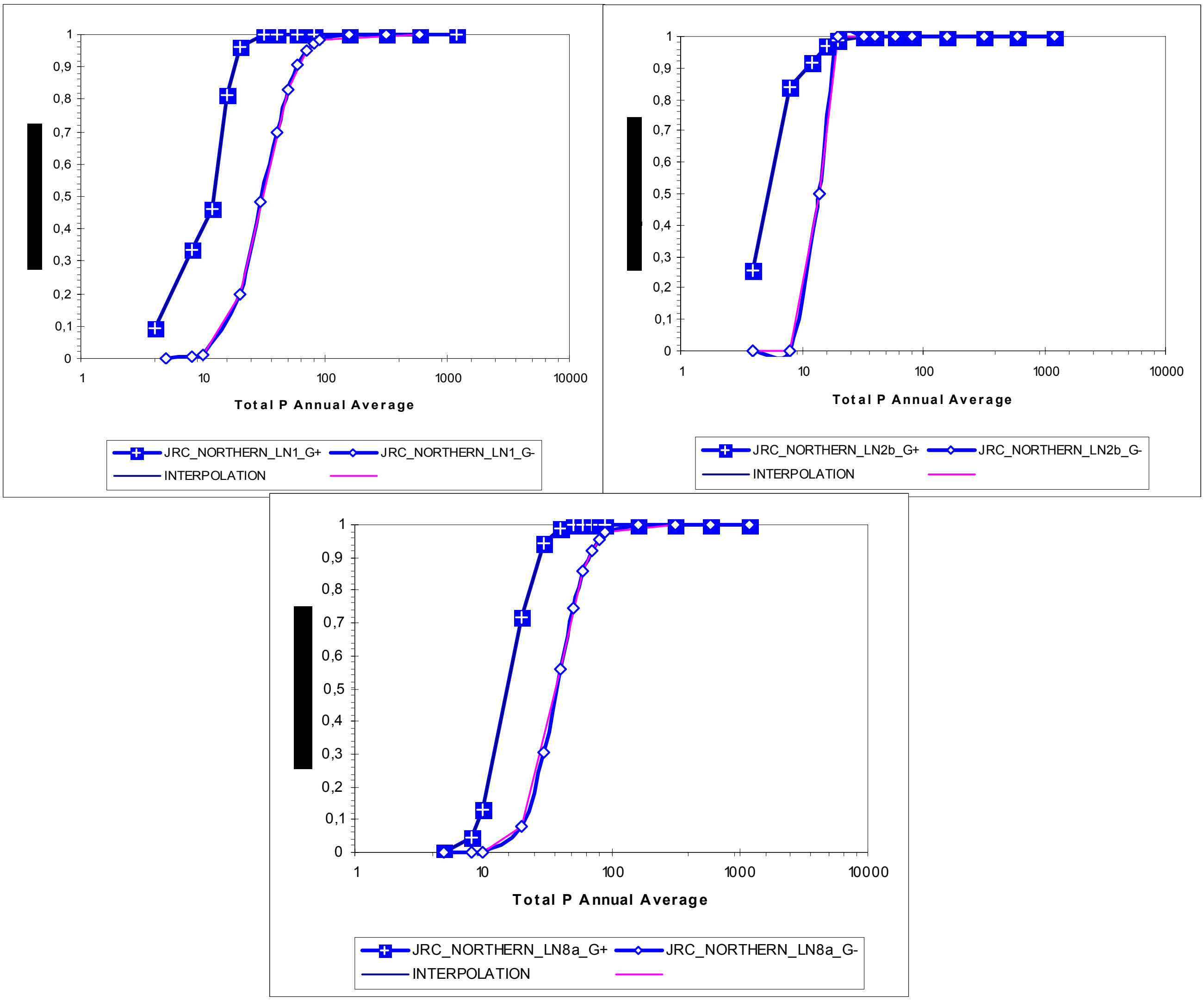


Figure 3.19. Interpolated risk curve proposed for the Northern ecotypes.

MEDITERRANEAN AND ATLANTIC ECOREGIONS

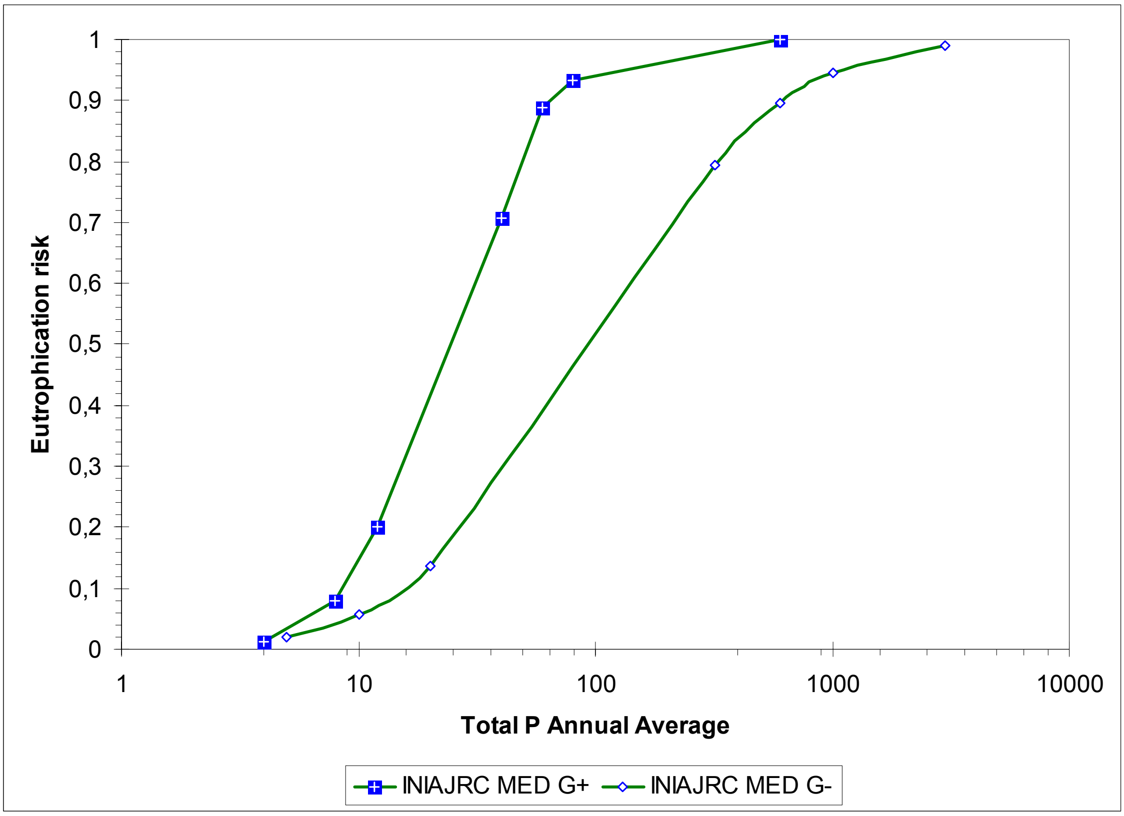


Figure 3.20. Interpolated risk curve proposed for the Mediterranean ecoregion.

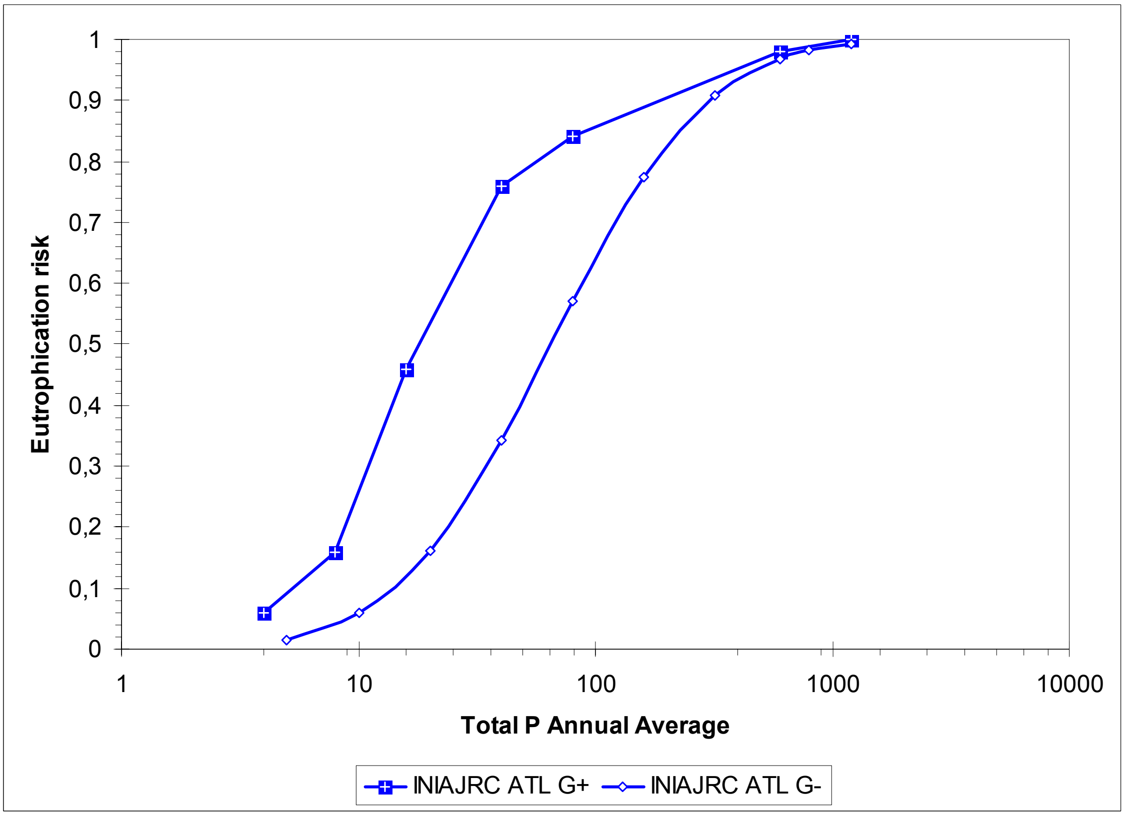


Figure 3.21. Interpolated risk curve proposed for the Atlantic ecoregion.

UPDATED RISK COMMUNICATION OPTIONS

The updated information on P-based detergent consumption provided by the industry includes information on laundry and dishwashing detergents. Therefore, the risk communication options have been adapted in order to present information for each type of detergents and for the combination of phosphorous emissions associated to both kinds of detergents. Following the recommendations from the experts attending the Madrid workshops, the contribution of all point sources is also presented for facilitating a comparative risk assessment of the main sources of point emissions: human metabolisms and use of P-based laundry and/or dishwashing detergents.

Due to the uncertainty in the estimation of the most-likely risk value, this estimation has not been included in the updated calculations, thus the eutrophication risk is presented as a range. The contribution of each phosphate source is presented through the comparison of the eutrophication risk estimated with and without that particular source. As the risk is presented as a range, the contribution is measured as the reduction in the upper and in the lower risk values, and the highest reduction is selected as a proper measure of the contribution of that source to the eutrophication risk.

For the deterministic examples, the risk is presented in a tabular form, which also includes the basic input values employed for that particular estimation, and a graphic comparing the different risk estimations. Figure 3.22 presents an example of this graphic representation. The risks are presented as percentages, with lines indicating the risk ranges associated to all sources, all sources except laundry detergents, all sources except dishwashing detergents, all sources except both detergents (i.e. human metabolisms and diffuse sources), and the resulting risk when all point sources are excluded (i.e ., risk of diffuse sources).

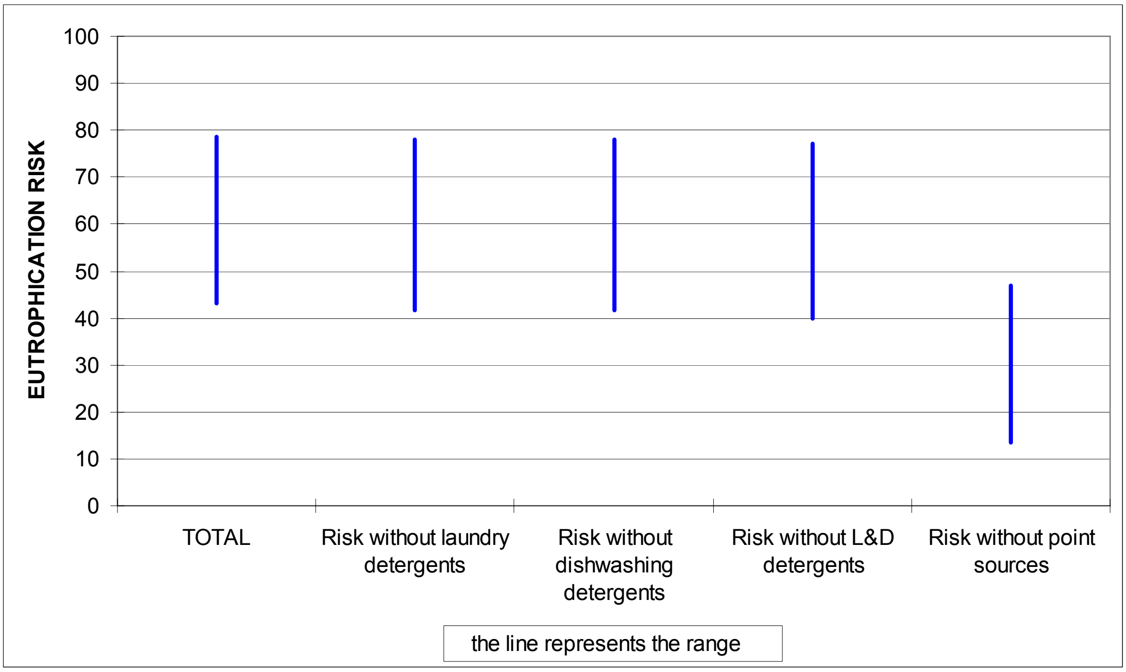


Figure 3.22. Example of the graphic representation for the deterministic scenarios.

The main improvements in terms of risk communication have been done for the probabilistic estimations. In this updated report, following the experts' suggestions expressed at the second Madrid workshop, the Pan-European coverage is obtained by individual estimations for each of the four main ecoregions:

- Northern
- Central/Baltic
- Atlantic
- Mediterranean

The contribution of P-based detergents (laundry and/or dishwashing) to the eutrophication risk is presented by risk exceedence curves, presenting the likelihood for having a risk contribution higher than that indicated in the figure. Three complementary methods have been selected for this representation: Estimated risk contribution for each source (Figure 3.23), comparative assessment of total versus reduced risks (Figure 3.24) and trends in the estimated risk reduction, presenting the certainty bands for the 10th, 25th, 50th and 90th percentiles (Figure 3.25).

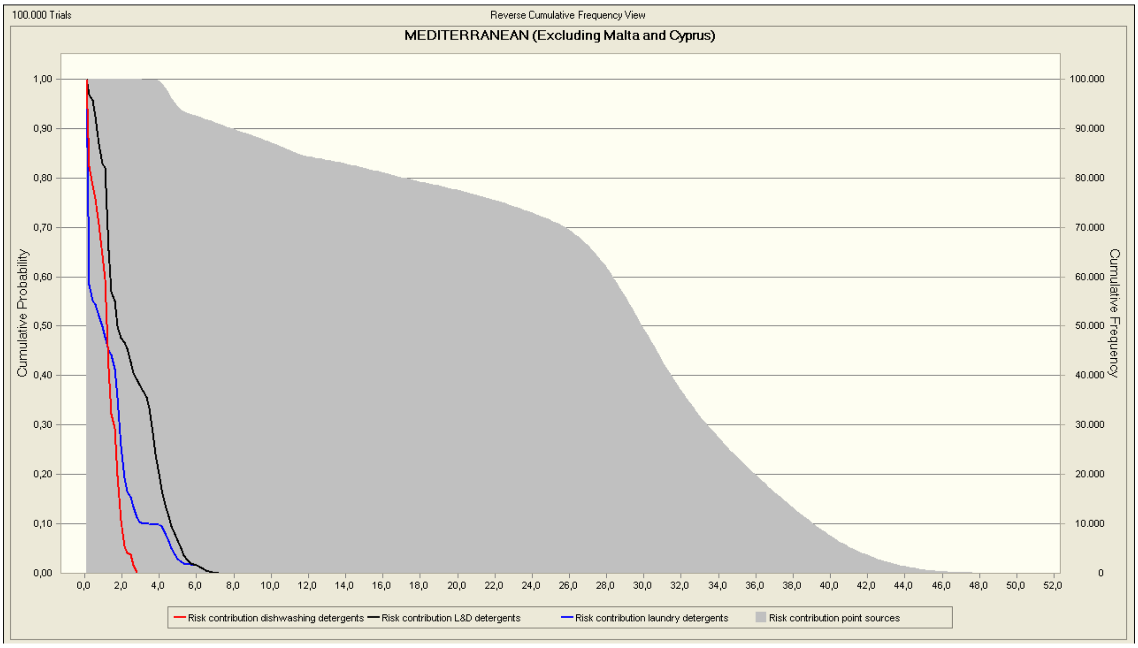


Figure 3.23. Exceedence curves for the estimated risk contribution for laundry (blue line), dishwashing (red line), laundry plus dishwashing detergents (blank line), and all point sources (grey area). The probability in the Y axis represents the likelihood for the contribution to be higher than the percentage represented in the X axis. For example, considering an X value equal to 4, the likelihood for the risk contribution to be higher than 4% is close to 0 for dishwashing detergents, around 0.1 (10%) for laundry detergents, around 0.2 (20%) for the sum of both detergents, and close to 1 (100%) for the combination of all point sources.

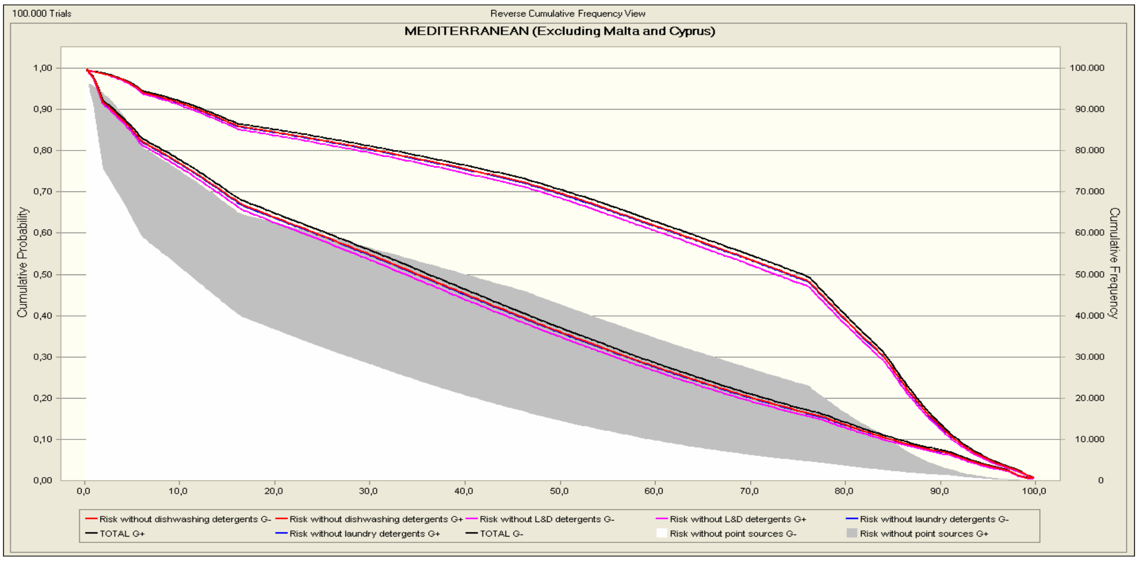


Figure 3.24. Comparative assessment of the eutrophication risk estimation, and the risk reduction obtained by excluding some sources. The risk is presented as a range, defined by the each set of lines with the same colour; the drift from the black lines represents the risk reduction obtained by extracting the contribution of laundry (blue lines), dishwashing (red lines) and both types (pink lines) of detergents respectively. The grey area defines the maximum reduction achievable by controlling point source emissions. The probabilities in the Y axis represent the likelihood for the risk to be higher than the percentage represented in the X axis. For example, considering an X value equal to 50, the likelihood for the total risk to be higher than 50% is between 0.37 and 0.71 (37-71%), and this likelihood will be reduced to around 0.36-0.7 by excluding the contribution of laundry or dishwashing detergents, to around 0.35-0.69 by excluding both types of detergents, and to 0.15-0.43 by excluding all point sources.

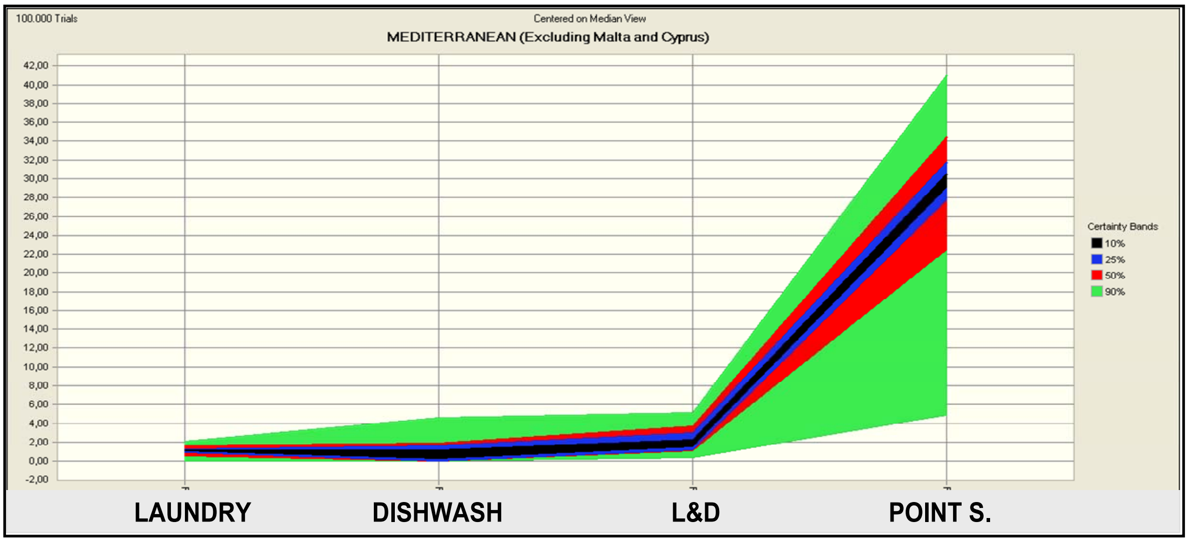


Figure 3.25. Trends in the reduction of the eutrophication risk. The figure represents the certainty bands for the 10th, 25th, 50th and 90th risk reduction percentiles obtained by extracting the contribution of dishwashing, laundry, both types of detergents, and the maximum reduction achievable by controlling point source emissions, respectively. Each band represents the certainty ranges into which the actual values of the forecasts fall. For example, the band which represents the 90% certainty range shows the range of values into which a forecast has a 90% chance of falling. The bands are centred on the median of each forecast.

SECTION 4: VALIDATION PROCESS.
PHASE 2.- UPDATED RISK RESULTS

The report issued in 2007 included a set of estimations for deterministic scenarios, using European averages and worst case values for the detergent consumption, and different combinations of the model complementary values (river flow/surface area, population density, land use patterns, etc.). Some specific river basins and country scenarios were also included.

The highest risk contribution was estimated for the scenario Poland2a, the detergent contribution ranged from 1.3 to 13%, as expected, minor changes are observed using the updated curves, using the previous figure for P-detergent consumption in Poland, 0.66 g/person and day, the recalculated risk contribution would range from 1.4 to 10.5 %. If the updated AISE data for the consumption of P-based detergents in Poland in 2007 is used, the updated risk contribution would be 1.2 - 8.6 % for laundry detergents and 1.3 - 9.3 % for the combination of laundry and dishwashing detergents.

Following the SCHER recommendations and the suggestions from the experts, a new set of deterministic scenarios has been included in this report using realistic TP concentrations. For facilitating the comparisons, the scenarios are based on a similar set of default environmental values, using European averages. For each ecoregion, the population weighted average consumption of P-based detergents is used. Comparisons are presented for three TP concentrations, 50, 100 and 150 µgP/L for the Northern ecoregion, and 50, 150 and 300 µgP/L for the other ecoregions.

For the probabilistic implementation, independent estimations have been conducted for each ecoregion. European average population densities were selected for the Central/Baltic, Atlantic and Mediterranean ecoregions, while a reduced value was employed for the Northern ecoregion. The land use patterns for each country were obtained from EUROSTAT, ranges covering the highest and lowest values for the countries covered by the ecoregion were employed for the estimations.

The results of the deterministic and probabilistic approaches are summarised in the following sections. Other scenarios can be easily included if the Detergents Working Group considers that additional calculations would facilitate the discussion.

MODEL IMPLEMENTATION AND RISK CHARACTERIZATION: RE-CALCULATION OF THE RESULTS OBTAINED FOR THE SET OF GENERIC EUROPEAN SCENARIOS

Twelve deterministic scenarios covering the four ecoregions have been selected. The effect assessment for the Northern ecoregion was based on the chlorophyll a boundaries.

For consistency, the P-based detergent consumption estimated for Cyprus according to the AISE data has not been included in the population weighted average estimations for the Mediterranean ecoregion, as the value is considered an outlier; nevertheless, a sensitivity assessment has been conducted, and the inclusion of the value for Cyprus would not modify the conclusions (the detergents contribution to the eutrophication risk does not increase by more than 0.1 percent units when the Cyprus value in included).

Table 4.1 summarises the selected scenarios, which represent the contribution expected using averaged values at three pre-selected TP concentrations.

Table 4.1 Summary characteristics of the deterministic scenarios selected for this comparison

Example	Use P-based laundry det.	Use P-based dishwashing det.	Ecoregion	TP total conc.
No.	**gP/person/day**	**gP/person/day**		**µgP/L**
1	0.158	0.173	Atlantic	50
2	0.158	0.173	Atlantic	150
3	0.158	0.173	Atlantic	300
4	0.172	0.183	Central/Baltic	50
5	0.172	0.183	Central/Baltic	150
6	0.172	0.183	Central/Baltic	300
7	0.131	0.181	Northern	50
8	0.131	0.181	Northern	100
9	0.131	0.181	Northern	150
10	0.125	0.100	Mediterranean	50
11	0.125	0.100	Mediterranean	150
12	0.125	0.100	Mediterranean	300

EXAMPLE 1: Generic assessment based on:

- **Average European values**
- **Atlantic ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: low level**

INPUTS

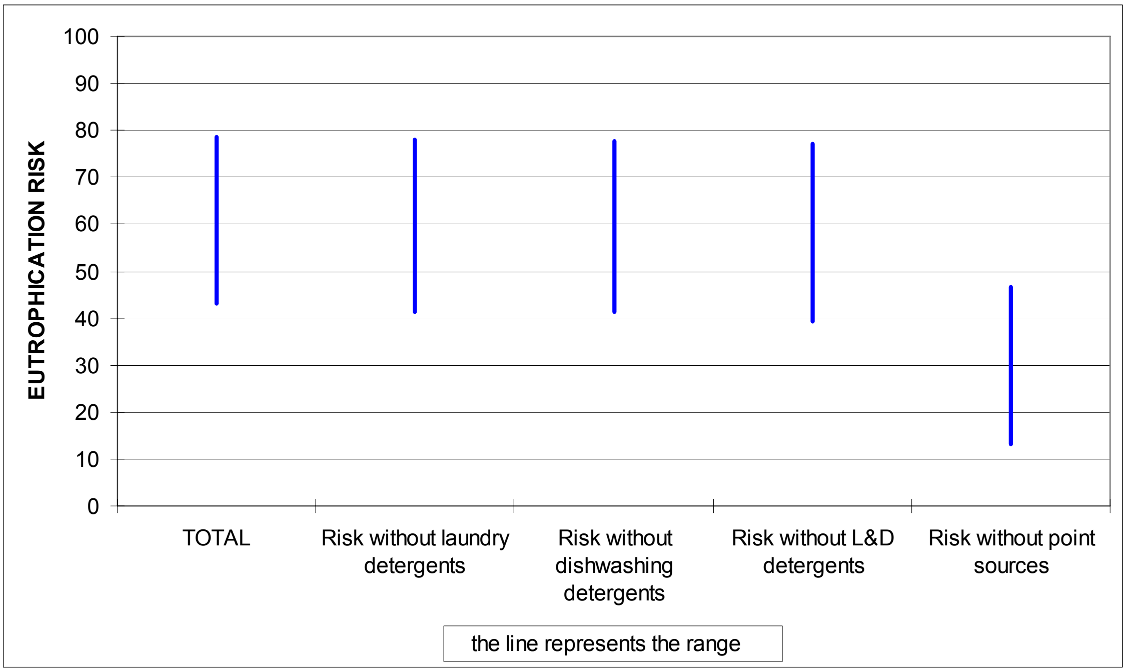
Case ID	Scenario name	Generic	
	Effect assessment distribution	ATLANTIC	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,158	g/person/day
	P emission from Dishwashing Detergents	0,173	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	50,0	µg P/l	100,0	%
From laundry detergents	2,9	µg P/l	5,8	%
From dishwashing detergents	3,2	µg P/l	6,4	%
From L&D detergents	6,1	µg P/l	12,2	%
From human metabolims	27,6	µg P/l	55,2	%
From diffuse sources	16,3	µg P/l	32,6	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	**p(TP|G-)**	
TOTAL	78,6	43,2	%
Risk without laundry detergents	77,9	41,5	%
Risk without dishwashing detergents	77,8	41,3	%
Risk without L&D detergents	77,1	39,4	%
Risk without point sources	46,7	13,2	%



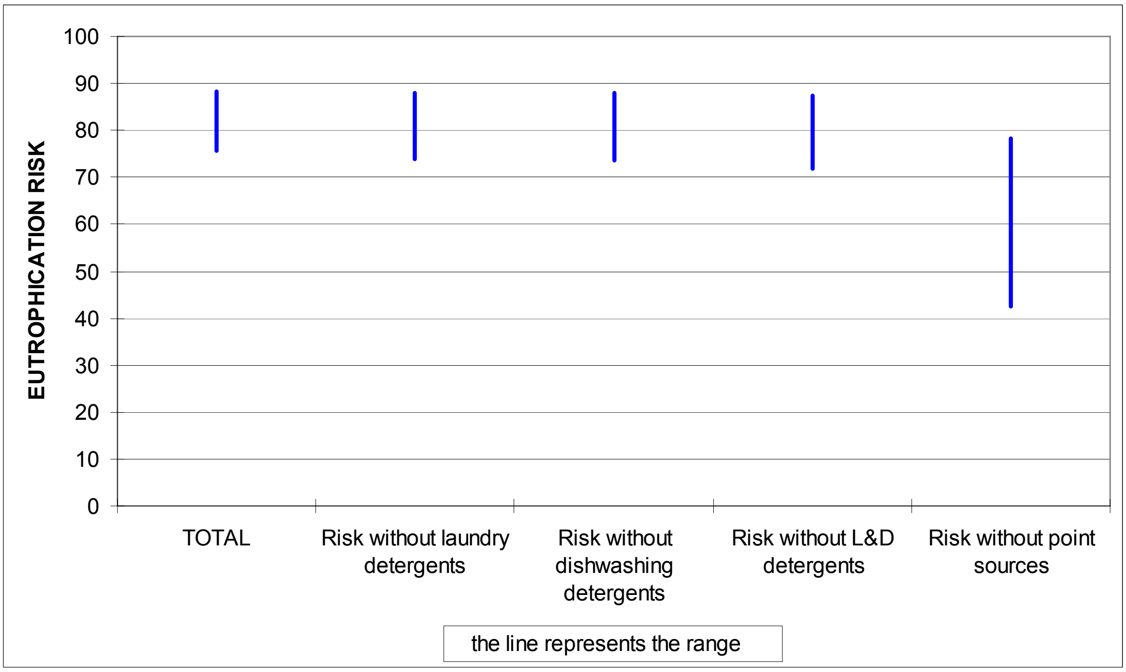
EXAMPLE 2: Generic assessment based on:

- **Average European values**
- **Atlantic ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: moderate level**

INPUTS			
Case ID	Scenario name	Generic	
	Effect assessment distribution	ATLANTIC	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,158	g/person/day
	P emission from Dishwashing Detergents	0,173	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS				
Total P concentration	150,0	µg P/l	100,0	%
From laundry detergents	8,7	µg P/l	5,8	%
From dishwashing detergents	9,5	µg P/l	6,4	%
From L&D detergents	18,3	µg P/l	12,2	%
From human metabolims	82,8	µg P/l	55,2	%
From diffuse sources	49,0	µg P/l	32,6	%

EUTROPHICATION RISK ESTIMATIONS	**p(TP|G+)**	**p(TP|G-)**	
TOTAL	88,4	75,6	%
Risk without laundry detergents	88,0	73,9	%
Risk without dishwashing detergents	87,9	73,7	%
Risk without L&D detergents	87,5	71,8	%
Risk without point sources	78,3	42,6	%



EXAMPLE 3: Generic assessment based on:

- **Average European values**
- **Atlantic ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: high level**

INPUTS

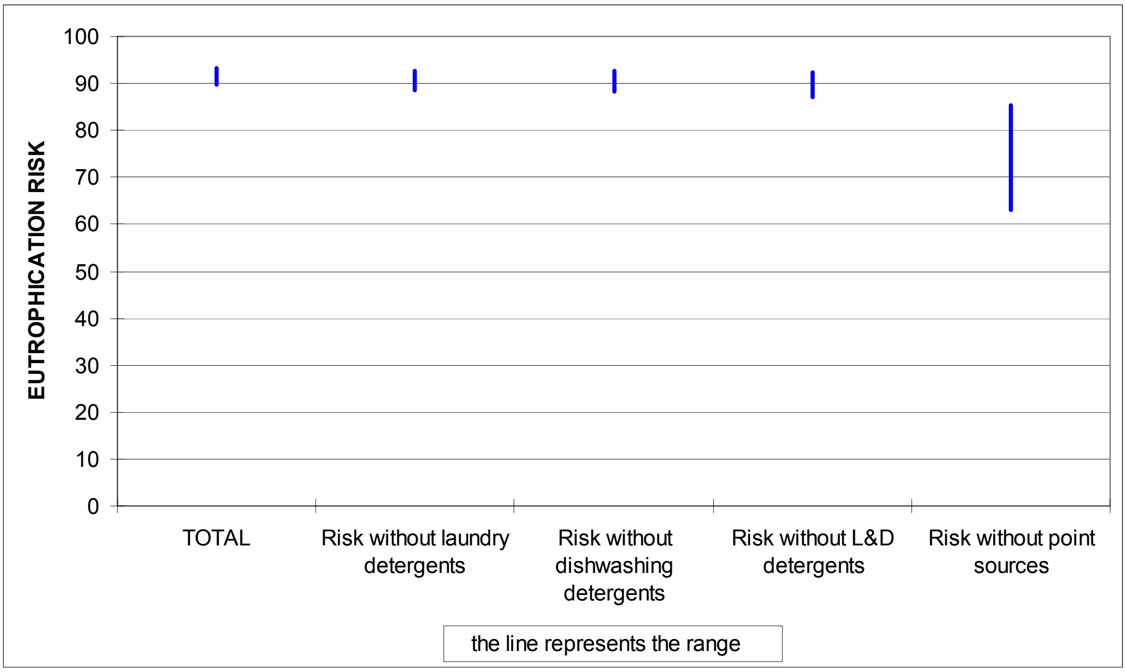
Case ID	Scenario name	Generic	
	Effect assessment distribution	ATLANTIC	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,158	g/person/day
	P emission from Dishwashing Detergents	0,173	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	300,0	µg P/l	100,0	%
From laundry detergents	17,4	µg P/l	5,8	%
From dishwashing detergents	19,1	µg P/l	6,4	%
From L&D detergents	36,5	µg P/l	12,2	%
From human metabolims	165,5	µg P/l	55,2	%
From diffuse sources	97,9	µg P/l	32,6	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	**p(TP|G-)**	
TOTAL	93,2	89,7	%
Risk without laundry detergents	92,8	88,5	%
Risk without dishwashing detergents	92,7	88,4	%
Risk without L&D detergents	92,3	87,2	%
Risk without point sources	85,4	63,1	%



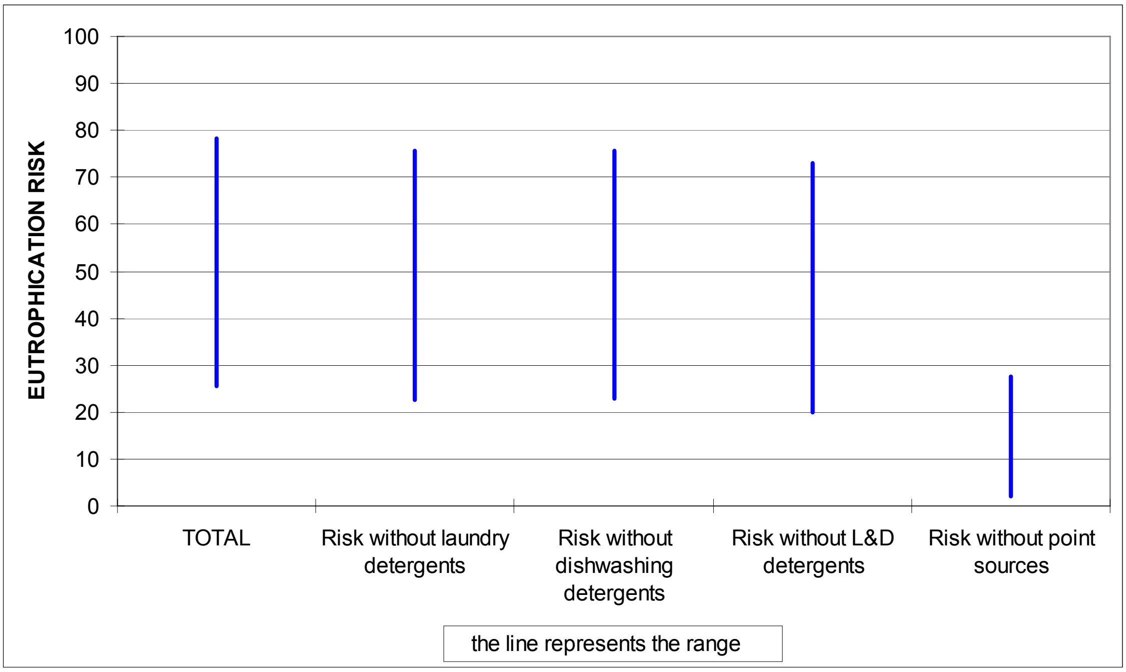
EXAMPLE 4: Generic assessment based on:

- **Average European values**
- **Central/Baltic ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: low level**

INPUTS			
Case ID	Scenario name	Generic	
	Effect assessment distribution	CENTRAL BALTIC	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,172	g/person/day
	P emission from Dishwashing Detergents	0,183	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS				
Total P concentration	50,0	µg P/l	100,0	%
From laundry detergents	3,1	µg P/l	6,3	%
From dishwashing detergents	3,3	µg P/l	6,7	%
From L&D detergents	6,5	µg P/l	12,9	%
From human metabolims	27,3	µg P/l	54,7	%
From diffuse sources	16,2	µg P/l	32,4	%

EUTROPHICATION RISK ESTIMATIONS	**p(TP|G+)**	**p(TP|G-)**	
TOTAL	78,3	25,4	%
Risk without laundry detergents	75,4	22,4	%
Risk without dishwashing detergents	75,2	22,2	%
Risk without L&D detergents	72,0	18,9	%
Risk without point sources	26,6	1,9	%



EXAMPLE 5: Generic assessment based on:

- **Average European values**
- **Central/Baltic ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: moderate level**

INPUTS

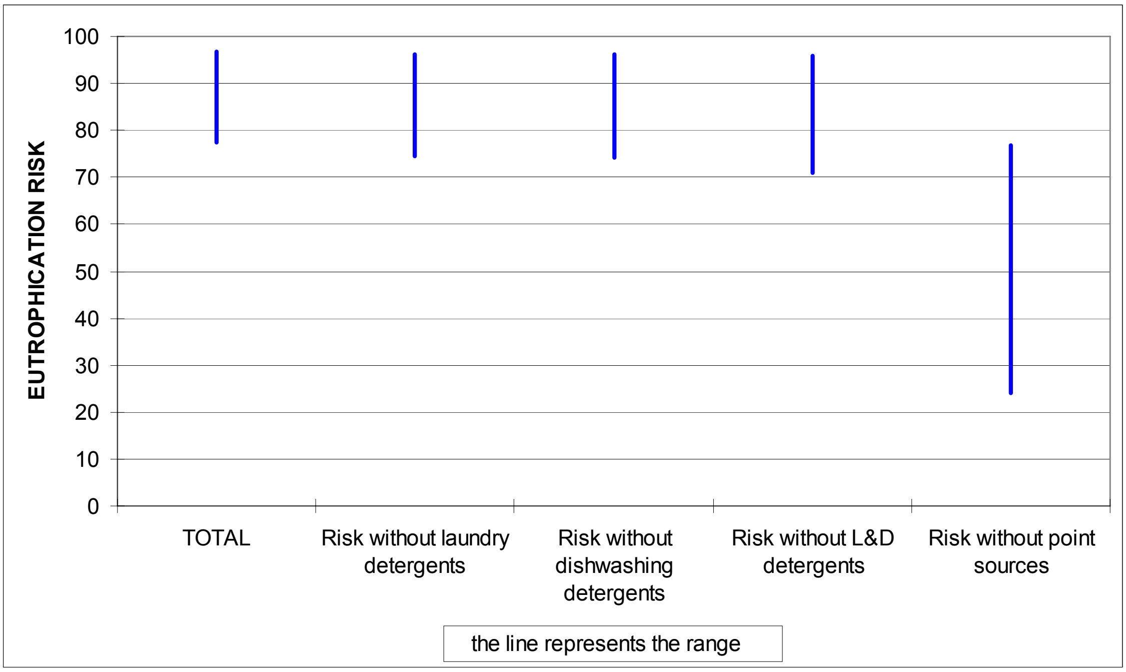
Case ID	Scenario name	Generic	
	Effect assessment distribution	CENTRAL BALTIC	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,172	g/person/day
	P emission from Dishwashing Detergents	0,183	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	150,0	µg P/l	100,0	%
From laundry detergents	9,4	µg P/l	6,3	%
From dishwashing detergents	10,0	µg P/l	6,7	%
From L&D detergents	19,4	µg P/l	12,9	%
From human metabolims	82,0	µg P/l	54,7	%
From diffuse sources	48,5	µg P/l	32,4	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	**p(TP|G-)**	
TOTAL	96,8	77,5	%
Risk without laundry detergents	96,3	74,5	%
Risk without dishwashing detergents	96,3	74,3	%
Risk without L&D detergents	95,9	71,0	%
Risk without point sources	77,0	24,0	%



EXAMPLE 6: Generic assessment based on:

- **Average European values**
- **Central/Baltic ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: high level**

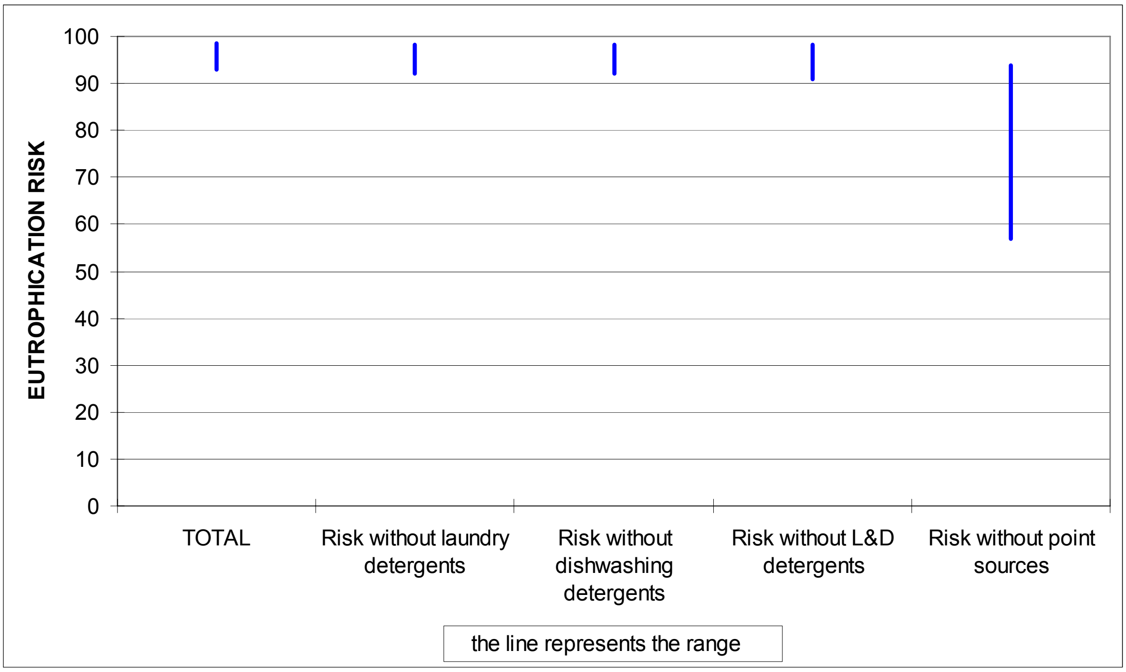
INPUTS			
Case ID	Scenario name	Generic	
	Effect assessment distribution	CENTRAL BALTIC	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,172	g/person/day
	P emission from Dishwashing Detergents	0,183	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	300,0	µg P/l	100,0	%
From laundry detergents	18,8	µg P/l	6,3	%
From dishwashing detergents	20,0	µg P/l	6,7	%
From L&D detergents	38,8	µg P/l	12,9	%
From human metabolims	164,1	µg P/l	54,7	%
From diffuse sources	97,1	µg P/l	32,4	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	p(TP|G-)	
TOTAL	98,5	93,0	%
Risk without laundry detergents	98,4	92,0	%
Risk without dishwashing detergents	98,4	92,0	%
Risk without L&D detergents	98,2	90,9	%
Risk without point sources	93,9	56,9	%



EXAMPLE 7: Generic assessment based on:

- Average European values
- Northern ecoregion
- Ecoregion population weighted average consumption of P-based detergents
- TP total concentration: low level

INPUTS

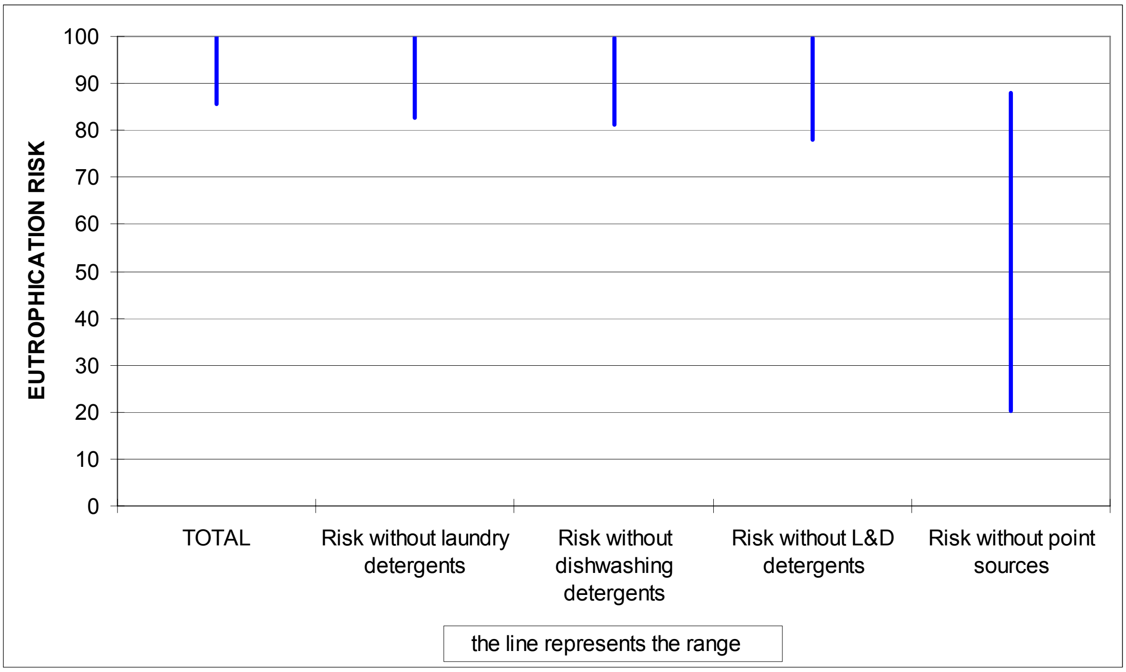
Case ID	Scenario name	Generic	
	Effect assessment distribution	NORTHERN	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,131	g/person/day
	P emission from Dishwashing Detergents	0,181	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	50,0	µg P/l	100,0	%
From laundry detergents	2,4	µg P/l	4,9	%
From dishwashing detergents	3,4	µg P/l	6,7	%
From L&D detergents	5,8	µg P/l	11,6	%
From human metabolims	27,8	µg P/l	55,6	%
From diffuse sources	16,4	µg P/l	32,9	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	**p(TP|G-)**	
TOTAL	99,9	85,8	%
Risk without laundry detergents	99,9	82,6	%
Risk without dishwashing detergents	99,8	81,3	%
Risk without L&D detergents	99,8	77,9	%
Risk without point sources	88,1	20,1	%



EXAMPLE 8: Generic assessment based on:

- **Average European values**
- **Northern ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: moderate level**

INPUTS

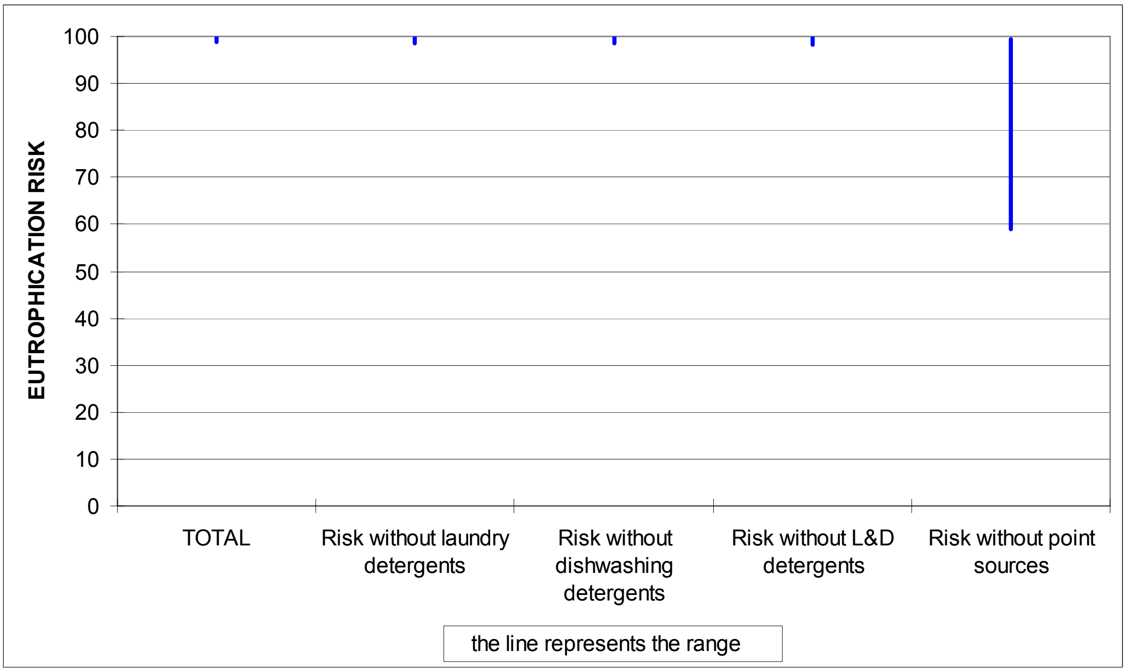
Case ID	Scenario name	Generic	
	Effect assessment distribution	NORTHERN	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,131	g/person/day
	P emission from Dishwashing Detergents	0,181	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	100,0	µg P/l	100,0	%
From laundry detergents	4,9	µg P/l	4,9	%
From dishwashing detergents	6,7	µg P/l	6,7	%
From L&D detergents	11,6	µg P/l	11,6	%
From human metabolims	55,6	µg P/l	55,6	%
From diffuse sources	32,9	µg P/l	32,9	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	**p(TP|G-)**	
TOTAL	100,0	98,7	%
Risk without laundry detergents	100,0	98,6	%
Risk without dishwashing detergents	100,0	98,5	%
Risk without L&D detergents	100,0	98,2	%
Risk without point sources	99,3	58,8	%



EXAMPLE 9: Generic assessment based on:

- **Average European values**
- **Northern ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: high level**

INPUTS

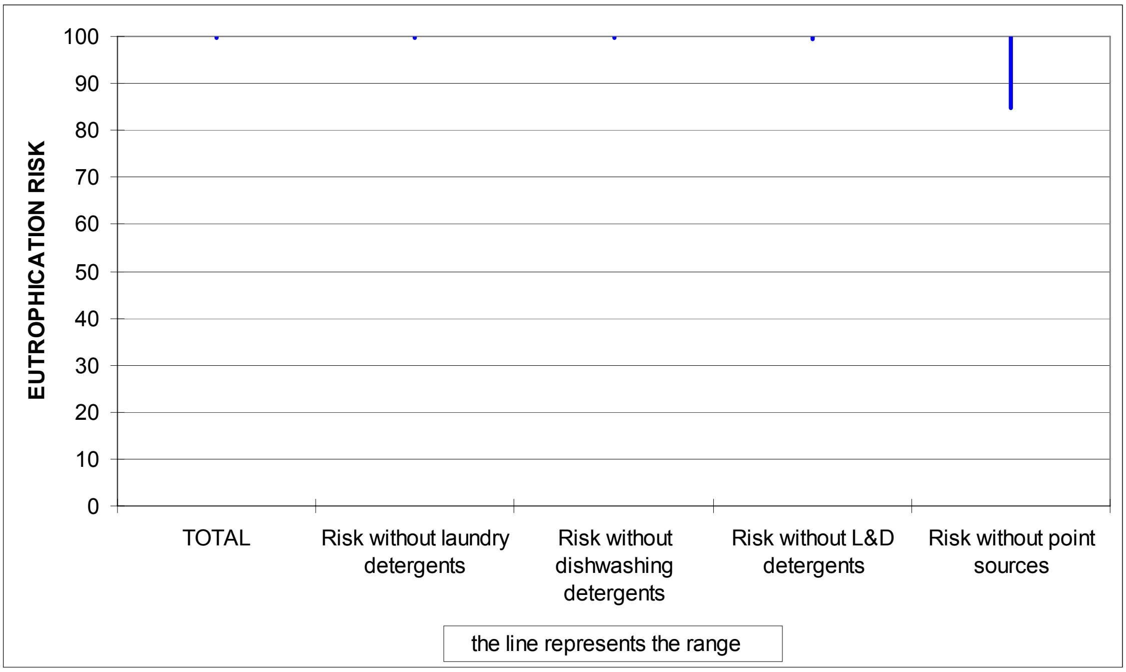
			Units
Case ID	Scenario name	Generic	
	Effect assessment distribution	NORTHERN	
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,131	g/person/day
	P emission from Dishwashing Detergents	0,181	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	150,0	µg P/l	100,0	%
From laundry detergents	7,3	µg P/l	4,9	%
From dishwashing detergents	10,1	µg P/l	6,7	%
From L&D detergents	17,3	µg P/l	11,6	%
From human metabolims	83,3	µg P/l	55,6	%
From diffuse sources	49,3	µg P/l	32,9	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	**p(TP|G-)**	
TOTAL	100,0	99,8	%
Risk without laundry detergents	100,0	99,6	%
Risk without dishwashing detergents	100,0	99,6	%
Risk without L&D detergents	100,0	99,4	%
Risk without point sources	99,9	84,9	%



EXAMPLE 10 Generic assessment based on:

- **Average European values**
- **Mediterranean ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: low level**

INPUTS

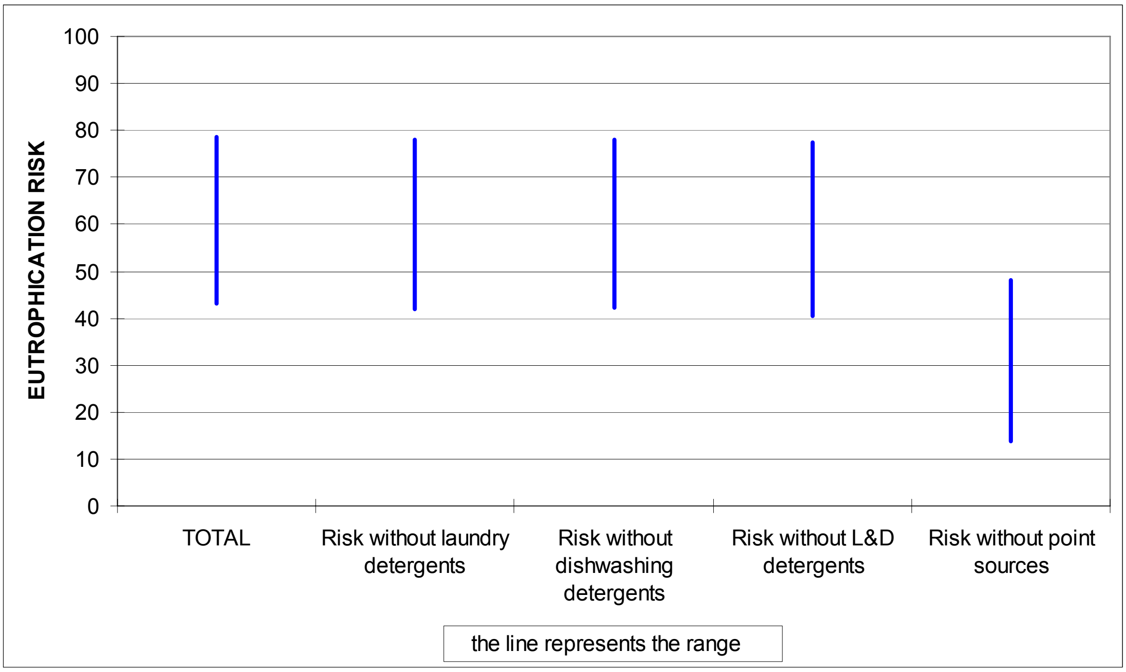
Case ID	Scenario name	Generic		
	Effect assessment distribution	MEDITERRANEAN		
				Units
Physical Characteristics	PopulationDensity		1,17	person/ha
	CatchmentArea		10000000	ha
	RiverFlow		640	m3/s
	LanduseArableLand		26	%
	LandusePasture		26	%
	LanduseForest		38	%
	LanduseOther		10	%
Export coefficients	ArableLand coefficient		0,66	kg/ha/year
	Pasture coefficient		0,4	kg/ha/year
	Forest coefficient		0,02	kg/ha/year
	Other uses coefficient		0,2	kg/ha/year
	P emission from Population		1,5	g/person/day
	P emission from Laundry Detergents		0,125	g/person/day
	P emission from Dishwashing Detergents		0,1	g/person/day
	Current P reduction at STP		20	%
	Sedimentation correction		YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	50,0	µg P/l	100,0	%
From laundry detergents	2,4	µg P/l	4,8	%
From dishwashing detergents	1,9	µg P/l	3,8	%
From L&D detergents	4,3	µg P/l	8,6	%
From human metabolims	28,7	µg P/l	57,4	%
From diffuse sources	17,0	µg P/l	34,0	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	**p(TP|G-)**	
TOTAL	78,6	43,2	%
Risk without laundry detergents	78,0	41,8	%
Risk without dishwashing detergents	78,1	42,1	%
Risk without L&D detergents	77,5	40,6	%
Risk without point sources	48,0	13,8	%



EXAMPLE 11: Generic assessment based on:

- **Average European values**
- **Mediterranean ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: moderate level**

INPUTS

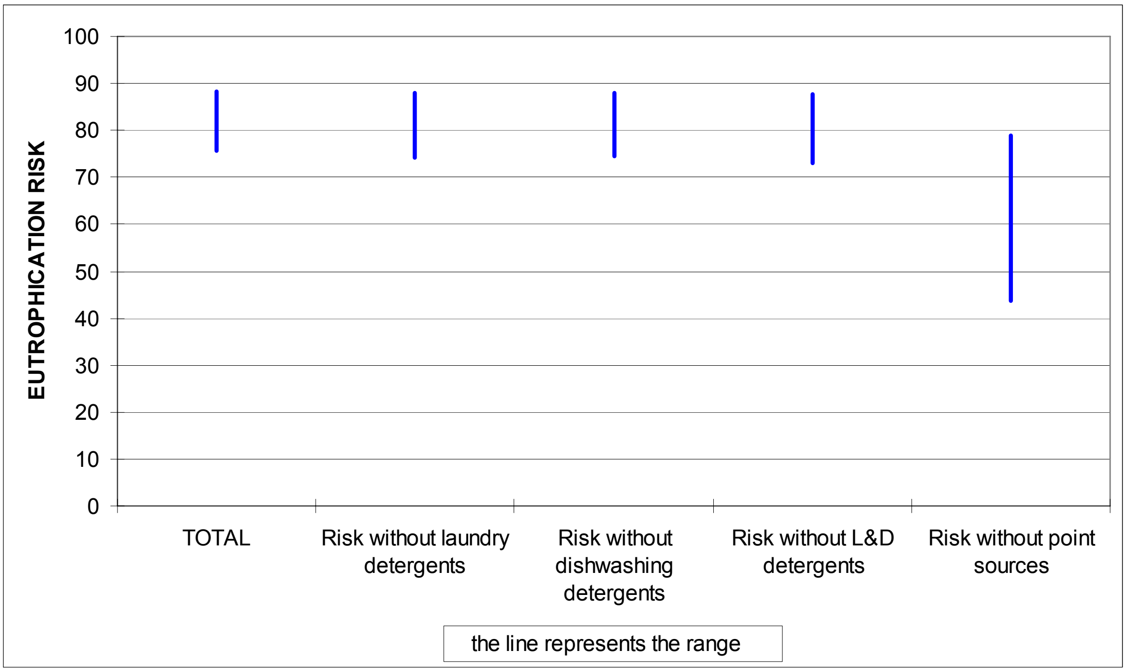
Case ID	Scenario name	Generic	
	Effect assessment distribution	MEDITERRANEAN	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,125	g/person/day
	P emission from Dishwashing Detergents	0,1	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	150,0	µg P/l	100,0	%
From laundry detergents	7,2	µg P/l	4,8	%
From dishwashing detergents	5,7	µg P/l	3,8	%
From L&D detergents	12,9	µg P/l	8,6	%
From human metabolims	86,1	µg P/l	57,4	%
From diffuse sources	51,0	µg P/l	34,0	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	**p(TP|G-)**	
TOTAL	88,4	75,6	%
Risk without laundry detergents	88,0	74,2	%
Risk without dishwashing detergents	88,1	74,5	%
Risk without L&D detergents	87,7	73,0	%
Risk without point sources	78,8	43,8	%



EXAMPLE 12: Generic assessment based on:

- **Average European values**
- **Mediterranean ecoregion**
- **Ecoregion population weighted average consumption of P-based detergents**
- **TP total concentration: high level**

INPUTS

Case ID	Scenario name	Generic	
	Effect assessment distribution	MEDITERRANEAN	
			Units
Physical Characteristics	PopulationDensity	1,17	person/ha
	CatchmentArea	10000000	ha
	RiverFlow	640	m3/s
	LanduseArableLand	26	%
	LandusePasture	26	%
	LanduseForest	38	%
	LanduseOther	10	%
Export coefficients	ArableLand coefficient	0,66	kg/ha/year
	Pasture coefficient	0,4	kg/ha/year
	Forest coefficient	0,02	kg/ha/year
	Other uses coefficient	0,2	kg/ha/year
	P emission from Population	1,5	g/person/day
	P emission from Laundry Detergents	0,125	g/person/day
	P emission from Dishwashing Detergents	0,1	g/person/day
	Current P reduction at STP	20	%
	Sedimentation correction	YES	

PREDICTED EXPOSURE LEVELS

Total P concentration	300,0	µg P/l	100,0	%
From laundry detergents	14,4	µg P/l	4,8	%
From dishwashing detergents	11,5	µg P/l	3,8	%
From L&D detergents	25,8	µg P/l	8,6	%
From human metabolims	172,2	µg P/l	57,4	%
From diffuse sources	101,9	µg P/l	34,0	%

EUTROPHICATION RISK ESTIMATIONS

	p(TP|G+)	**p(TP|G-)**	
TOTAL	93,2	89,7	%
Risk without laundry detergents	92,8	88,7	%
Risk without dishwashing detergents	92,9	88,9	%
Risk without L&D detergents	92,6	87,9	%
Risk without point sources	85,7	64,2	%

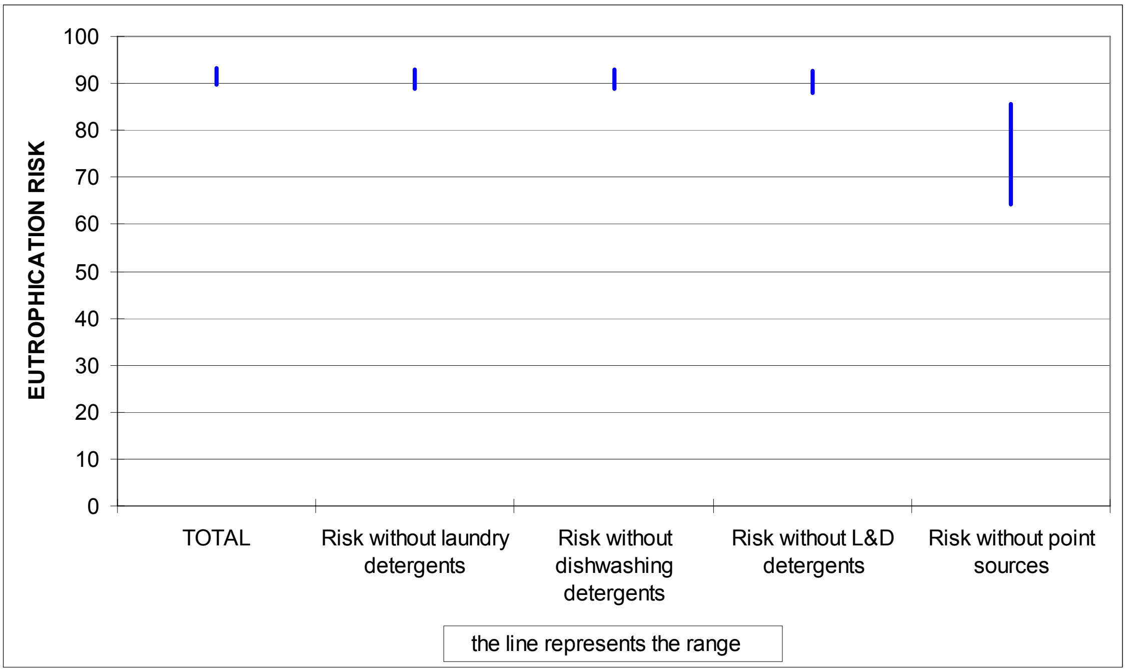


Table 4.2 summarises the results obtained for the selected deterministic scenarios which represents average European conditions.

Table 4.2. Contribution of P-based detergents to the eutrophication risk obtained for the selected deterministic scenarios.

Example	Ecoregion	Detergent contribution		TP conc.	Risk contribution from detergents		
		Laundry	Dishwash		Laundry	Dishwash	Both
		%	%	µg/l	%	%	%
1	Atlantic	5.8	6.4	50	0.7-1.8	0.8-1.9	1.5-3.8
2	Atlantic	5.8	6.4	150	0.4-1.8	0.5-1.9	0.9-3.8
3	Atlantic	5.8	6.4	300	0.4-1.2	0.5-1.3	0.9-2.5
4	Central/Baltic	6.3	6.7	50	3.0-3.1	3.2-3.3	6.4-6.6
5	Central/Baltic	6.3	6.7	150	0.4-3.1	0.4-3.3	0.9-6.6
6	Central/Baltic	6.3	6.7	300	0.1-1.0	0.1-1.1	0.3-2.2
7	Northern	4.9	6.7	50	0.0-3.2	0.0-4.5	0.1-7.9
8	Northern	4.9	6.7	100	0.0-0.1	0.0-0.2	0.0-0.5
9	Northern	4.9	6.7	150	0.0-0.1	0.0-0.2	0.0-0.3
10	Mediterranean	4.8	3.8	50	0.6-1.6	0.4-1.1	1.1-2.8
11	Mediterranean	4.8	3.8	150	0.4-1.6	0.3-1.1	0.7-2.8
12	Mediterranean	4.8	3.8	300	0.4-1.0	0.3-0.8	0.7-1.8

PROBABILISTIC MODEL IMPLEMENTATION: RE-CALCULATION OF THE Pan-EUROPEAN EUTROPHICATION RISK OF PHOSPHATES IN DETERGENTS

Monte Carlo Analyses have been conducted for a quantitative assessment of the contribution of P-based laundry and/or dishwashing detergents in the four main European ecoregions. Table 4.3 summarised the information selected for these calculations.

Table 4.3. Summary conditions employed for the Monte Carlo probabilistic assessments.

PARAMETER	CENTRAL/BALTIC	MEDITERRANEAN	ATLANTIC	NORTHERN
Countries	Belgium Bulgaria Czech Republic Denmark Germany Estonia France Latvia Lithuania Luxembourg Hungary Netherlands Austria Poland Slovakia Slovenia	Greece Spain Italy Portugal Romania	Ireland United Kingdom	Finland Sweden Ireland United Kingdom
P-based consumption	Country values weighted according to population			
TP concentration	JRC IC data	JRC IC + INIA data	JRC IC data	JRC IC data Chlorophyll a & Macrophytes
TP distribution	Lognormal (best fit)	Lognormal (best fit)	Lognormal (best fit)	Lognormal (best fit)
Population density	EU average	EU average	EU average	1/3 EU average
% arable land	20-53	17-54	10-67	4-8
% pasture land	20-53	15-42	10-67	4-8
% forest	10-58	29-52	9-10	74-75
% others	4-32	2-23	23-28	17.5-18.5
Effect distributions	Chlorophyll a	Chlorophyll a	Chlorophyll a	Chlorophyll a & Macrophytes
Additional assessment for Ecotypes	CB1 CB2 CB3			LN1 LN2b LN8a

CENTRAL BALTIC ECOREGION

The contribution to the eutrophication risk (Figure 4.1; Table 4.4) is estimated as the reduction in the expected risk when the TP concentration is reduced in the same proportion than the estimated contribution of P-based detergents. The grey area is the contribution of all point sources, and therefore represents the maximum achievable reduction in the eutrophication risk that could be theoretically achieved by managing point source emissions.

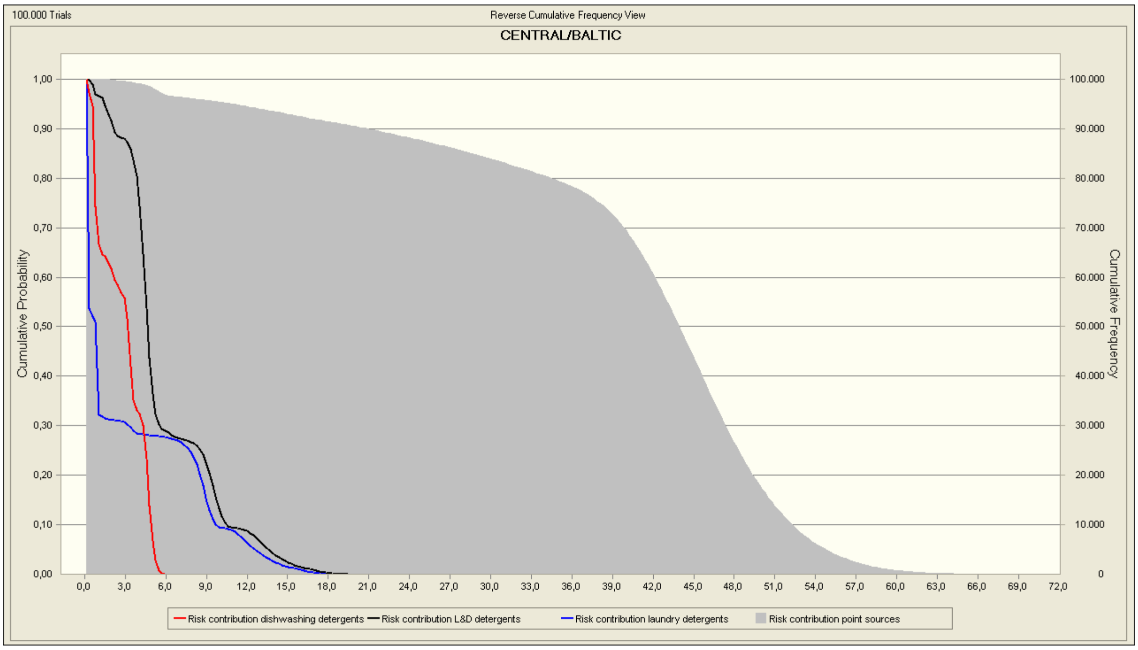


Figure 4.1. Exceedence curves for the estimated risk contribution for laundry (blue line), dishwashing (red line), laundry plus dishwashing detergents (blank line), and all point sources (grey area) in the Central/Baltic Ecoregion. The probability in the Y axis represents the likelihood for the contribution to be higher than the percentage represented in the X axis.

Table 4.4. Summary results for the contribution of detergents to the eutrophication risk in the Central/Baltic ecoregion.
Values are presented as percentages of the eutrophication risk.

Risk Contribution	Mean	Median	10th Percentile	90th Percentile
Laundry	3.1	0.8	0.0	9.6
Dishwashing	2.7	3.1	0.6	4.8
Laundry & Dishwash	5.8	4.5	2.0	10.4

CENTRAL BALTIC ECOTYPES

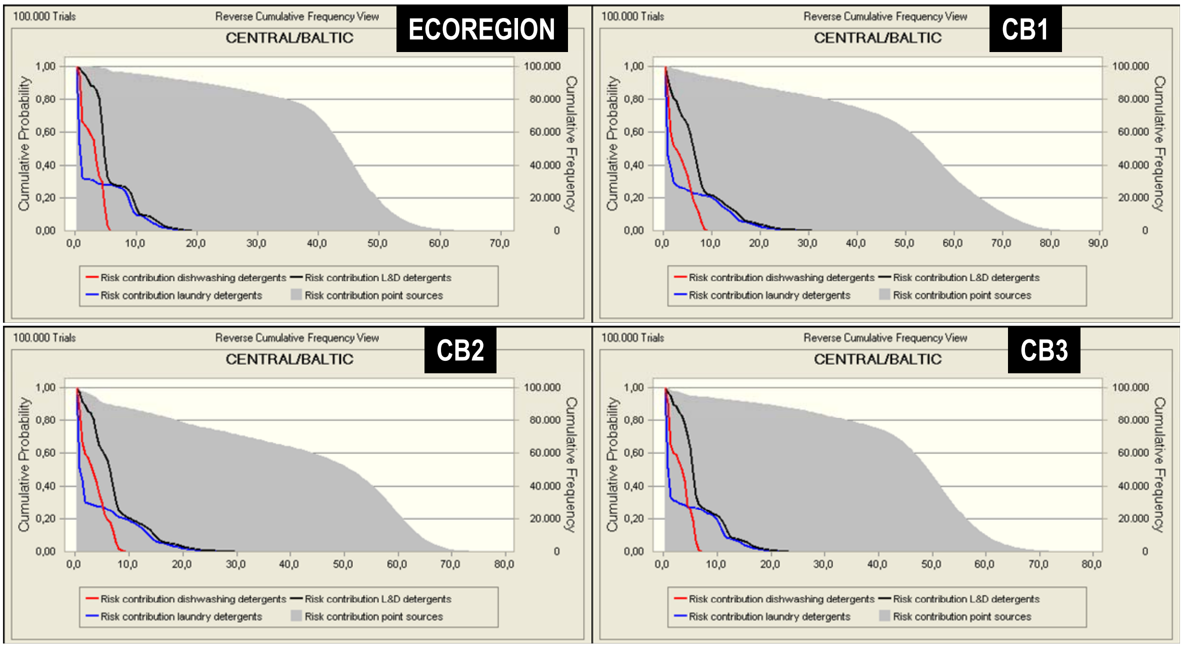


Figure 4.2. Comparisons of the exceedence curves for the estimated risk contribution for laundry (blue line), dishwashing (red line), laundry plus dishwashing detergents (blank line), and all point sources (grey area) in the Central/Baltic Ecoregion using the generic effect assessment estimation and the specific estimations for the three ecotypes defined for this ecoregion. The probability in the Y axis represents the likelihood for the contribution to be higher than the percentage represented in the X axis.

Table 4.5. Summary results for the contribution of detergents to the eutrophication risk in the Central/Baltic ecoregion.
Values are presented as percentages of the eutrophication risk.

Risk Contribution	Ecoregion	CB1	CB2	CB3
Mean value				
Laundry	3.1	3.6	3.7	3.3
Dishwashing	2.7	3.1	3.2	3.2
Laundry & Dishwash	5.8	6.8	6.9	6.3

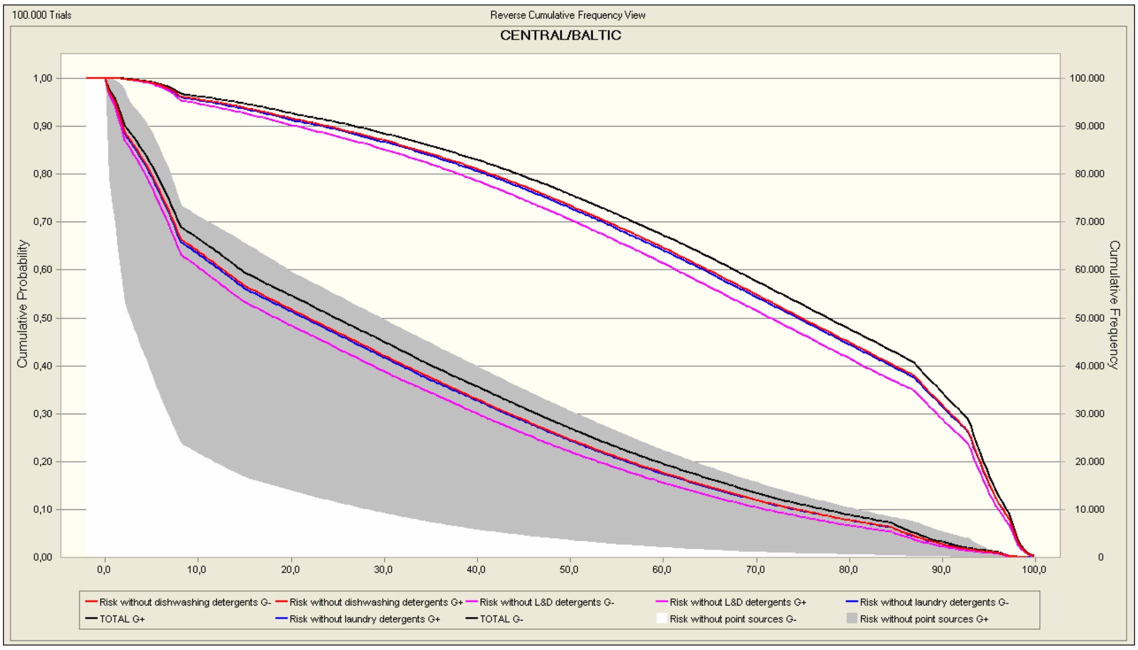


Figure 4.3. Comparative assessment of the generic eutrophication risk estimation for the Central/Baltic ecoregion. The risk is presented as a range, defined by the each set of lines with the same colour; the drift from the black lines represents the risk reduction obtained by extracting the contribution of laundry (blue lines), dishwashing (red lines) and both types (pink lines) of detergents respectively. The grey area defines the maximum reduction achievable by controlling point source emissions.

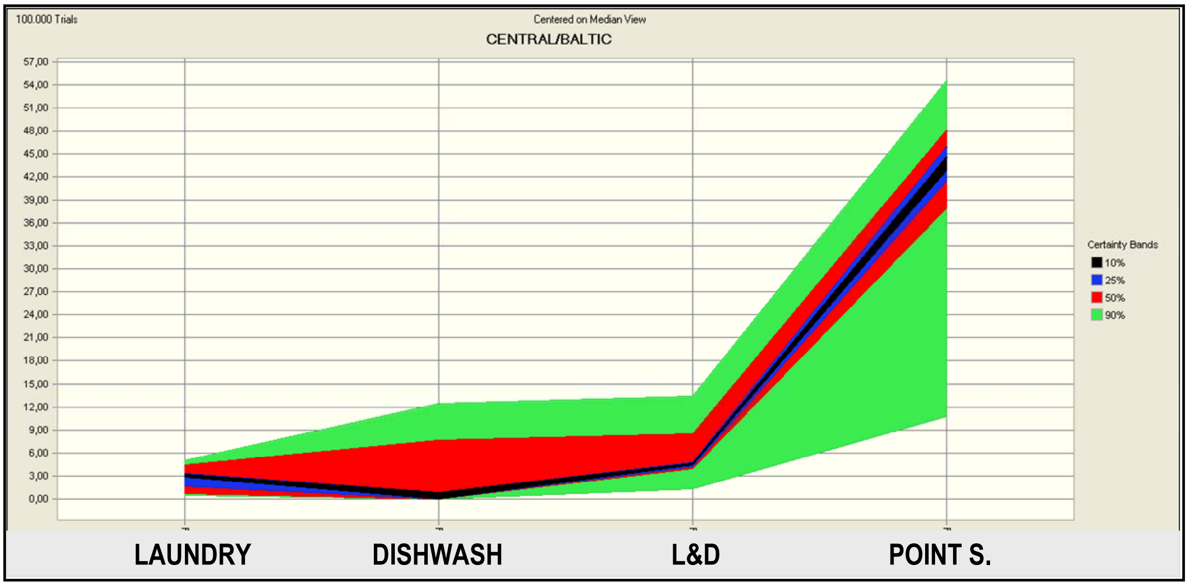


Figure 4.4. Trends in the reduction of the generic eutrophication risk estimation for the Central/Baltic ecoregion. The figure represents the 10th, 25th, 50th and 90th risk reduction percentiles obtained by extracting the contribution of dishwashing, laundry, both types of detergents, and the maximum reduction achievable by controlling point source emissions, respectively.

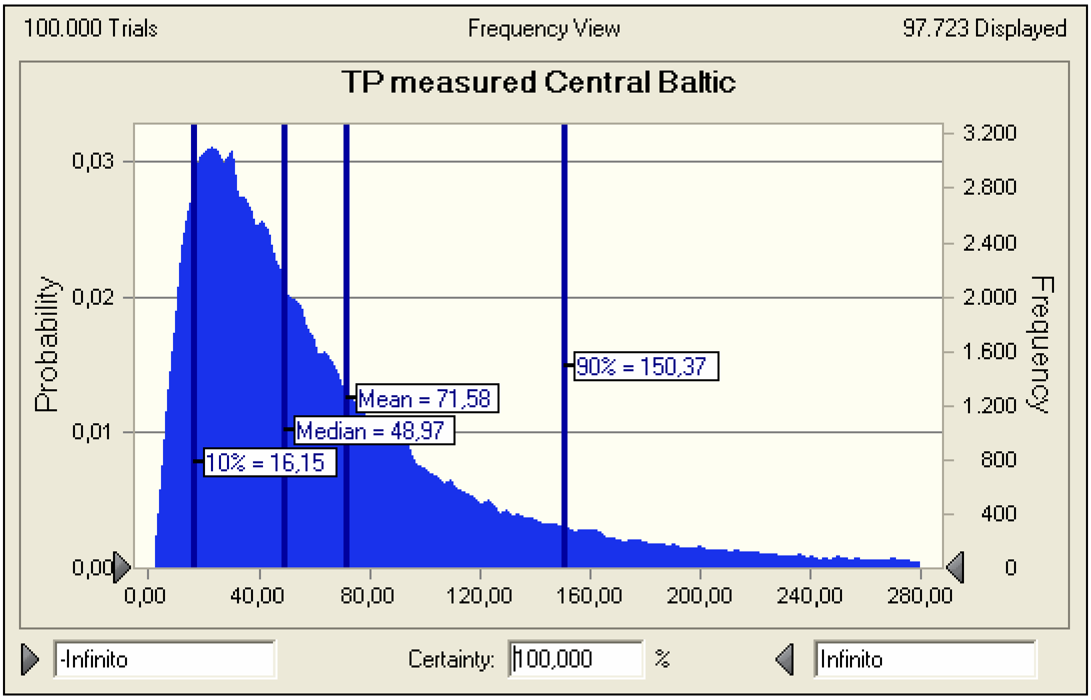


Figure 4.5. Distribution of TP employed for the probabilistic assessment of the eutrophication risk in the Central/Baltic ecoregion.

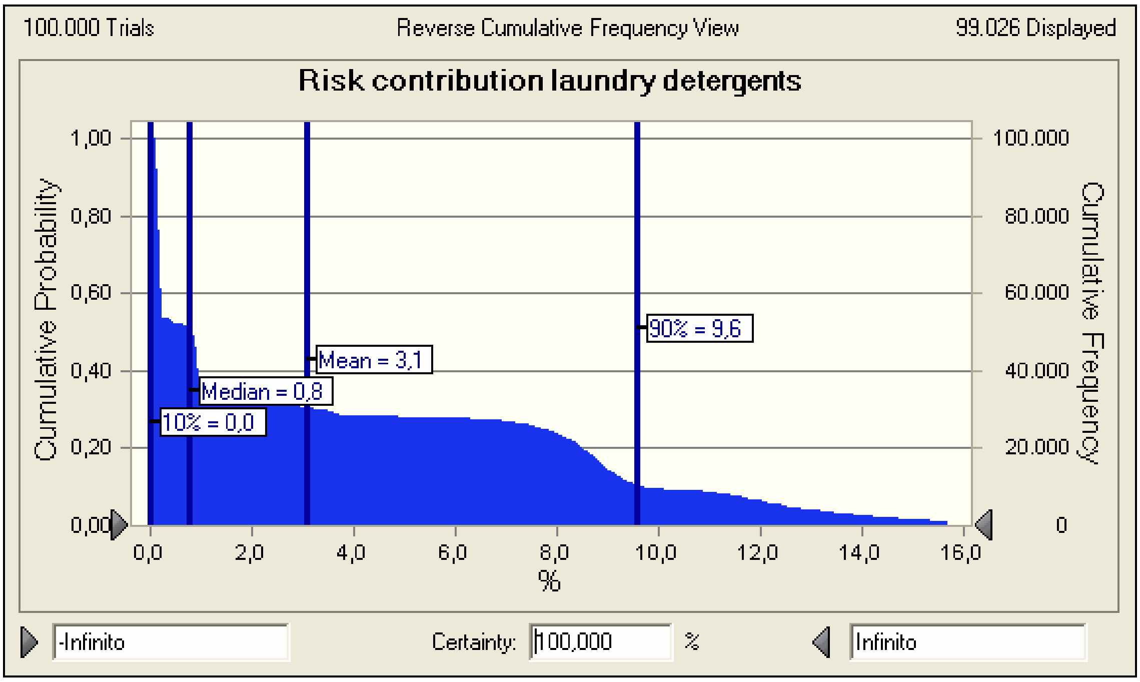
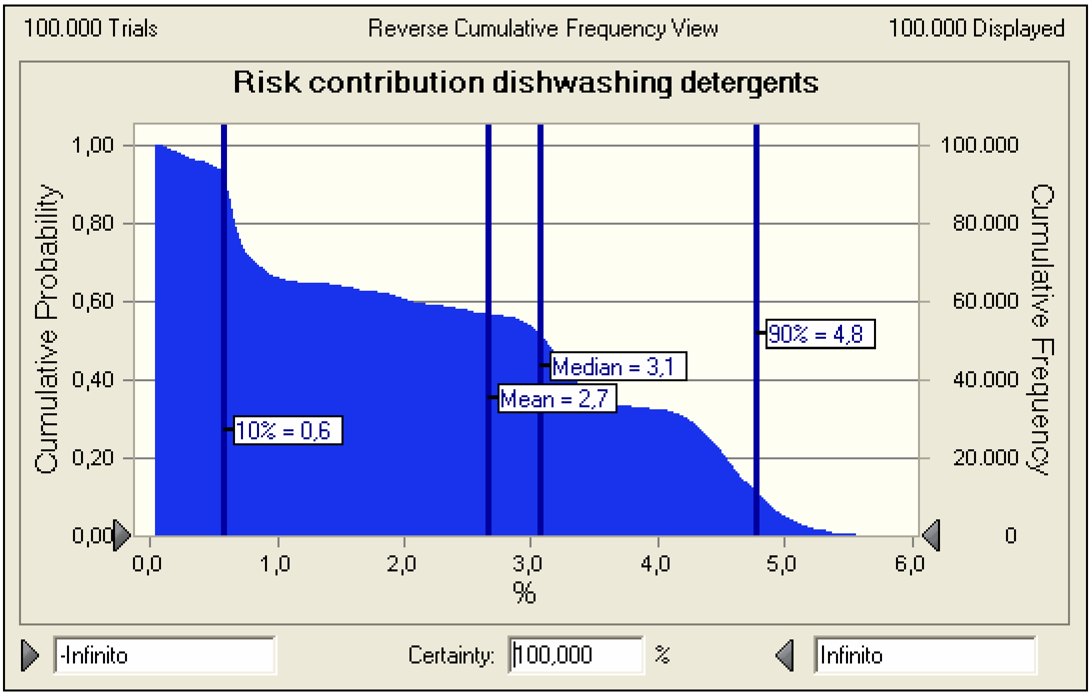
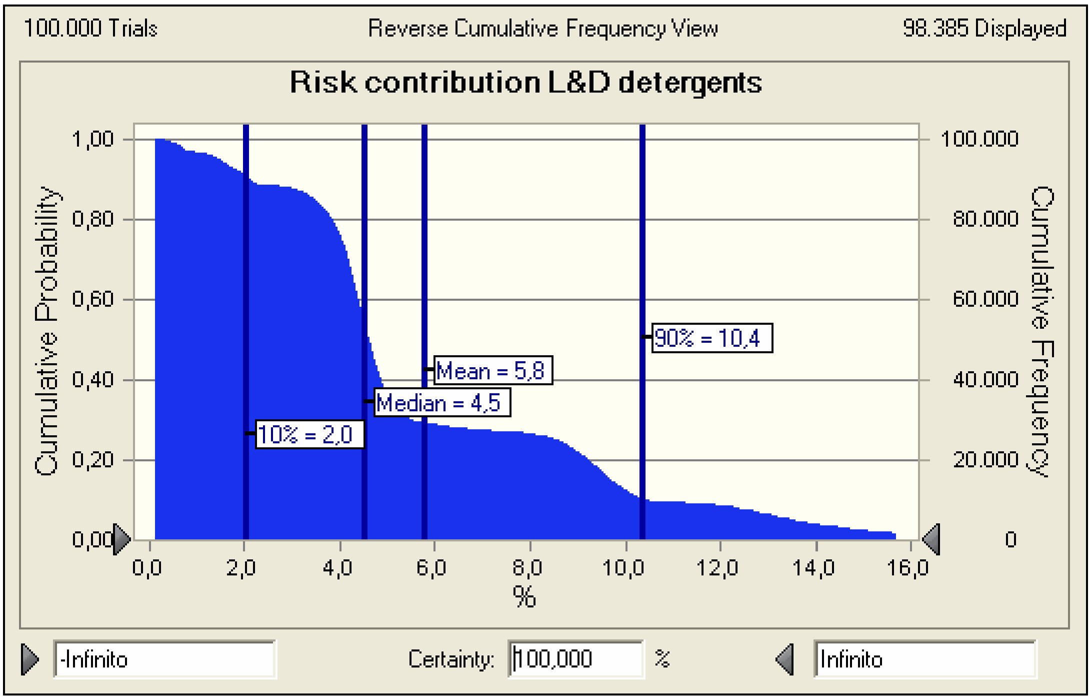


Figure 4.6. Probabilistic estimation of the contribution of P-based laundry detergents to the eutrophication risk in the Central/Baltic ecoregion.



-Infinito
Certainty: 100,000 %
Infinito

Figure 4.7. Probabilistic estimation of the contribution of P-based dishwashing detergents to the eutrophication risk in the Central/Baltic ecoregion.



-Infinito
Certainty: 100,000 %
Infinito

Figure 4.8. Probabilistic estimation of the contribution of P-based laundry & dishwashing detergents to the eutrophication risk in the Central/Baltic ecoregion.

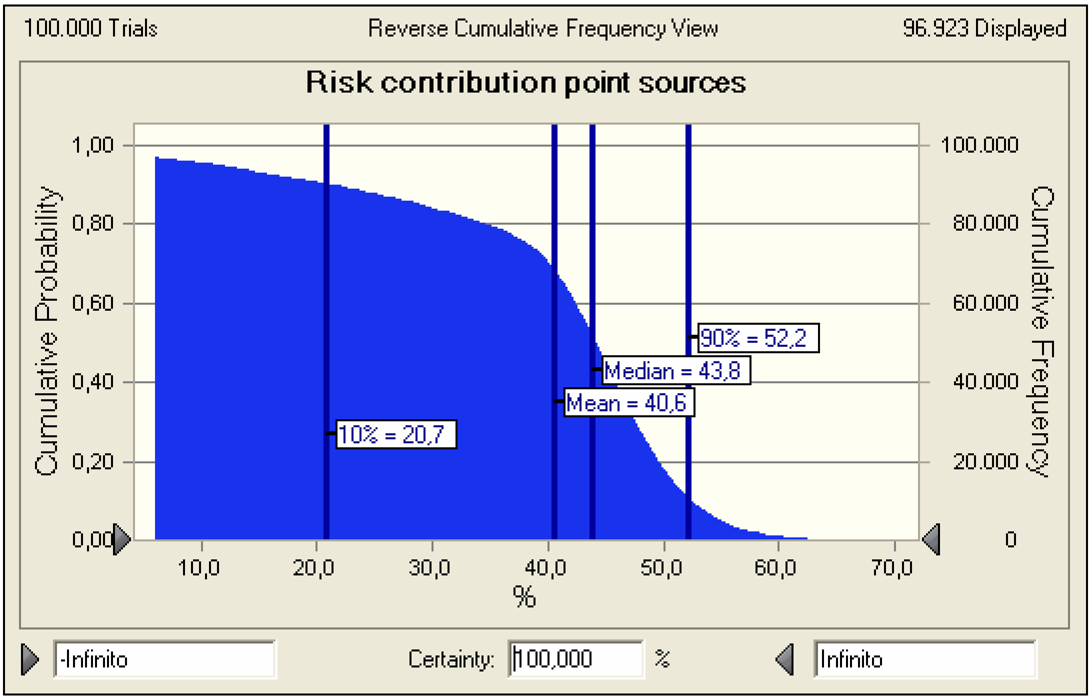


Figure 4.9. Probabilistic estimation of the maximum reduction achievable by controlling point source emissions to the eutrophication risk in the Central/Baltic ecoregion.

MEDITERRANEAN ECOREGION

The contribution to the eutrophication risk (Figure 4.10; Table 4.6) is estimated as the reduction in the expected risk when the TP concentration is reduced in the same proportion than the estimated contribution of P-based detergents. The grey area is the contribution of all point sources, and therefore represents the maximum achievable reduction in the eutrophication risk that could be theoretically achieved by managing point source emissions.

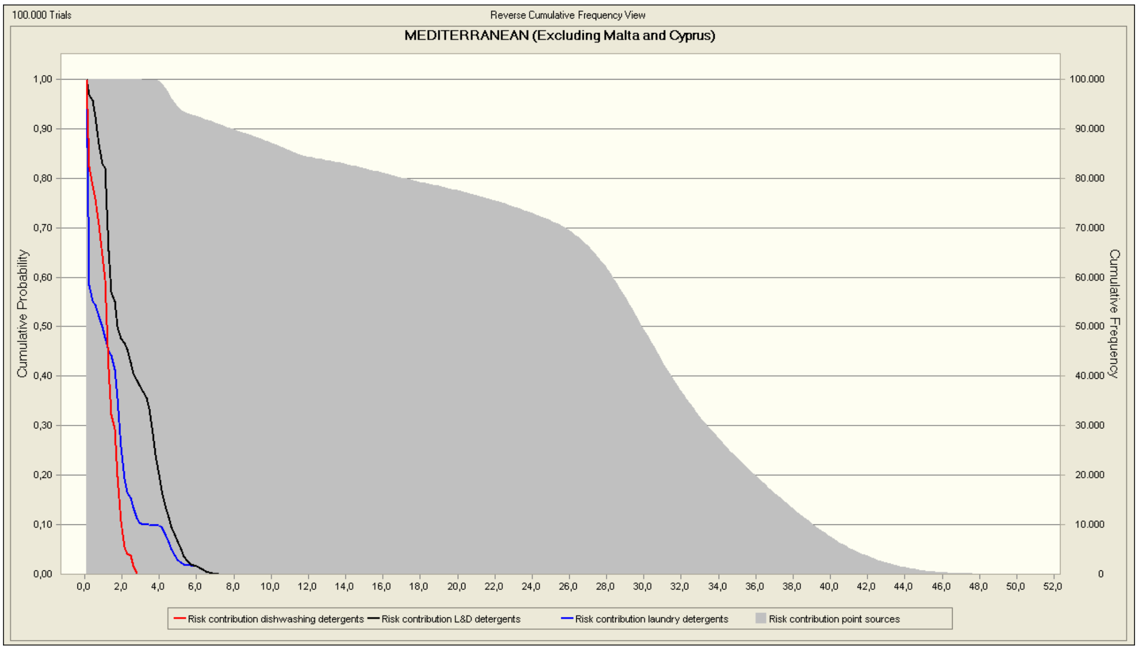


Figure 4.10. Exceedence curves for the estimated risk contribution for laundry (blue line), dishwashing (red line), laundry plus dishwashing detergents (blank line), and all point sources (grey area) in the Mediterranean Ecoregion. The probability in the Y axis represents the likelihood for the contribution to be higher than the percentage represented in the X axis.

Table 4.6. Summary results for the contribution of detergents to the eutrophication risk in the Mediterreanean ecoregion.
Values are presented as percentages of the eutrophication risk.

Risk Contribution	Mean	Median	10th Percentile	90th Percentile
Laundry	1.2	0.9	0.0	3.2
Dishwashing	1.1	1.1	0.0	1.9
Laundry & Dishwash	2.3	1.7	0.5	4.5

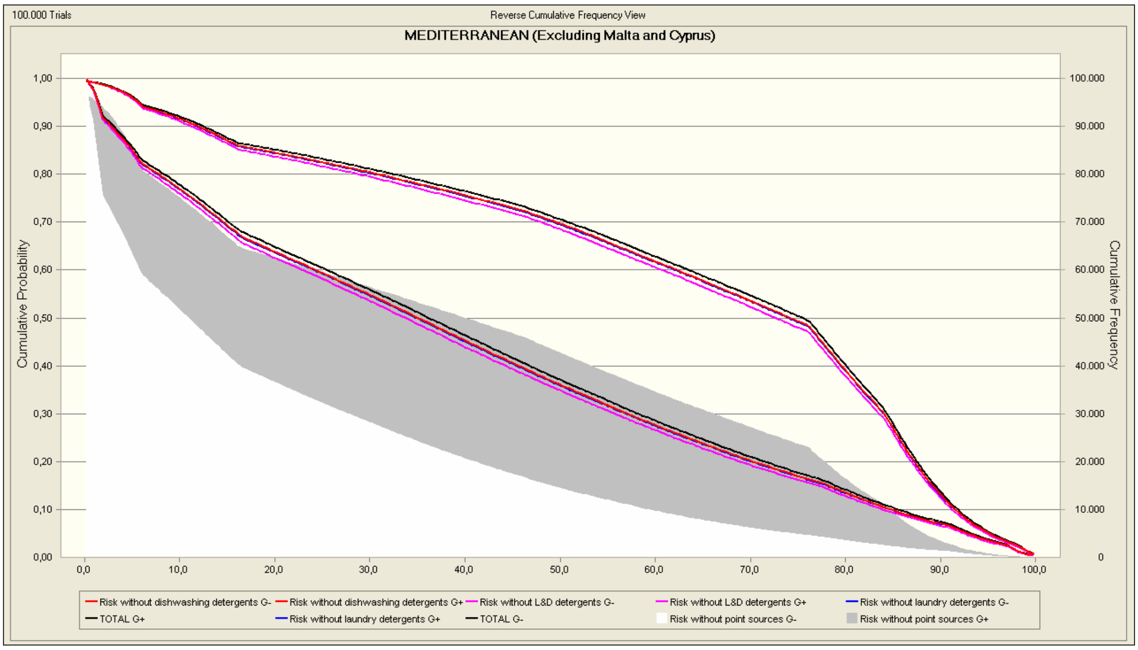


Figure 4.11. Comparative assessment of the generic eutrophication risk estimation for the Mediterranean ecoregion. The risk is presented as a range, defined by the each set of lines with the same colour; the drift from the black lines represents the risk reduction obtained by extracting the contribution of laundry (blue lines), dishwashing (red lines) and both types (pink lines) of detergents respectively. The grey area defines the maximum reduction achievable by controlling point source emissions.

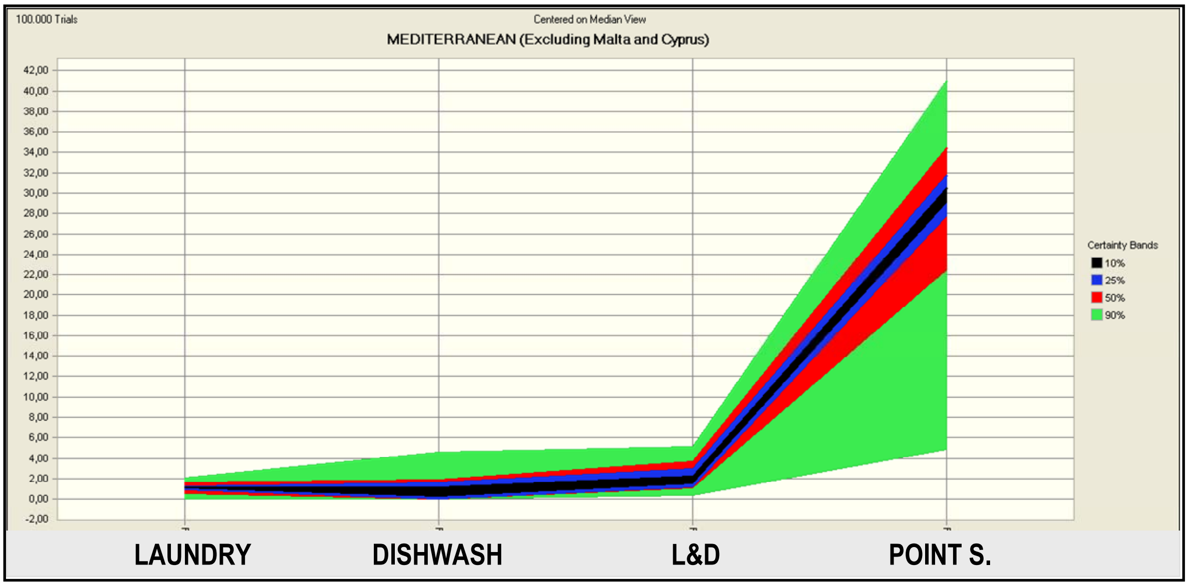


Figure 4.12. Trends in the reduction of the generic eutrophication risk estimation for the Mediterranean ecoregion. The figure represents the 10th, 25th, 50th and 90th risk reduction percentiles obtained by extracting the contribution of dishwashing, laundry, both types of detergents, and the maximum reduction achievable by controlling point source emissions, respectively.

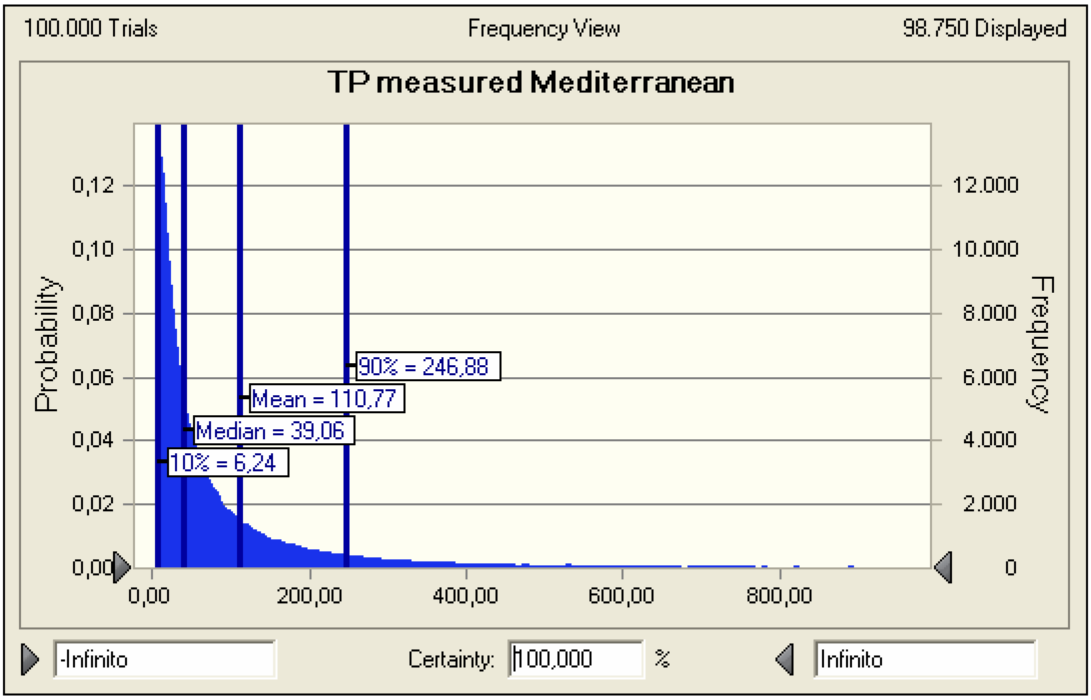


Figure 4.13. Distribution of TP employed for the probabilistic assessment of the eutrophication risk in the Mediterranean ecoregion.

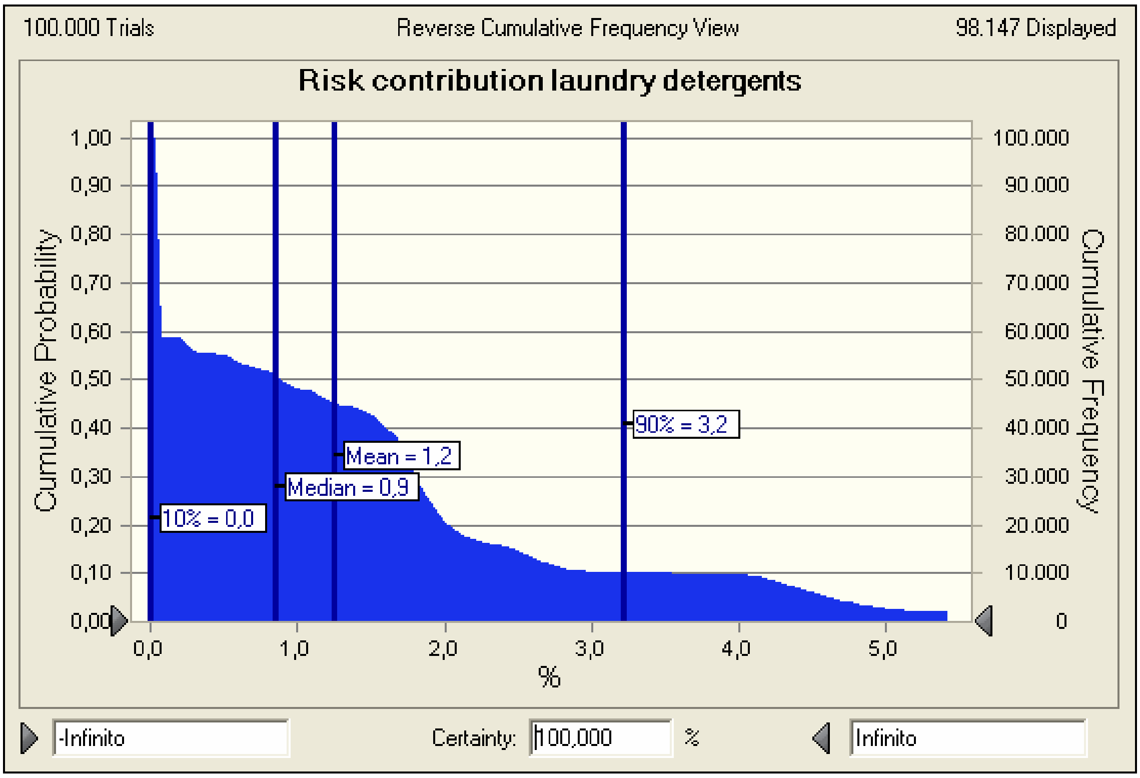


Figure 4.14. Probabilistic estimation of the contribution of P-based laundry detergents to the eutrophication risk in the Mediterranean ecoregion.

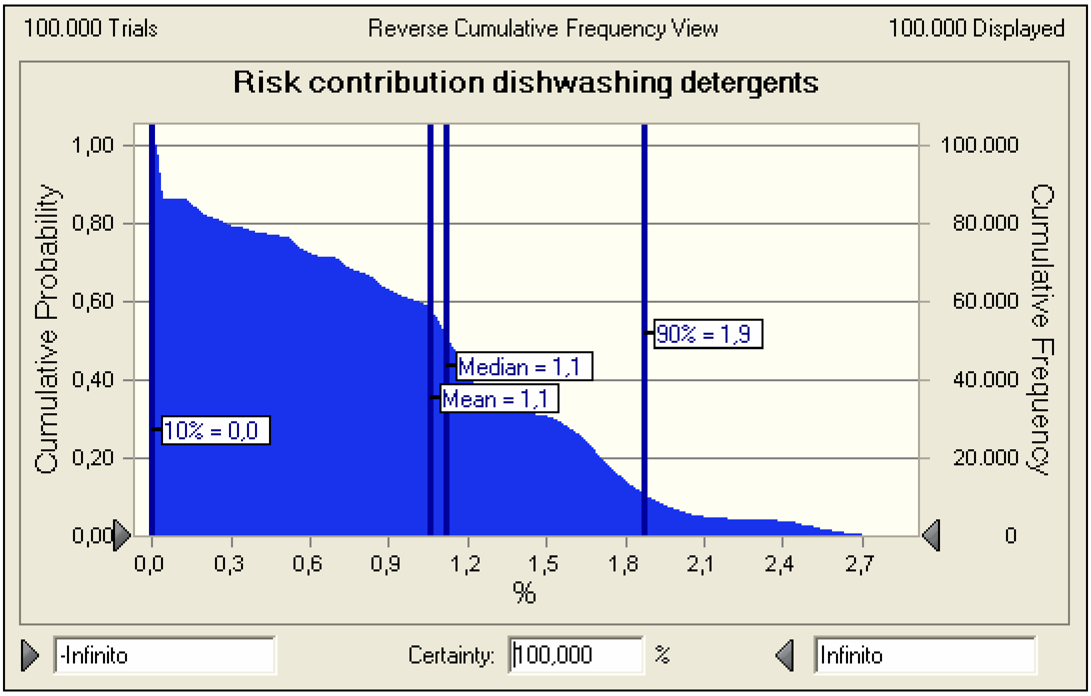


Figure 4.15. Probabilistic estimation of the contribution of P-based dishwashing detergents to the eutrophication risk in the Mediterranean ecoregion.

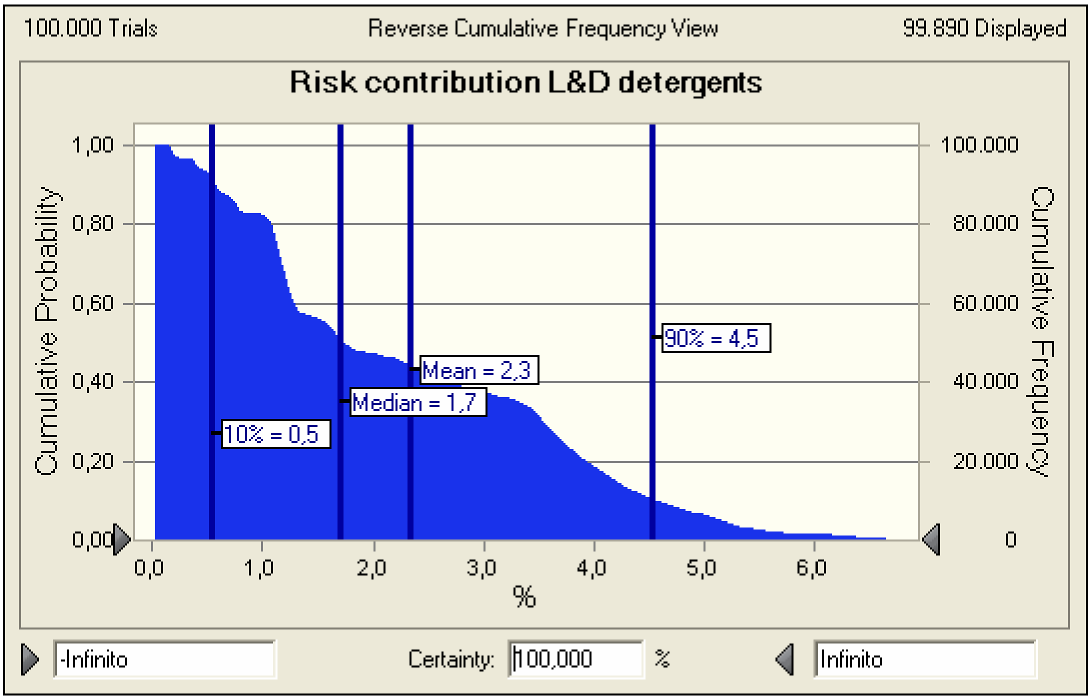
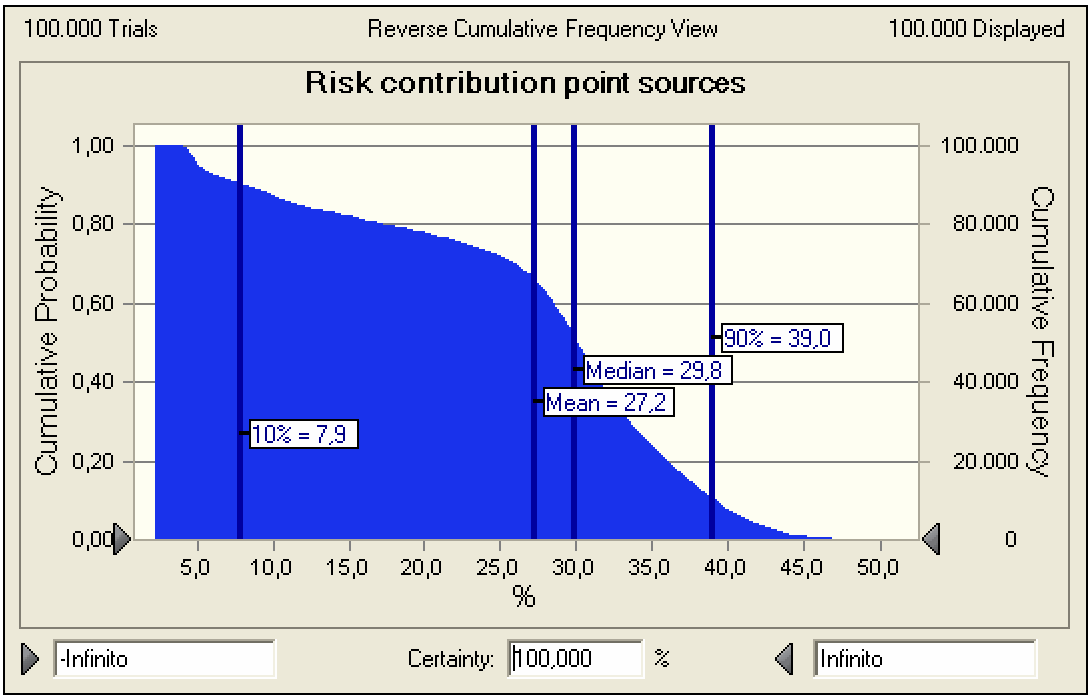


Figure 4.16. Probabilistic estimation of the contribution of P-based laundry & dishwashing detergents to the eutrophication risk in the Mediterranean ecoregion.



-Infinito

Certainty: 100,000 %

Infinito

Figure 4.17. Probabilistic estimation of the maximum reduction achievable by controlling point source emissions to the eutrophication risk in the Mediterranean ecoregion.

NORTHERN ECOREGION

The contribution to the eutrophication risk (Figure 4.18; Table 4.7) is estimated as the reduction in the expected risk when the TP concentration is reduced in the same proportion than the estimated contribution of P-based detergents. The grey area is the contribution of all point sources, and therefore represents the maximum achievable reduction in the eutrophication risk that could be theoretically achieved by managing point source emissions.

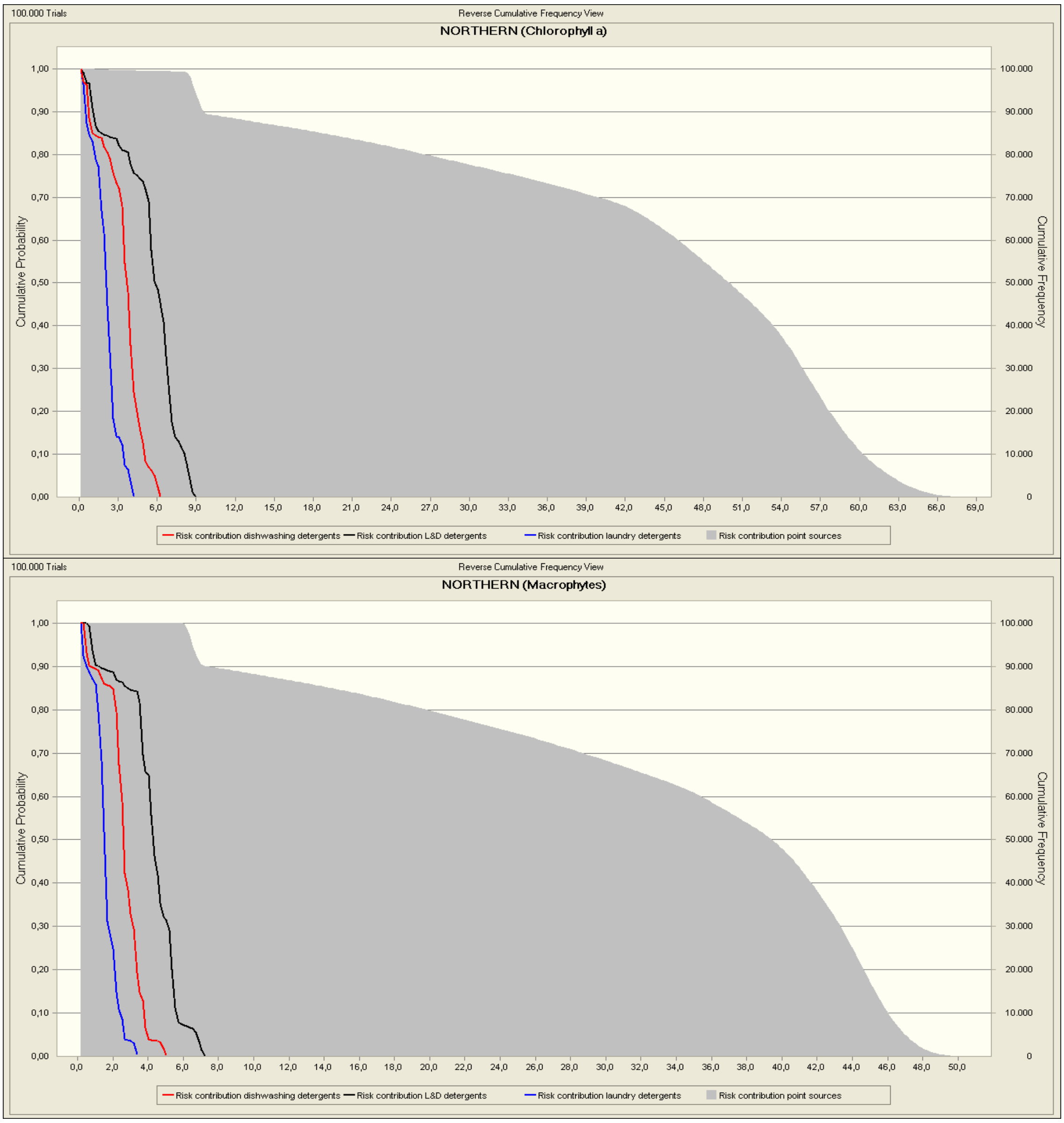


Figure 4.18. Exceedence curves for the estimated risk contribution for laundry (blue line), dishwashing (red line), laundry plus dishwashing detergents (blank line), and all point sources (grey area) in the Northern Ecoregion. The probability in the Y axis represents the likelihood for the contribution to be higher than the percentage represented in the X axis. The upper figure presents the estimations based on the chlorophyll a boundaries. The lower figure presents the estimations based on the macrophytes boundaries.

Table 4.7. Summary results for the contribution of detergents to the eutrophication risk in the Northern ecoregion.
Values are presented as percentages of the eutrophication risk.

Risk Contribution	Mean	Median	10th Percentile	90th Percentile
Chlorophyll a effect assessment curve				
Laundry	2.0	1.9	0.3	3.2
Dishwashing	3.3	3.6	0.6	4.9
Laundry & Dishwash	5.3	5.7	1.0	8.0
Macrophytes effect assessment curve				
Laundry	1.5	1.5	0.4	2.4
Dishwashing	2.5	2.5	0.7	3.7
Laundry & Dishwash	4.1	4.2	1.2	5.5

NORTHERN ECOTYPES

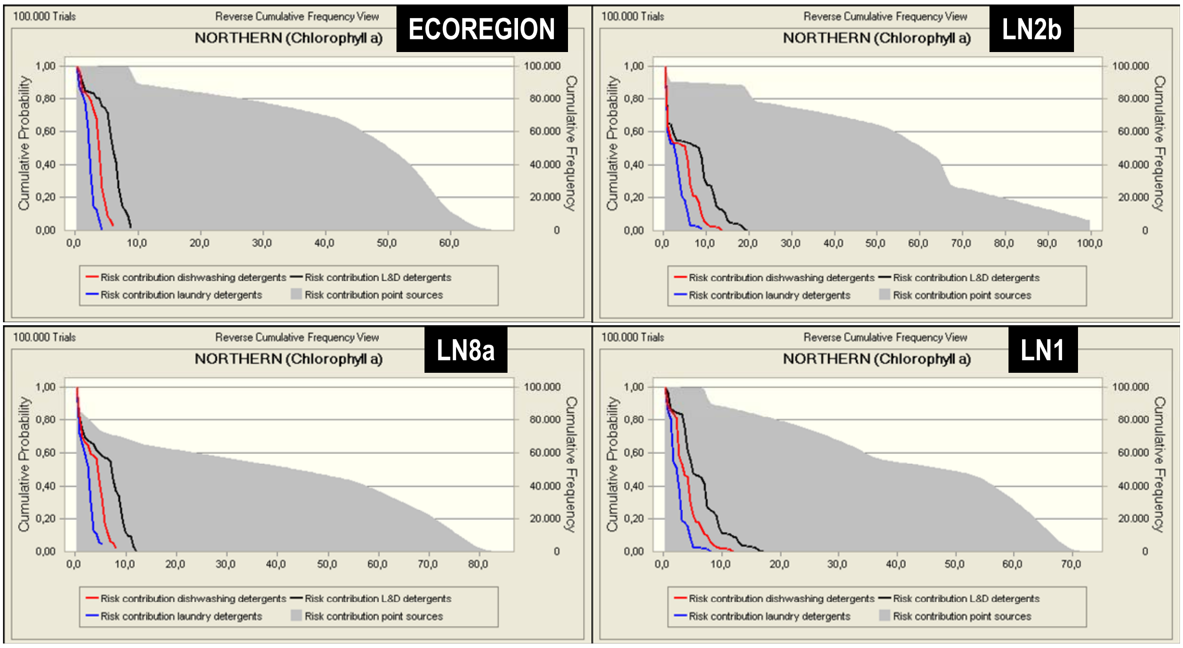


Figure 4.19. Comparisons of the exceedence curves for the estimated risk contribution for laundry (blue line), dishwashing (red line), laundry plus dishwashing detergents (blank line), and all point sources (grey area) in the Northern Ecoregion using the generic effect assessment estimation and the specific estimations for the three ecotypes selected for this ecoregion. The probability in the Y axis represents the likelihood for the contribution to be higher than the percentage represented in the X axis.

Table 4.8. Summary results for the contribution of detergents to the eutrophication risk in the Central/Baltic ecoregion.
Values are presented as percentages of the eutrophication risk.

Risk Contribution	Ecoregion	LN1	LN2b	LN8a
Mean value; Chlorophyll a effect assessment curve				
Laundry	2.0	2.1	2.4	2.4
Dishwashing	3.3	3.6	3.8	3.4
Laundry & Dishwash	5.3	5.7	6.2	5.5

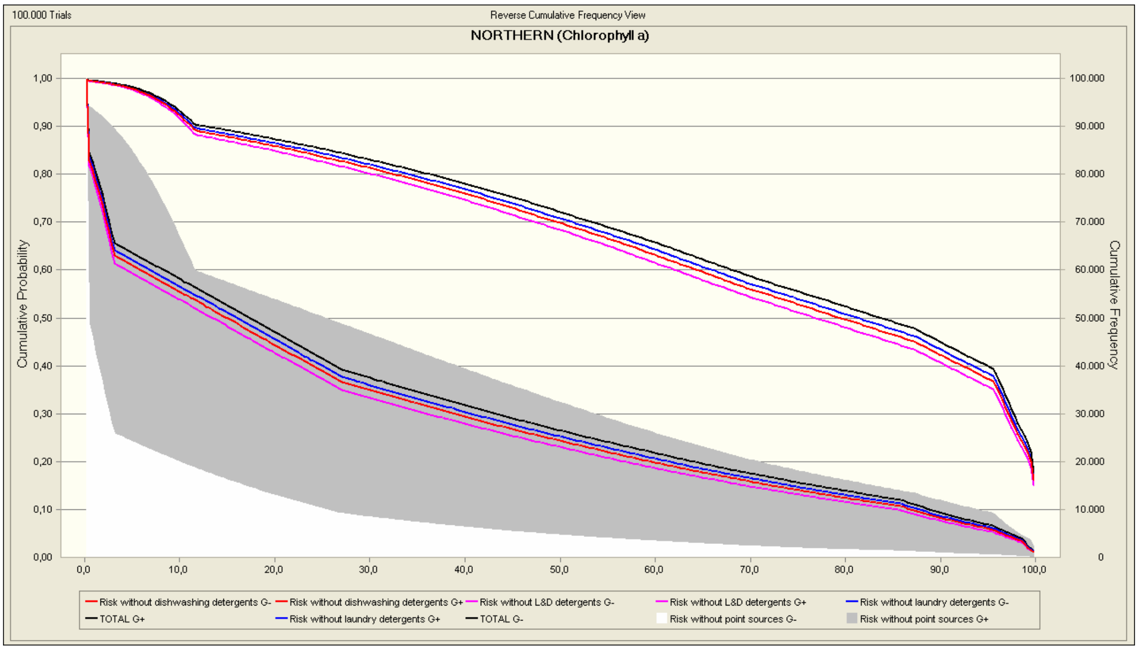


Figure 4.20. Comparative assessment of the generic eutrophication risk estimation for the Northern ecoregion. The risk is presented as a range, defined by the each set of lines with the same colour; the drift from the black lines represents the risk reduction obtained by extracting the contribution of laundry (blue lines), dishwashing (red lines) and both types (pink lines) of detergents respectively. The grey area defines the maximum reduction achievable by controlling point source emissions.

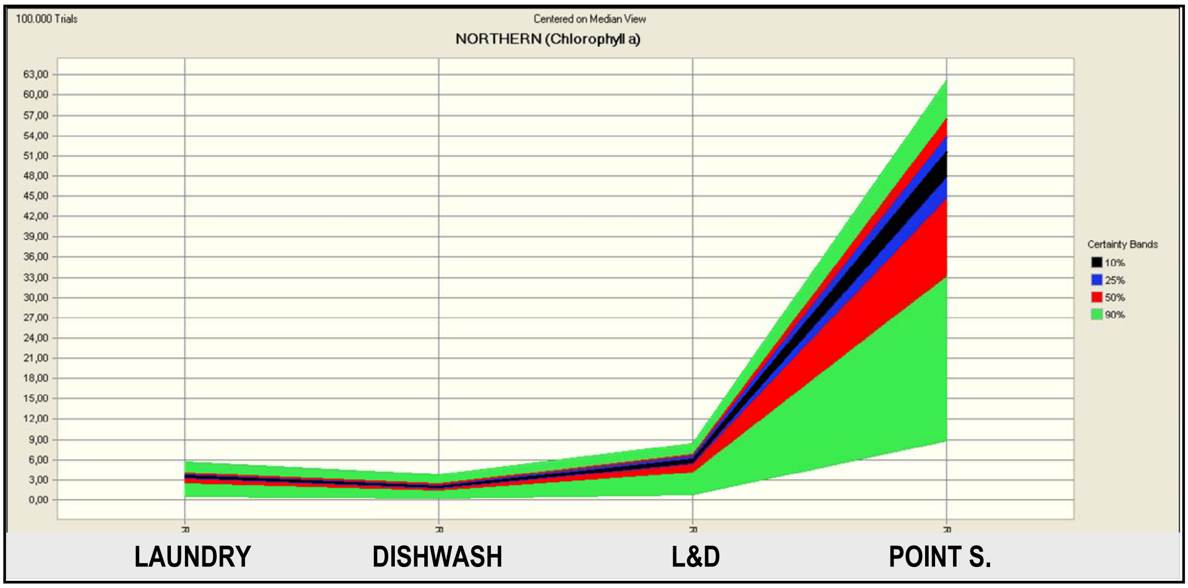


Figure 4.21. Trends in the reduction of the generic eutrophication risk estimation for the Northern ecoregion. The figure represents the 10th, 25th, 50th and 90th risk reduction percentiles obtained by extracting the contribution of dishwashing, laundry, both types of detergents, and the maximum reduction achievable by controlling point source emissions, respectively.

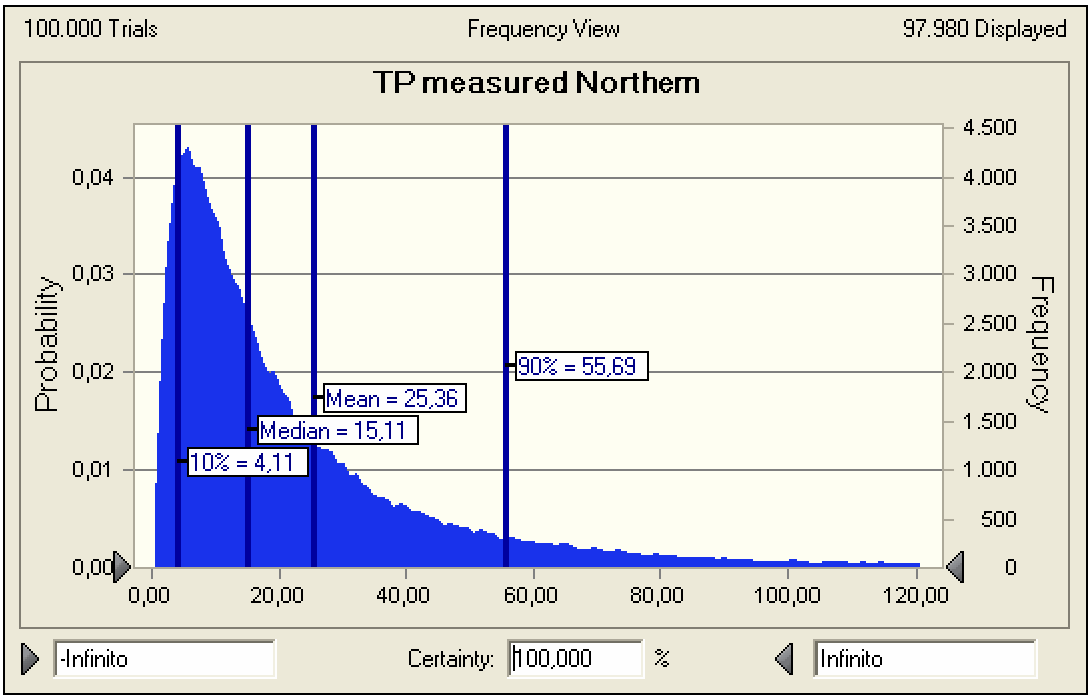


Figure 4.22. Distribution of TP employed for the probabilistic assessment of the eutrophication risk in the Northern ecoregion.

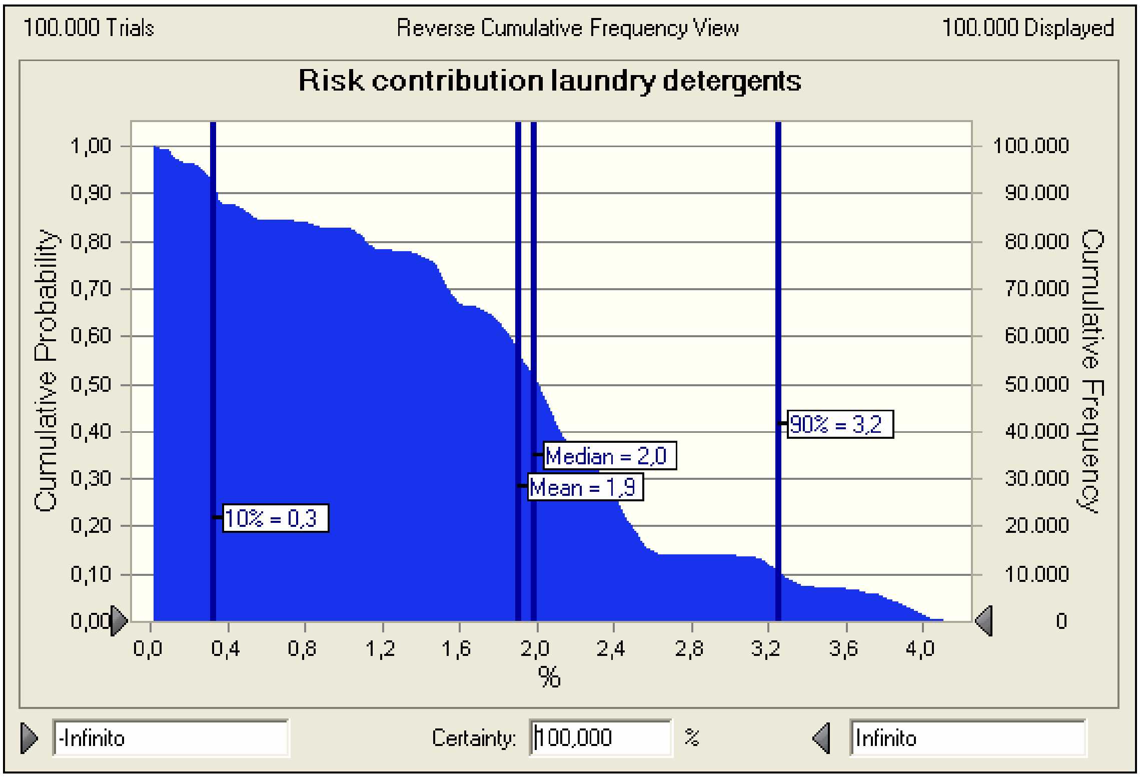
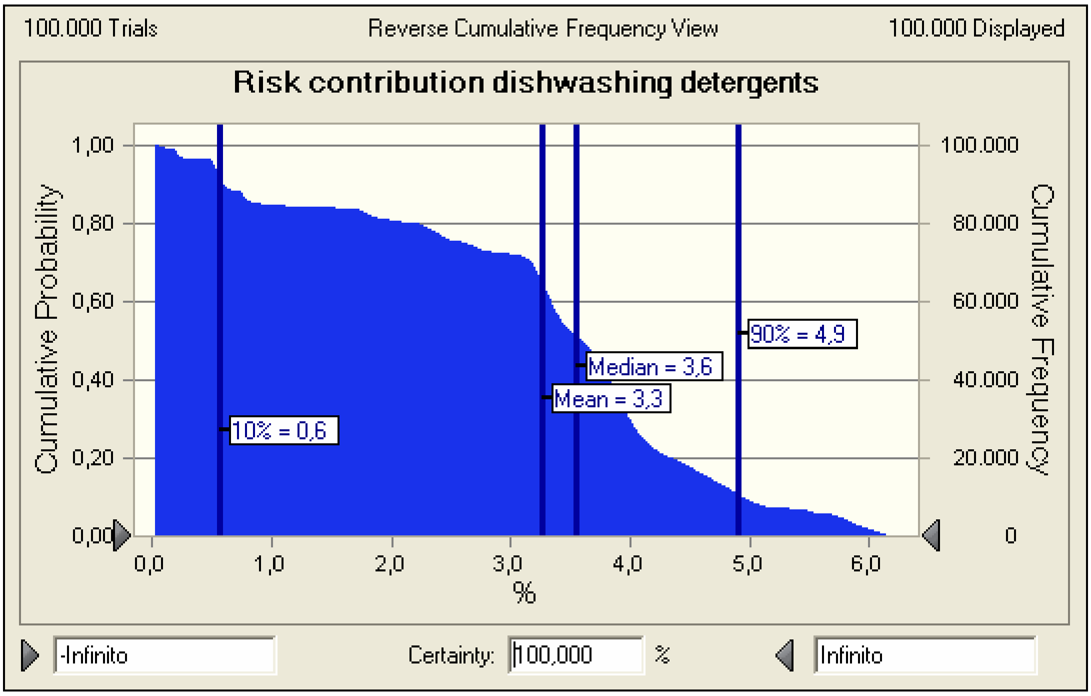
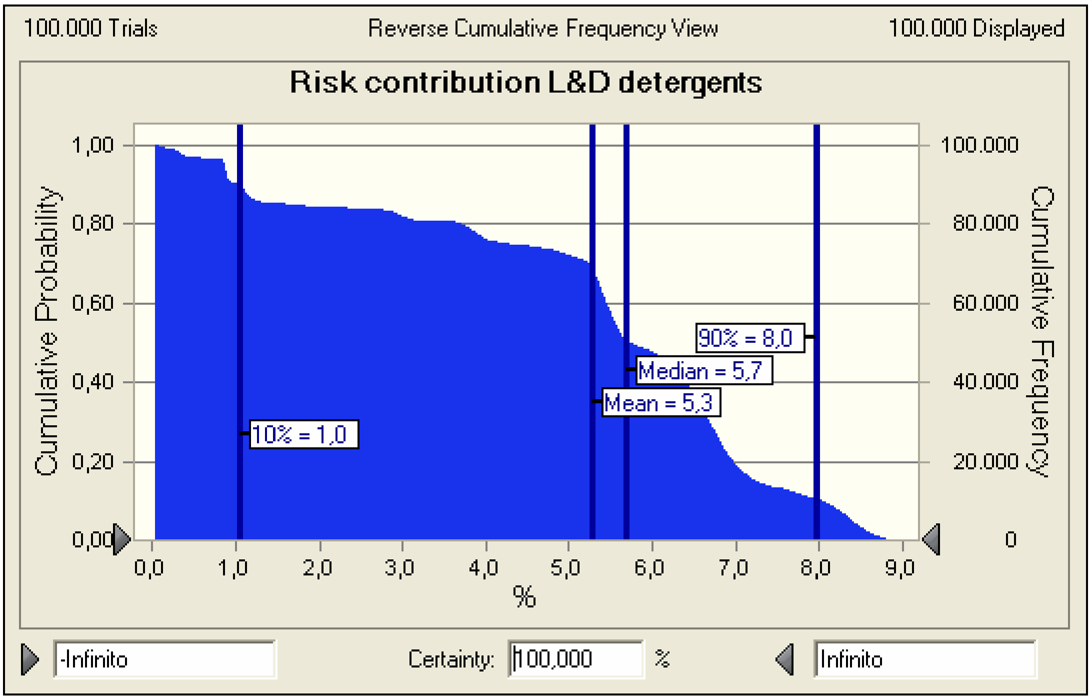


Figure 4.23. Probabilistic estimation of the contribution of P-based laundry detergents to the eutrophication risk in the Northern ecoregion, chlorophyll a curve.



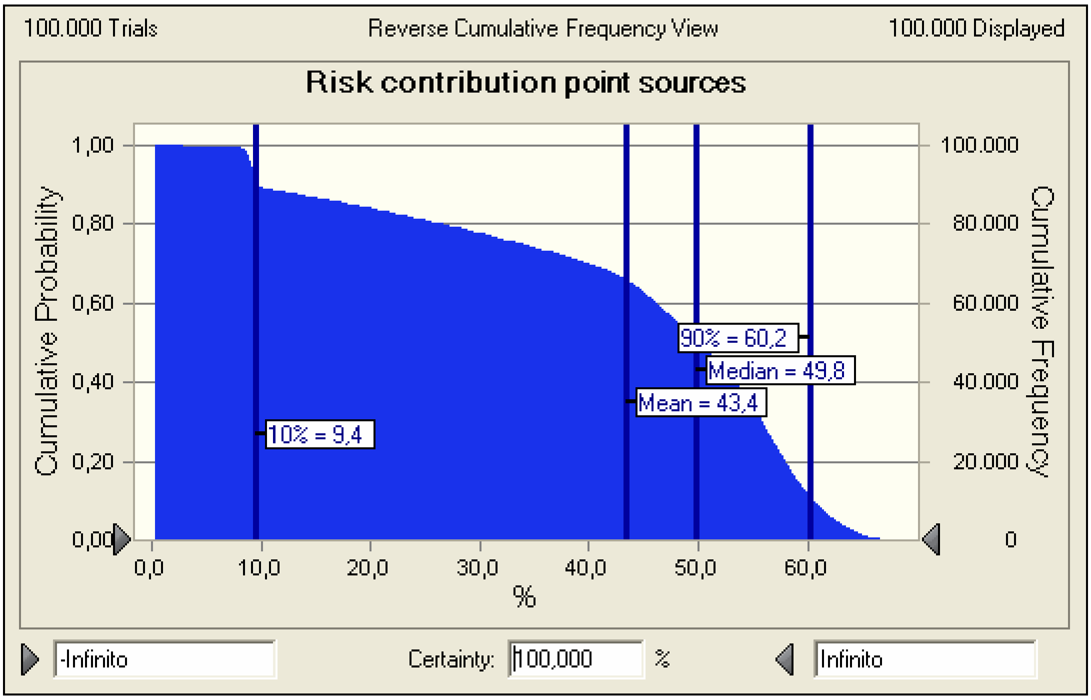
-Infinito Certainty: 100,000 % Infinito

Figure 4.24. Probabilistic estimation of the contribution of P-based dishwashing detergents to the eutrophication risk in the Northern ecoregion, chlorophyll a curve.



-Infinito Certainty: 100,000 % Infinito

Figure 4.25. Probabilistic estimation of the contribution of P-based laundry & dishwashing detergents to the eutrophication risk in the Northern ecoregion, chlorophyll a curve.



100.000 Trials Reverse Cumulative Frequency View 100.000 Displayed

-Infinito Certainty: 100,000 % Infinito

Figure 4.26. Probabilistic estimation of the maximum reduction achievable by controlling point source emissions to the eutrophication risk in the Northern ecoregion, chlorophyll a curve.

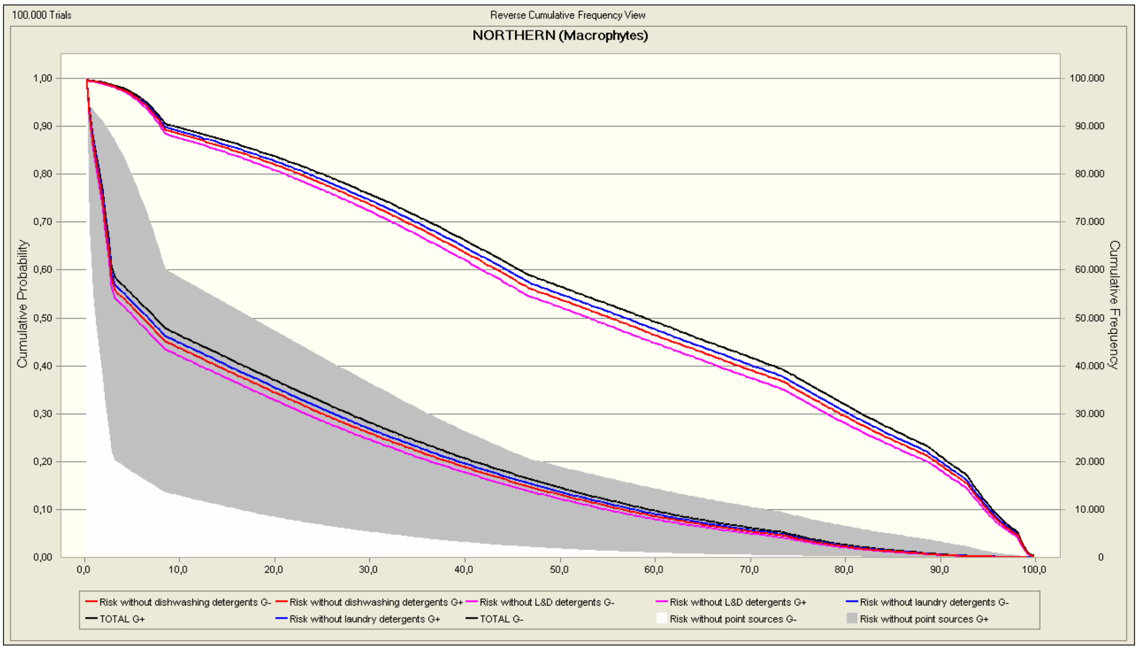


Figure 4.27. Comparative assessment of the generic eutrophication risk estimation for the Northern ecoregion. The risk is presented as a range, defined by the each set of lines with the same colour; the drift from the black lines represents the risk reduction obtained by extracting the contribution of laundry (blue lines), dishwashing (red lines) and both types (pink lines) of detergents respectively. The grey area defines the maximum reduction achievable by controlling point source emissions.

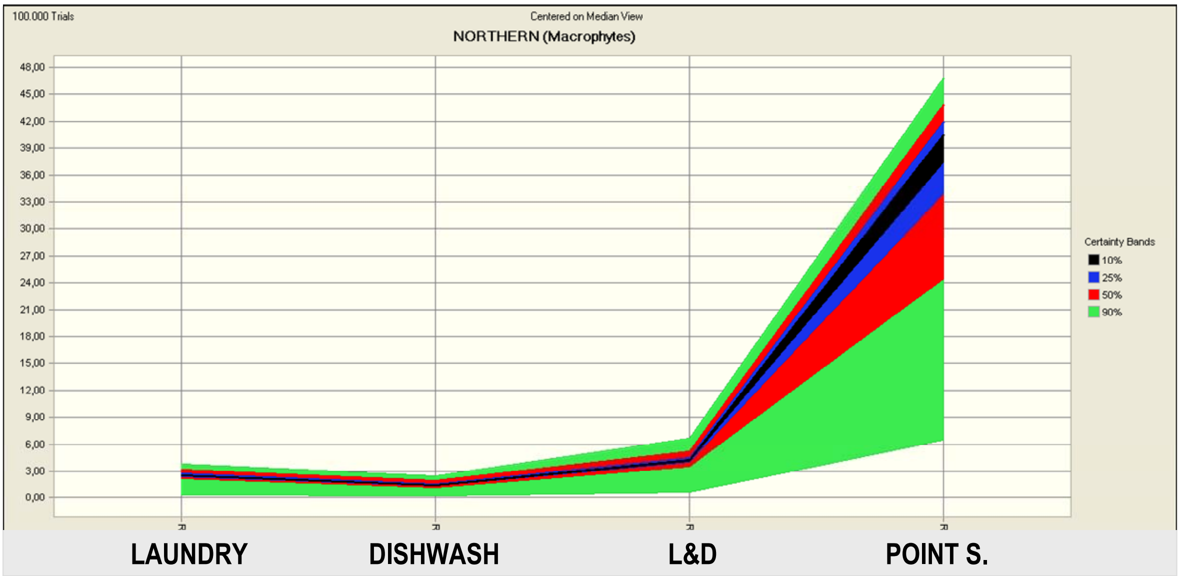
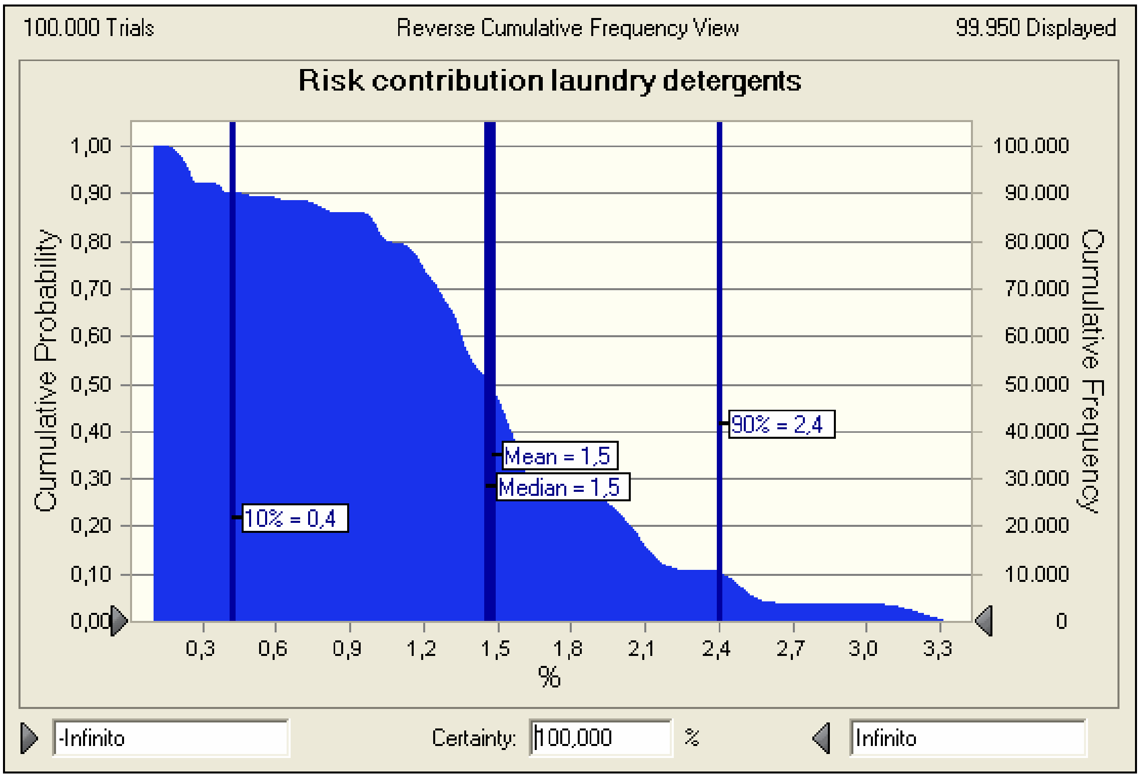
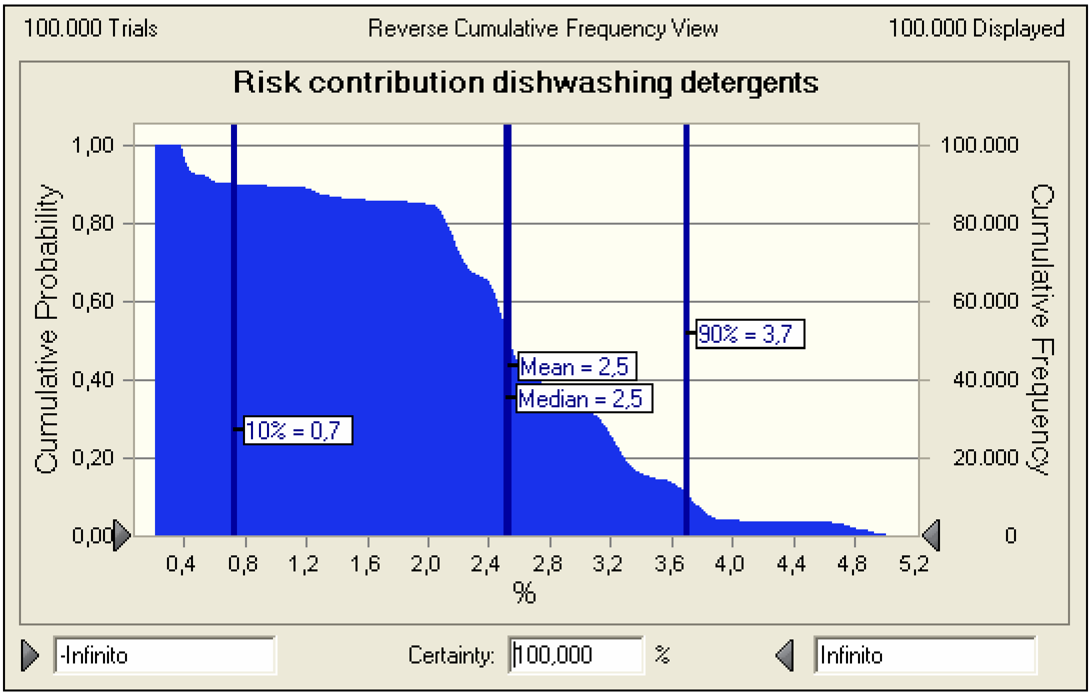


Figure 4.28. Trends in the reduction of the generic eutrophication risk estimation for the Northern ecoregion. The figure represents the 10th, 25th, 50th and 90th risk reduction percentiles obtained by extracting the contribution of dishwashing, laundry, both types of detergents, and the maximum reduction achievable by controlling point source emissions, respectively.


100.000 Trials — Reverse Cumulative Frequency View — 99.950 Displayed

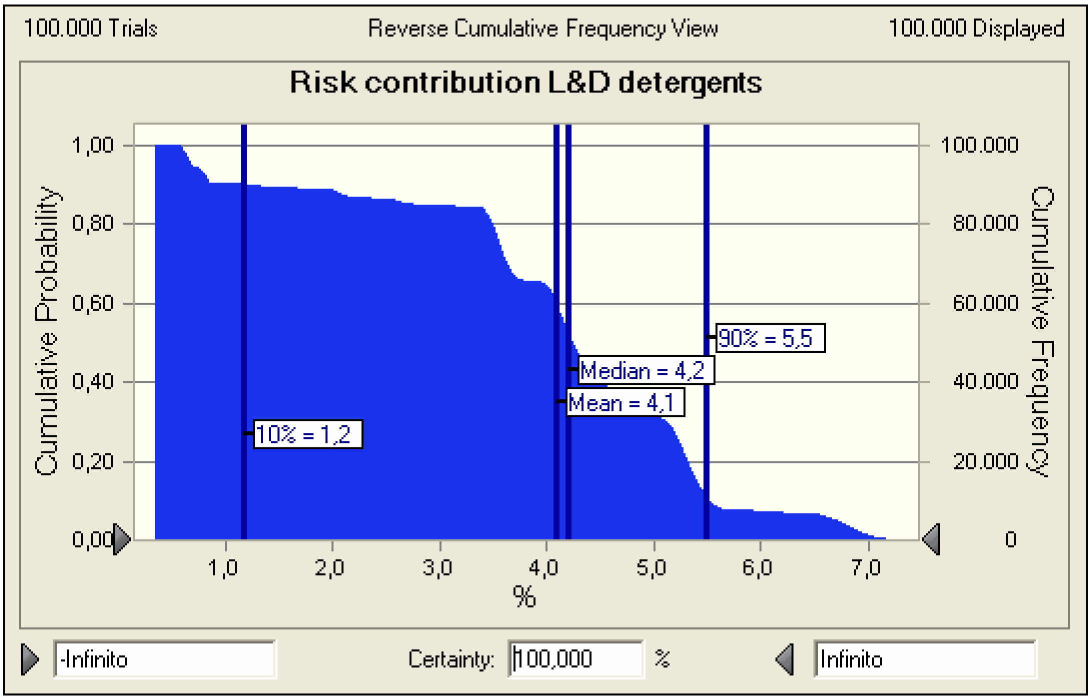
-Infinito — Certainty: 100,000 % — Infinito

Figure 4.29. Probabilistic estimation of the contribution of P-based laundry detergents to the eutrophication risk in the Northern ecoregion, macrophytes curve.


100.000 Trials — Reverse Cumulative Frequency View — 100.000 Displayed

-Infinito — Certainty: 100,000 % — Infinito

Figure 4.30. Probabilistic estimation of the contribution of P-based dishwashing detergents to the eutrophication risk in the Northern ecoregion, macrophytes curve.

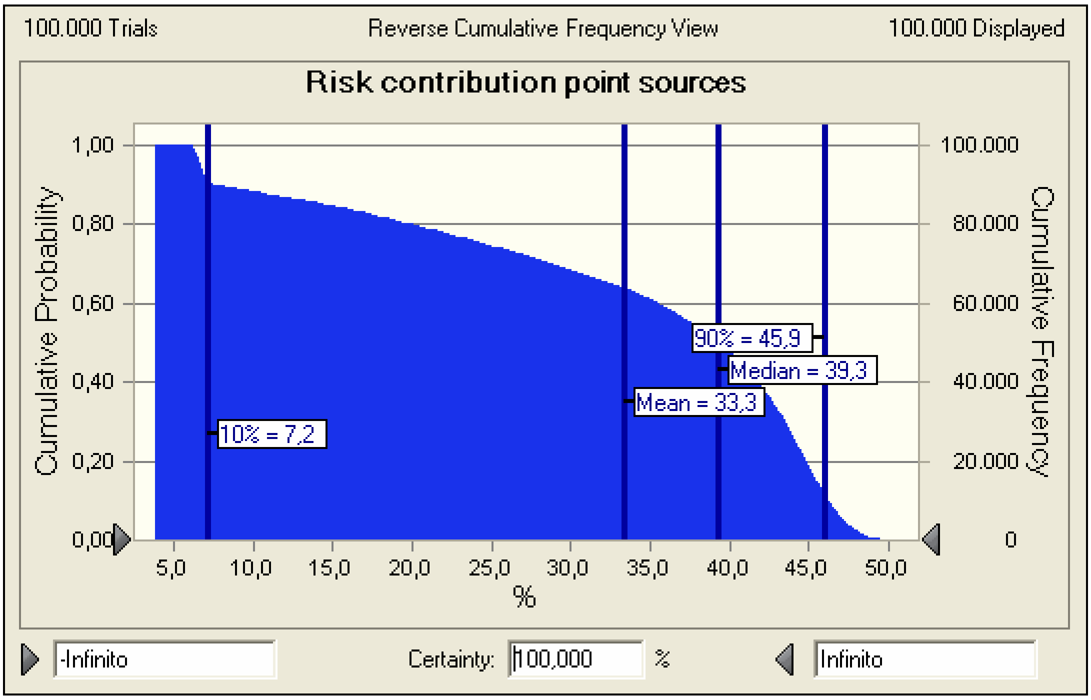


-Infinito

Certainty: 100,000 %

Infinito

Figure 4.31. Probabilistic estimation of the contribution of P-based laundry & dishwashing detergents to the eutrophication risk in the Northern ecoregion, macrophytes curve.



-Infinito

Certainty: 100,000 %

Infinito

Figure 4.32. Probabilistic estimation of the maximum reduction achievable by controlling point source emissions to the eutrophication risk in the Northern ecoregion, macrophytes curve.

ATLANTIC ECOREGION

The contribution to the eutrophication risk (Figure 4.33; Table 4.9) is estimated as the reduction in the expected risk when the TP concentration is reduced in the same proportion than the estimated contribution of P-based detergents. The grey area is the contribution of all point sources, and therefore represents the maximum achievable reduction in the eutrophication risk that could be theoretically achieved by managing point source emissions.

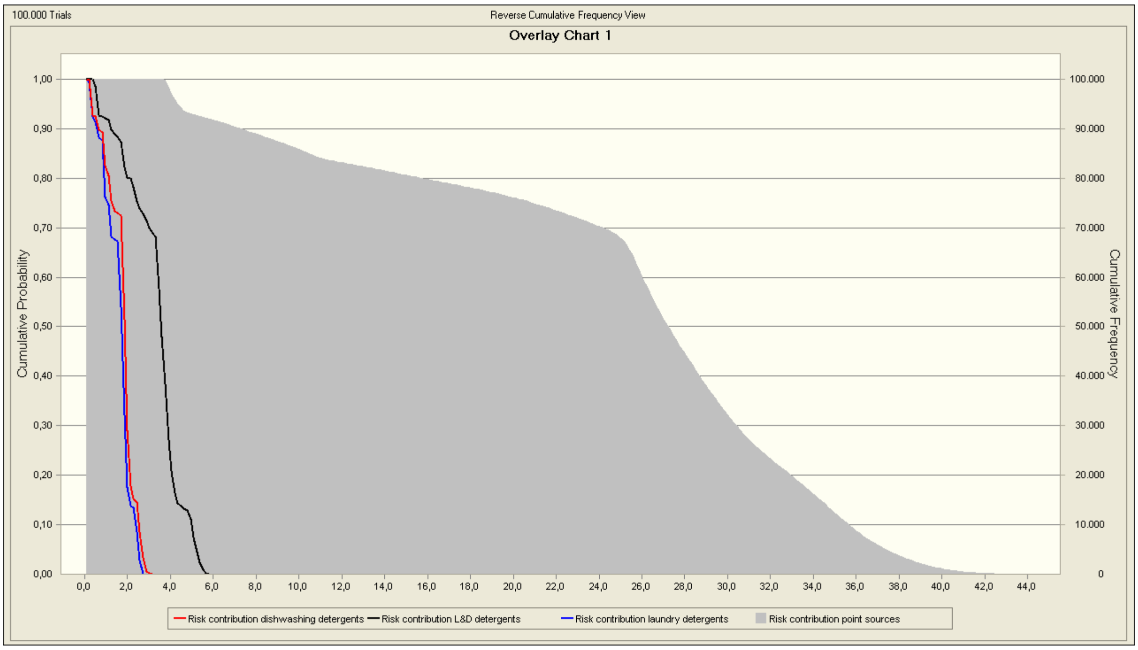


Figure 4.33. Exceedence curves for the estimated risk contribution for laundry (blue line), dishwashing (red line), laundry plus dishwashing detergents (blank line), and all point sources (grey area) in the Atlantic Ecoregion. The probability in the Y axis represents the likelihood for the contribution to be higher than the percentage represented in the X axis.

Table 4.9. Summary results for the contribution of detergents to the eutrophication risk in the Atlantic ecoregion.
Values are presented as percentages of the eutrophication risk.

Risk Contribution	**Mean**	**Median**	**10th Percentile**	**90th Percentile**
Laundry	1.5	1.6	0.5	2.3
Dishwashing	1.6	1.8	0.6	2.5
Laundry & Dishwash	3.2	3.5	1.2	4.9

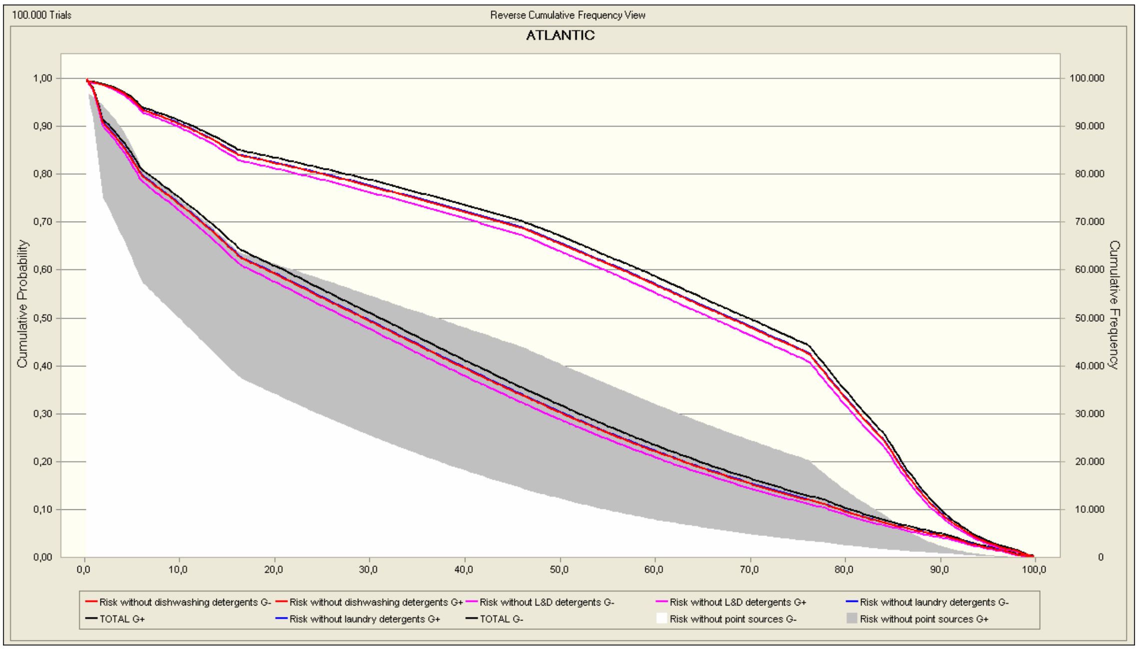


Figure 4.34. Comparative assessment of the generic eutrophication risk estimation for the Atlantic ecoregion. The risk is presented as a range, defined by the each set of lines with the same colour; the drift from the black lines represents the risk reduction obtained by extracting the contribution of laundry (blue lines), dishwashing (red lines) and both types (pink lines) of detergents respectively. The grey area defines the maximum reduction achievable by controlling point source emissions.

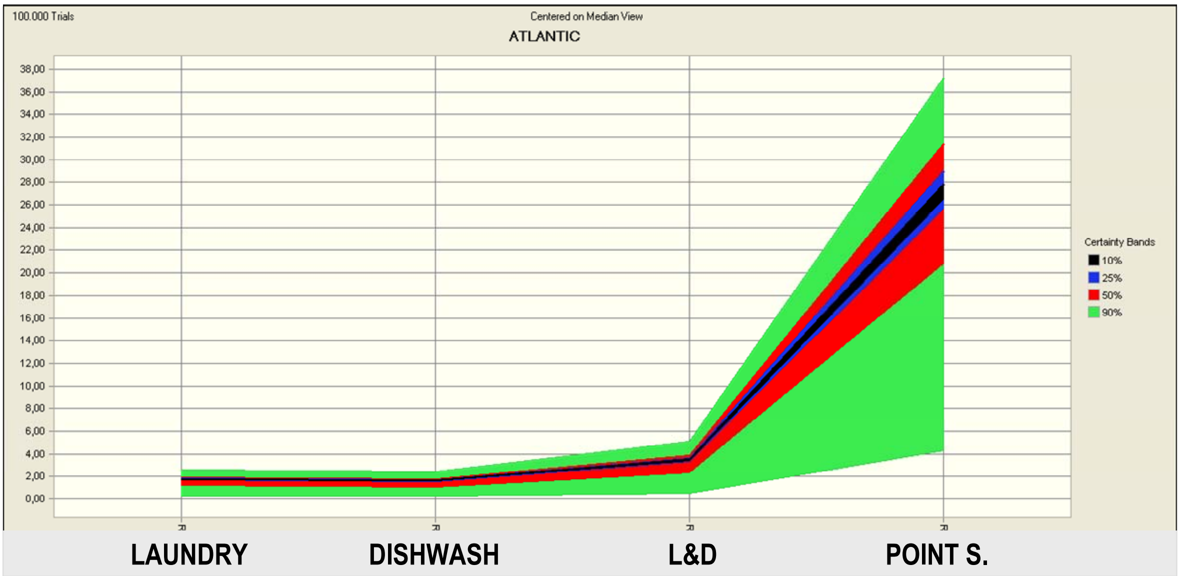


Figure 4.35. Trends in the reduction of the generic eutrophication risk estimation for the Atlantic ecoregion. The figure represents the 10th, 25th, 50th and 90th risk reduction percentiles obtained by extracting the contribution of dishwashing, laundry, both types of detergents, and the maximum reduction achievable by controlling point source emissions, respectively.

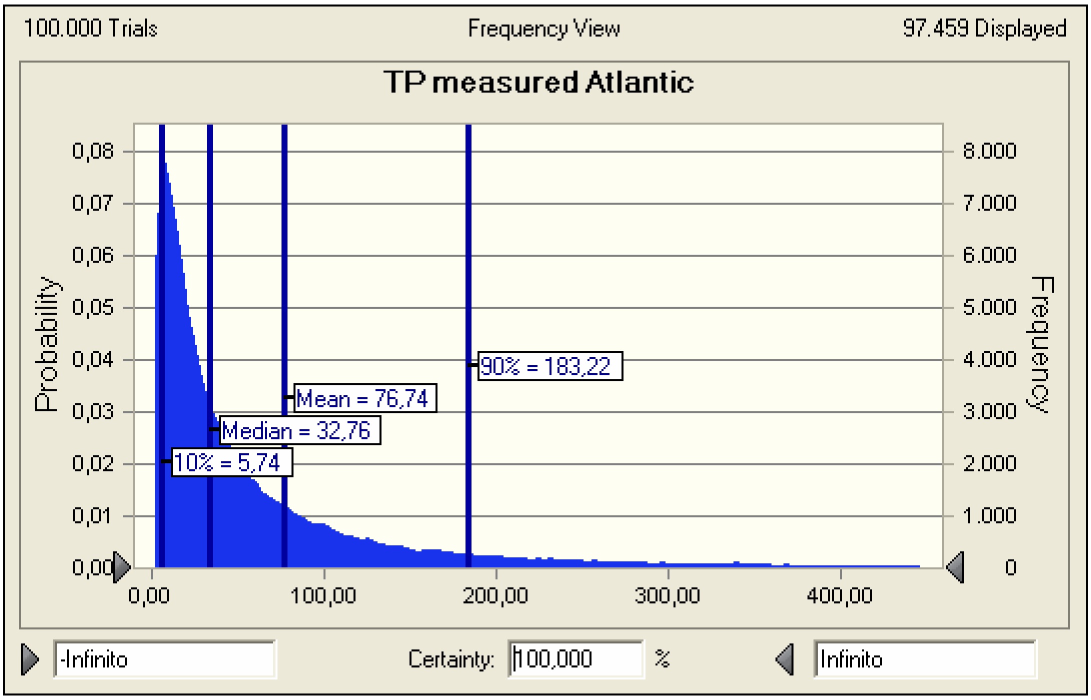


Figure 4.36. Distribution of TP employed for the probabilistic assessment of the eutrophication risk in the Atlantic ecoregion.

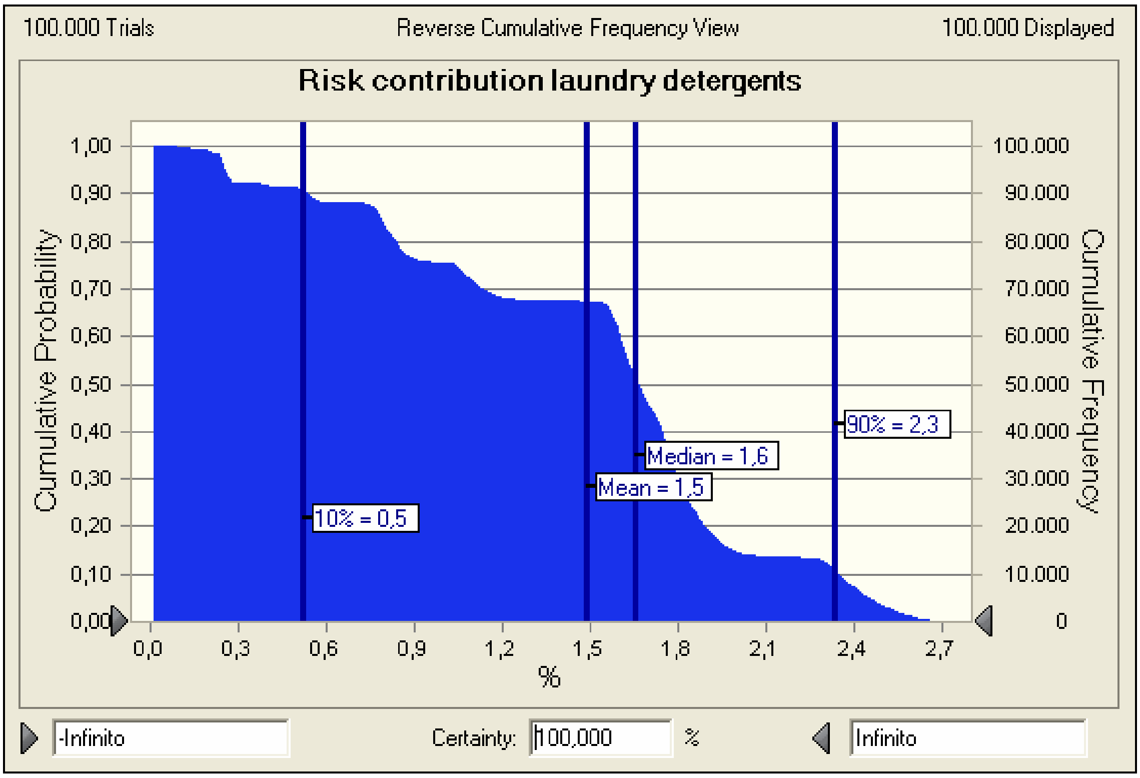
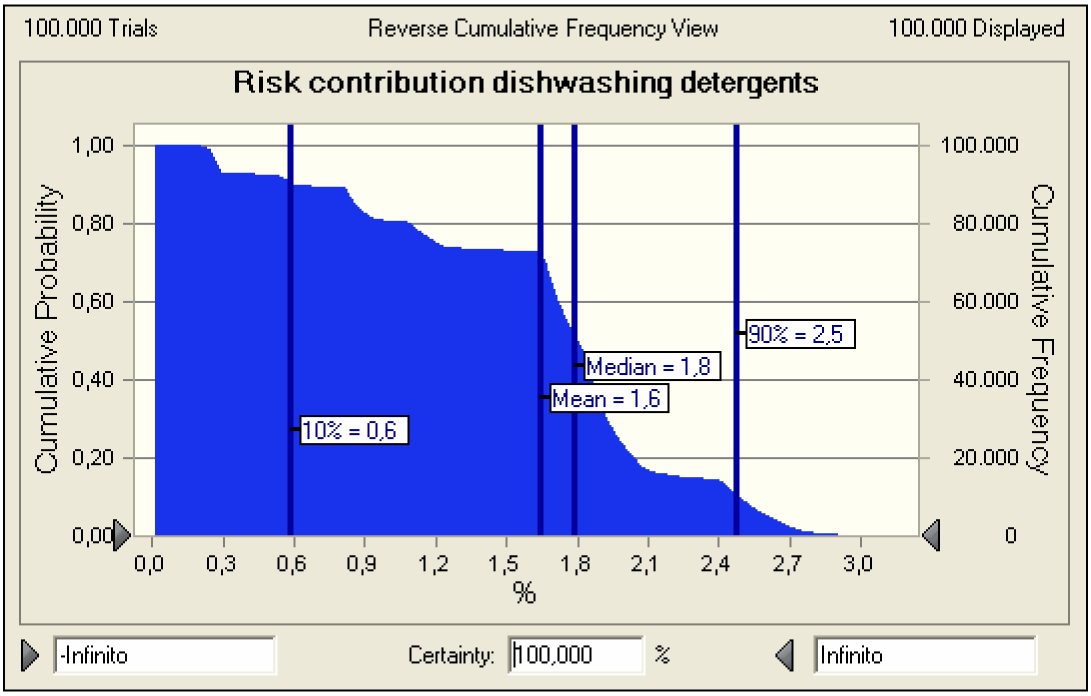


Figure 4.37. Probabilistic estimation of the contribution of P-based laundry detergents to the eutrophication risk in the Atlantic ecoregion.

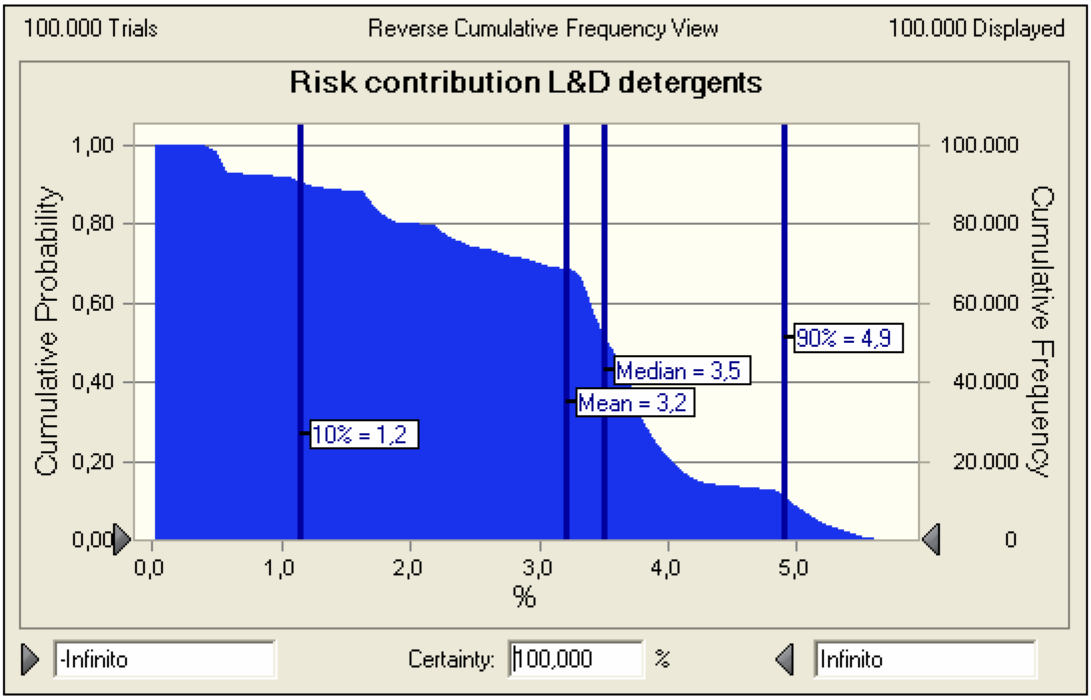


-Infinito

Certainty: 100,000 %

Infinito

Figure 4.38. Probabilistic estimation of the contribution of P-based dishwashing detergents to the eutrophication risk in the Atlantic ecoregion.



-Infinito

Certainty: 100,000 %

Infinito

Figure 4.39. Probabilistic estimation of the contribution of P-based laundry & dishwashing detergents to the eutrophication risk in the Atlantic ecoregion.

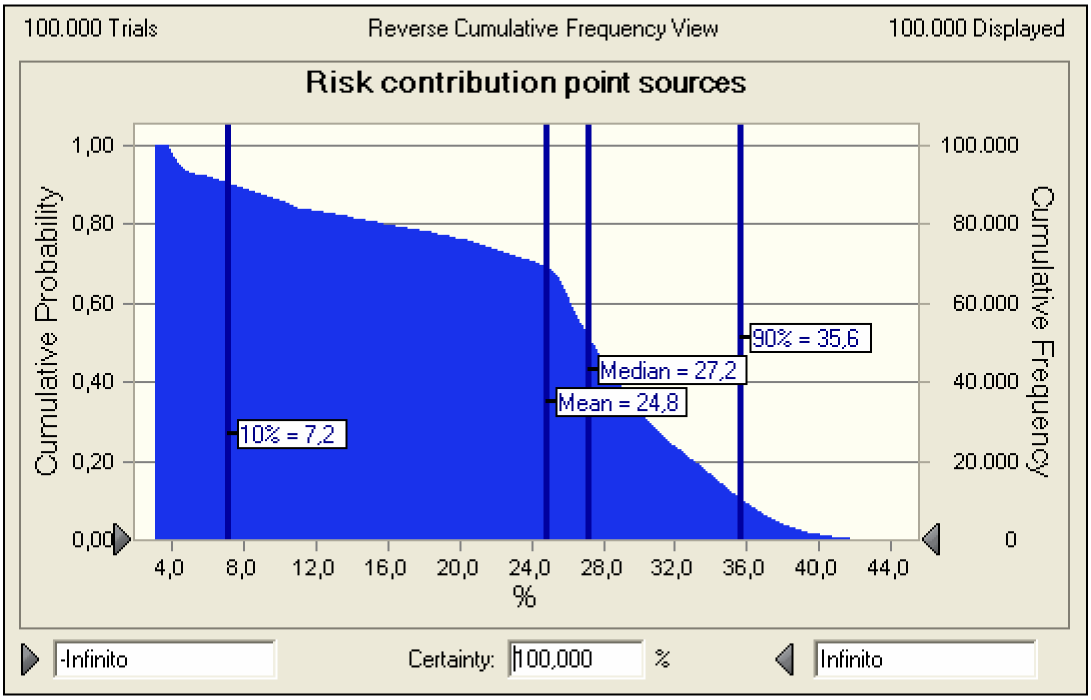


Figure 4.40. Probabilistic estimation of the maximum reduction achievable by controlling point source emissions to the eutrophication risk in the Atlantic ecoregion.

SECTION 5 COMPLEMENTARY STUDIES

The SCHER's opinion also suggested additional data sources, in particular EUROWATERNET and the REBECCA project. "*In order to improve the datasets the authors should obtain data from EUROWATERNET and the WFD intercalibration exercise as well as from the REBECCA project.*" The Scientific Committee also indicated the difficulties for combining data from different sources. "*Care should be taken in using these data, because they were derived using different sampling and analytical methods and may not be comparable in many instances.*"

The web page of the REBECCA project, and the Water Information System for Europe (WISE) portal, which expand the EEA EUROWATERNET, and other related web pages were searched. Large amounts of information are available however, the information, as presented in the public databases, was not suitable for the calibration and validation purposes of the model.

As an alternative, direct contacts with relevant organizations were organized under the initiative of DG Enterprise. Two main interactions were established, one with the Baltic scientific community, through the Baltic Nest Institute, and the other with the Danube scientific community, through the ICPDR (International Commission for the Protection of the Danube River).

The cooperation with the Baltic Nest Institute was established at the workshop held in Stockholm in 2008; the Institute provided a preliminary data set, which were analysed, and the results presented at the Madrid workshop. The cooperation with the ICPDR was offered at a meeting in Vienna, no information has been provided yet.

PRELIMINARY RESULS FOR THE BALTIC SEA

STATISTICAL ANALYSIS OF THE BALTIC DATA

INTRODUCTION

Following the workshop at the Baltic Nest Institute, it was agreed to explore the feasibility for developing the effect assessment and risk characterization part of an eutrophication risk model for the Baltic Sea. This development could by then used by the Baltic scientific community who has already developed models for covering the exposure of nutrients in general and phosphorous in particular.

The starting point was a compilation of data for the Baltic, producing a data set suitable for exploring the feasibility for developing such a model. It was agreed that any eutrophication model for the Baltic should not be based exclusively in phosphorous, but must consider simultaneously the role of phosphorous and nitrogen. Thus, the BNI provided INIA with a data base covering the different areas of the Baltic Sea, measured levels of TP and TN, and their own assessment on the eutrophication status of each water body. This information has been used for developing this preliminary proposal.

Time series of the annual basin-wide mean TN and TP concentrations in seven major basins were compiled. Empirical log-log relationships between nutrient concentrations and water transparency as indicator of the environmental status were used for the assessment. The maximum value of transparency reconstructed from both TN and TP time-series were compared to HELCOM's criteria to determine the status as "good" or "less than good".

This dataset does not fulfil some key criteria required for the proper application of the conceptual development which supports this eutrophication model. In particular, the status condition is not established from direct measurements of the biological community, but from calculations based on nutrient measurements. Thus, the results can be exclusively used for checking if the conceptual approach can be adapted and expanded to the Baltic Sea. Final conclusions regarding the concentration-risk relationships should not be established.

METHODOLOGY

A set of alternative proposals have been developed using an step approach, which increase progressively the complexity, and comparing the results obtained at each level.

The first alternative was the direct application of the approach developed by INIA and Green Planet for continental water bodies. This approach was not expected to give a proper result but was implemented for allowing comparisons with the other alternatives. The approach is also useful for checking if the continental model, although cannot offer a proper prediction of the Baltic situation, is or not protective.

The second alternative was an independent assessment of TP and TN, applying in parallel different statistical approaches to each nutrient.

The third step was the comparison of the independent results obtained for each nutrient and the combination of both nutrients into a single model.

The study has been done using STATGraphics and Crystal Ball programmes.

PRELIMINARY RESULTS

First step: conditional probability distributions for TP

The effect assessment and risk characterization for inland waters estimates the risk as a probability range. This range is defined by the conditional probability distributions p(TP | G+) and p(TP | G-), representing the distribution of TP concentrations in the sites with good and with less-than-good status respectively.

Therefore, the first step focused on estimating the conditional probability distributions p(TP | G+) and p(TP | G-) for the Baltic data base. The first step was to confirm that the conditional distributions for sites in good and less than good status represents statistically different sub-samples. The statistical results and the observed distributions are presented below.

```
Kolmogorov-Smirnov Test for Col_2 (Total Phosphorous) sorted by Good (Red line) or Less than
Good (Blue line) eutrophication status.
---------------------------------
Estimated overall statistic DN = 0.518981
Two-sided large sample K-S statistic = 3.8873
Approximate P value = 0.0
```

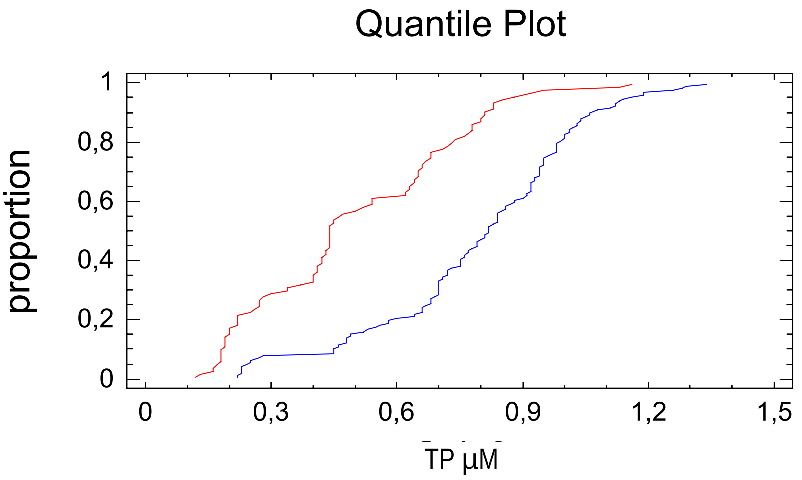


Figure 5.1. Comparison of the conditional distributions p(TP | G+) (red line) and p(TP | G-) (blue line).

Then, the possibility for fitting the data to a parametric distribution was explored. The goodness of fit was well below the selected p value of 0.05; thus the fitting was not accepted and the distribution of the raw data was selected; the mathematical implementation of these distributions was achieved through a set of linear interpolations of log-transformed data. The distributions and the raw data are presented in Figure 5.2.

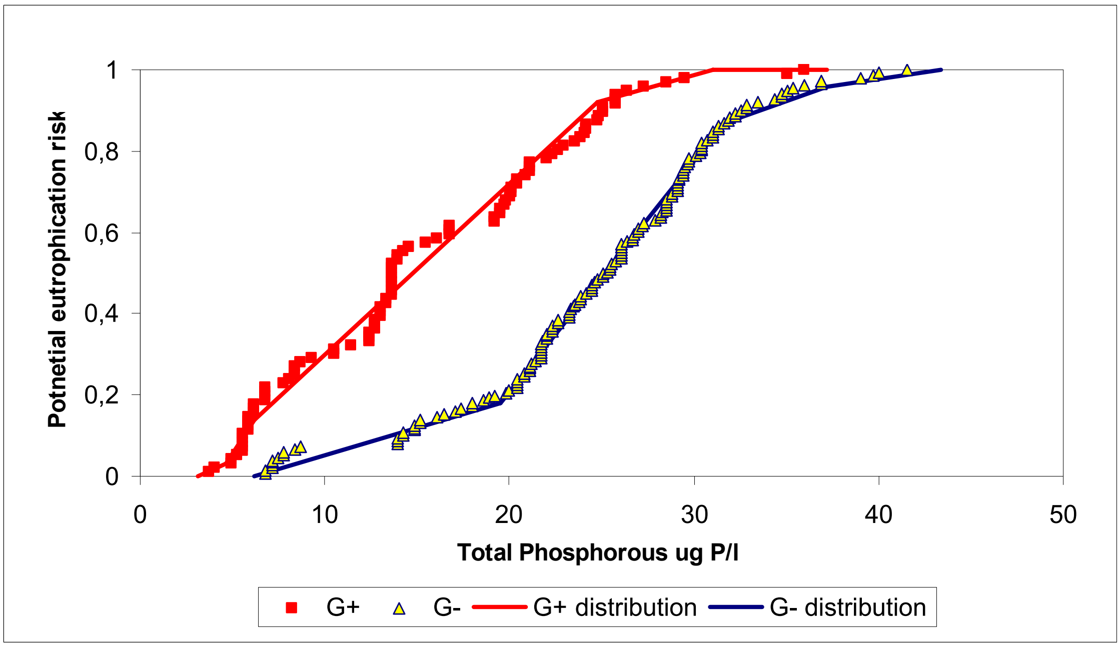


Figure 5.2. Selected conditional distributions p(TP | G+) (red line) and p(TP | G-) (blue line) and raw data cumulative frequency distributions.

For comparative purposes, Figure 5.3 presents the curves for inland waters (Northern and Central/Baltic ecoregions) produced in the JRC-INIA study, with those derived for the Baltic Sea.

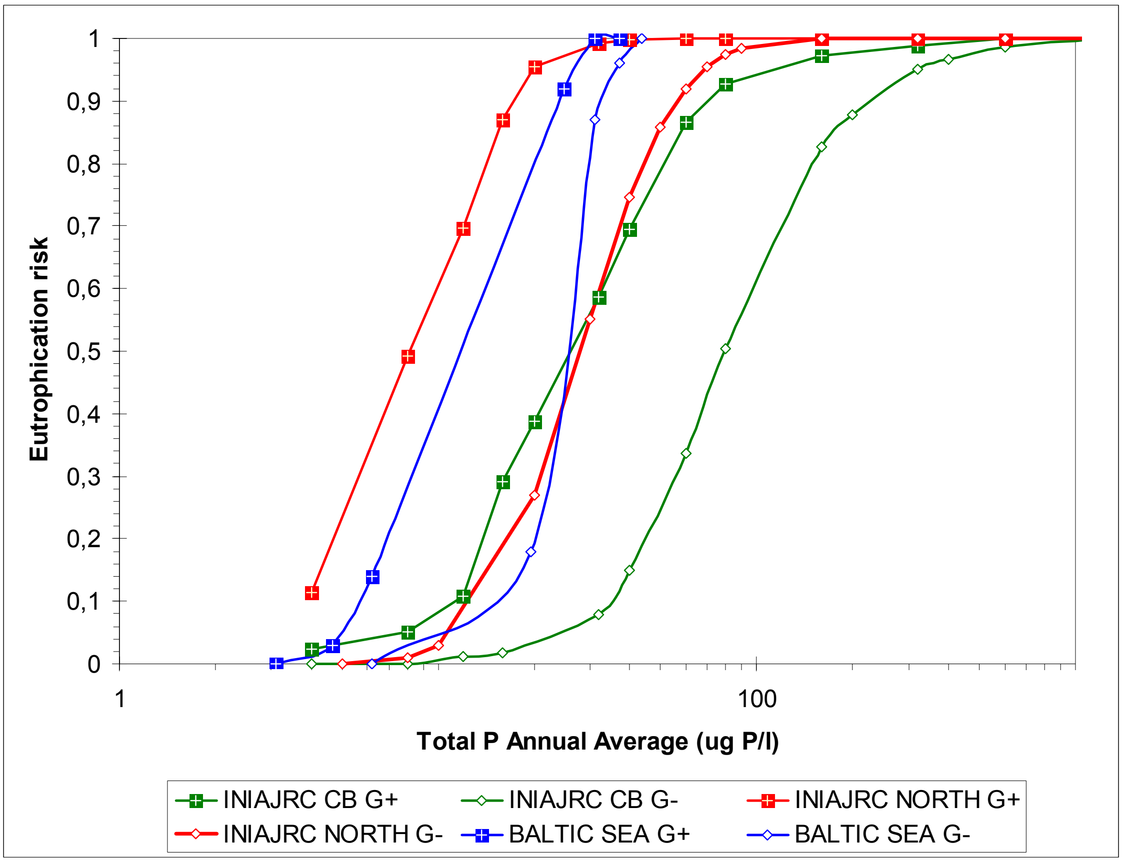


Figure 5.3. Conditional distributions p(TP | G+) and p(TP | G-) obtained for Northern inland waters (red lines); Central/Baltic inland waters (green lines) and the Baltic Sea (blue lines). For inland waters, the conditional distributions define the eutrophication risk range.

Second step: new conceptual model and parallel but independent assessments of TP and TN.

The use of the conditional distributions p(TP | G+) and p(TP | G-) and the derivation of an eutrophication risk range from those distributions in the case of inland water was required as the available information on could not be considered a random sample of water bodies within the area, as the water bodies had been specifically selected by their eutrophication status. In the initial INIA-Green Planet effect assessment database, the values were obtained from the open scientific literature, and the authors of each paper had selected a number of control and of potentially affected water bodies. The WFD Inter-calibration database provided by the JRC includes water bodies selected for covering the whole range of eutrophication status, and therefore cannot be considered a random sample. Thus in both cases the sample did not allowed the direct estimation of the eutrophication risk.

However, the database provided by the BNI offers a full coverage of the different areas of the Baltic Sea, and therefore, both the joint probability curve p(TP ∩ G-) and the probability distribution for TP p(TP), can be obtained. Considering the relationship between these probabilities, the conditional probability of a Baltic water body with a certain TP concentration for being in less than good status p(G-|TP) can be determined from the following equation:

$$p(G- \mid TP) = p(TP \cap G-) / p(TP)$$

This conditional probability could be used directly as an eutrophication risk index, and therefore, has been calculated from the provided Baltic data and is presented in Figure 5.4.

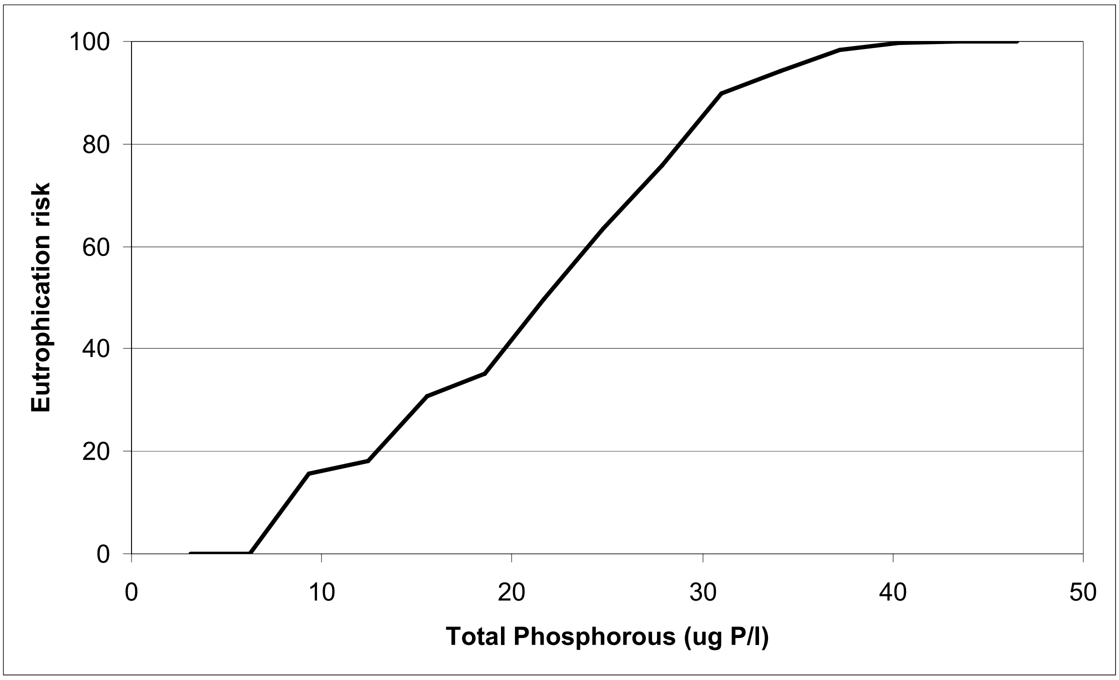


Figure 5.4. Conditional probability distributions p(G- |TP) representing the probability of being in less than good eutrophication status for a given TP.

Obviously, this line should be within the margins defined by the conditional probability distributions p(TP | G+) and p(TP | G-). The relationship among these three distributions is presented in Figure 5.5.

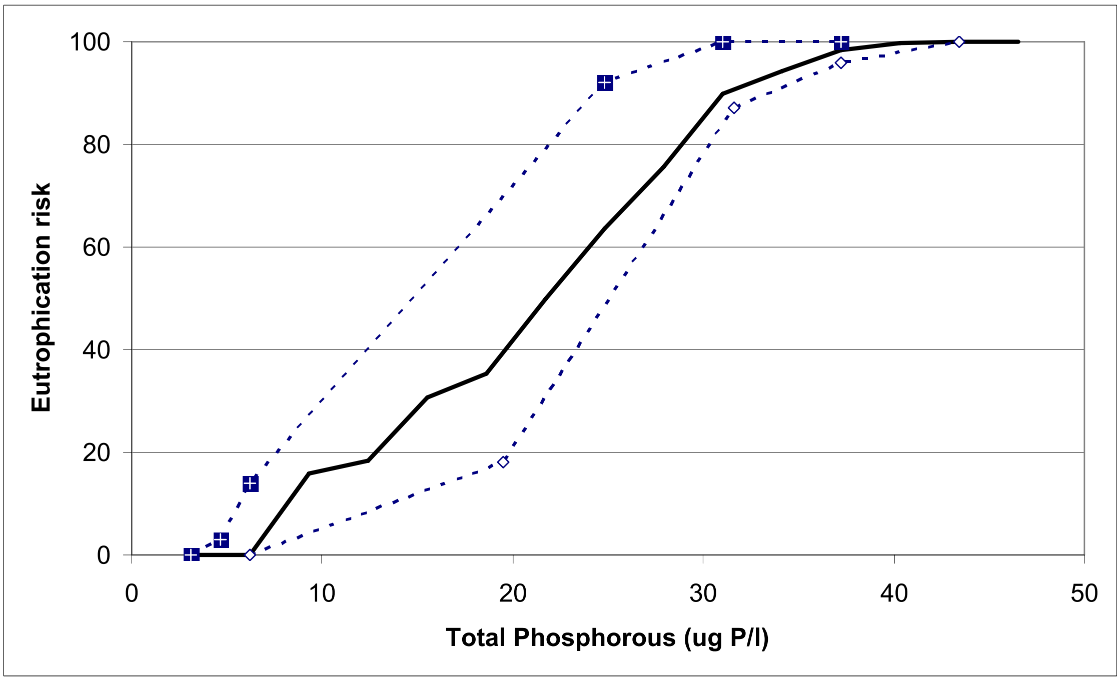


Figure 5.5. Comparison of p(G- | TP) (black solid line) with the conditional probability distributions p(TP | G+) and p(TP | G-) (blue lines).

A parallel assessment has been conducted for total nitrogen (TN). The equivalent distributions p(TN | G+) and p(TN | G-) where obtained for Total Nitrogen (TN). The main results are presented below. The Kolmogorov-Smirnov Test also identified statistically significant differences for TN between sites with good and less than good status.

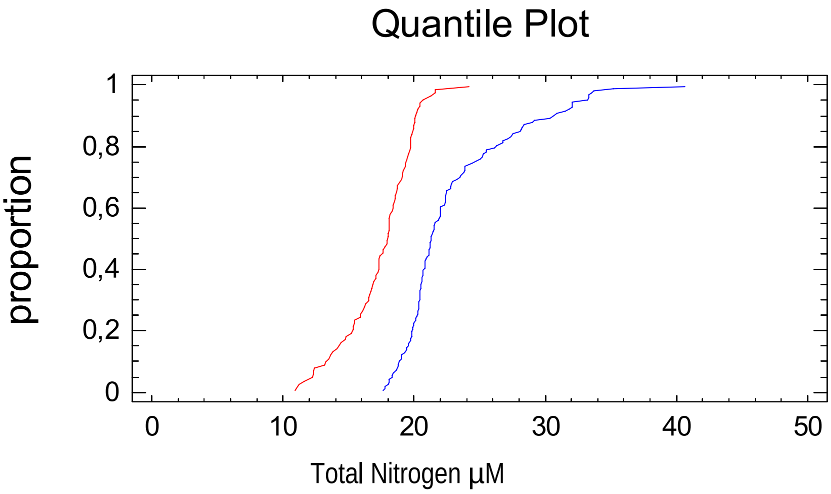


Figure 5.6. Comparison of the conditional distributions p(TN | G+) (red line) and p(TN | G-) (blue line).

Kolmogorov-Smirnov Test for Total Nitrogen sorted by Good (Red line) or Less than Good (Blue line) eutrophication status.

```
---------------------------------
Estimated overall statistic DN = 0.67662
Two-sided large sample K-S statistic = 5.06806
Approximate P value = 0.0
```

Then, the possibility of fitting the data to a parametric distribution was explored. The goodness of fit was well below the selected p value of 0.05; thus the fitting was not accepted and the distribution of the raw data was selected; the mathematical implementation of these distributions was achieved through a set of linear interpolations of log-transformed data. The distributions and the raw data are presented in Figure 5.7.

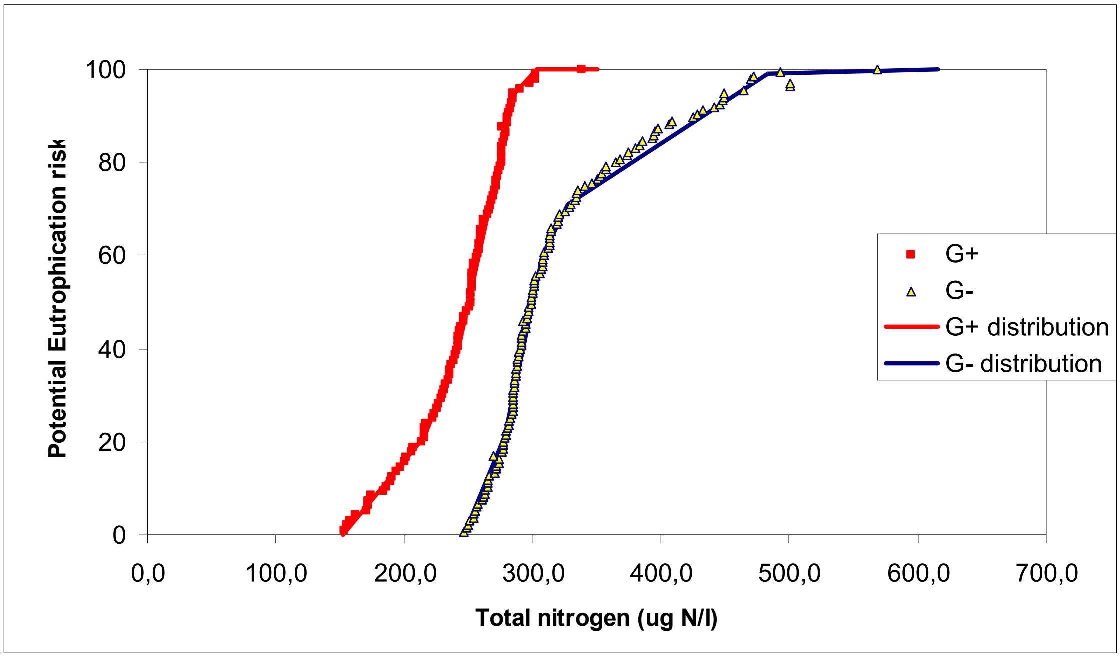


Figure 5.7. Selected conditional distributions p(TN | G+) (red line) and p(TN | G-) (blue line) and raw data cumulative frequency distributions.

As indicated for total phosphorous, the database provided by the BNI offers a full coverage of the different areas of the Baltic Sea, and therefore, both the joint probability curve p(TN ∩ G-) and the probability distribution for TN p(TN), can be obtained. Considering the relationship between these probabilities, the conditional probability of a Baltic water body with a certain TN concentration for being in less than good status p(G-|TN) can be determined from the following equation:

$$p(G- \mid TN) = p(TN \cap G-) / p(TN)$$

This conditional probability could be used directly as an eutrophication risk index, and therefore, has been calculated from the provided Baltic data and is presented in Figure 5.8.

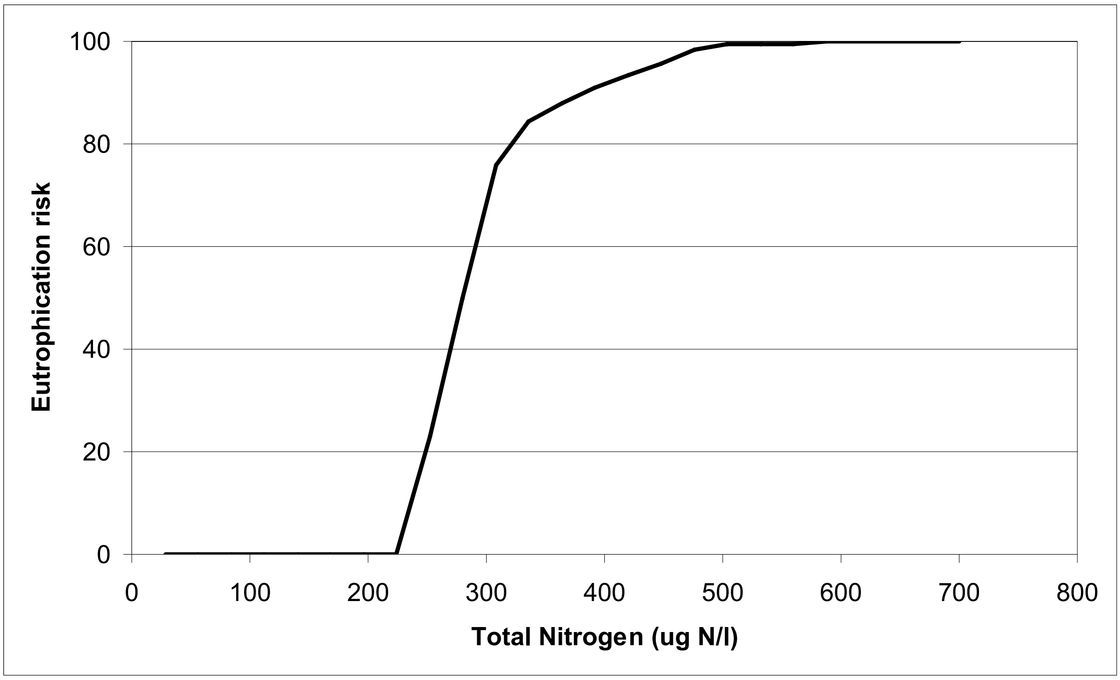


Figure 5.8. Conditional probability distributions p(G- |TN) representing the probability of being in less than good eutrophication status for a given TN.

Obviously, this line should be within the margins defined by the conditional probability distributions p(TN | G+) and p(TN | G-). The relationship among these three distributions is presented in Figure 5.9.

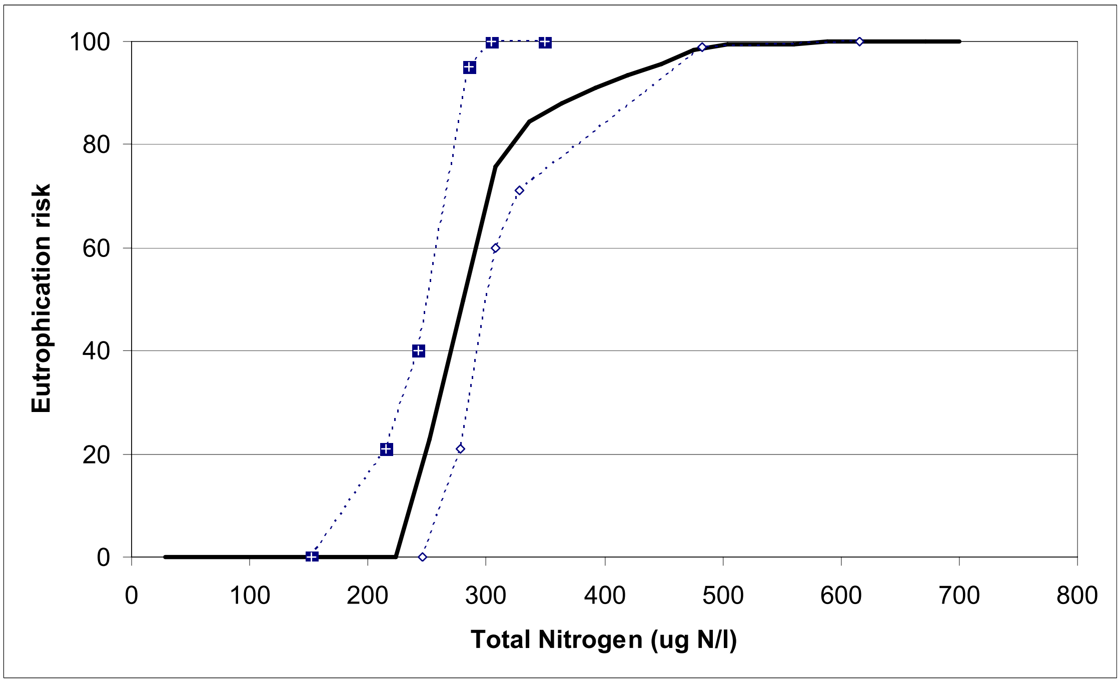


Figure 5.9. Comparison of p(G- | TN) (black solid line) with the conditional probability distributions p(TN | G+) and p(TN | G-) (blue lines).

Third step: comparison of the independent results obtained for each nutrient and combination into a single model.

The previous steps indicate that both, TP and TN, could have a contribution on the total risk. This third step was intended to identify some of the key elements of this relationship in order to prepare proposals to be tested with additional information.

The first assessment was to identify potential correlations among both parameters. A significant but week correlation was found between TP and TN, as presented in Figure 5.10, the linear correlation offered the best fit. The model explained about 25% of the variability.

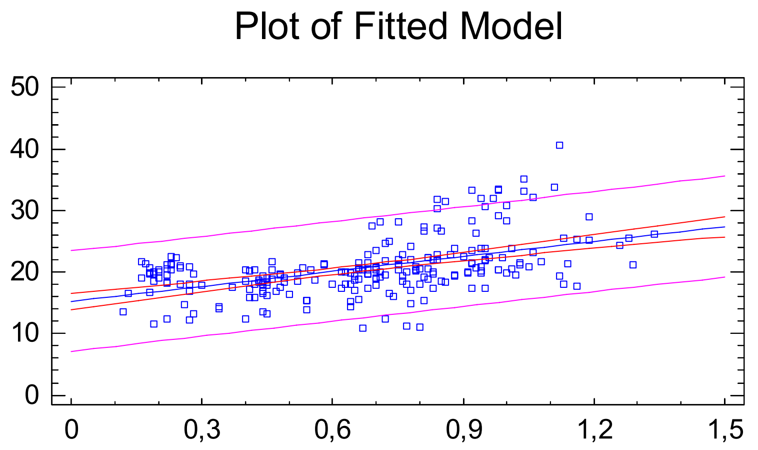


Figure 5.10. Linear correlation between TP and TN (concentrations are µM)

The parameters cannot be considered as independent variables, thus a set of alternative methods for combining TP and TN and establishing their relative relevance when quantifying the eutrophication risk have been considered and are presented here for discussion.

DIRECT GRAPHICAL EVALUATION

A set of screening analysis and graphical representations were performed; three figures have been selected below. Figure 5.11 presents a scatter plot of TP versus TN for sites in good and less than good status. The representation suggests that, at least for this data set, TN offers a clearer picture than TP, with two defined areas dominated by good status or by less than good status conditions, and a short interface, where both situations can be found.

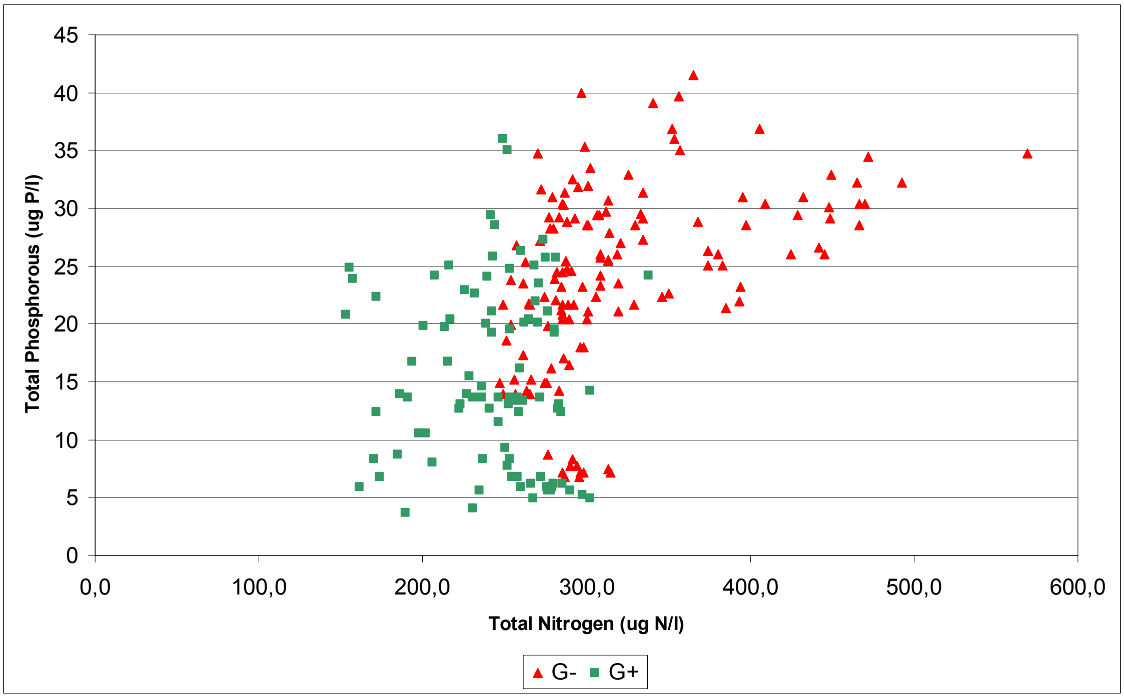


Figure 5.11. Scatter plot of TN vs TP concentrations in Baltic Sea sites with good (green squares) and less than good (red triangles) eutrophication status.

This information is confirmed by the frequency histograms, presented in Figures 5.12 and 5.13. For a model based on a single nutrient, the data would suggest that TN seems to be a better predictor of the eutrophication risk than TP.

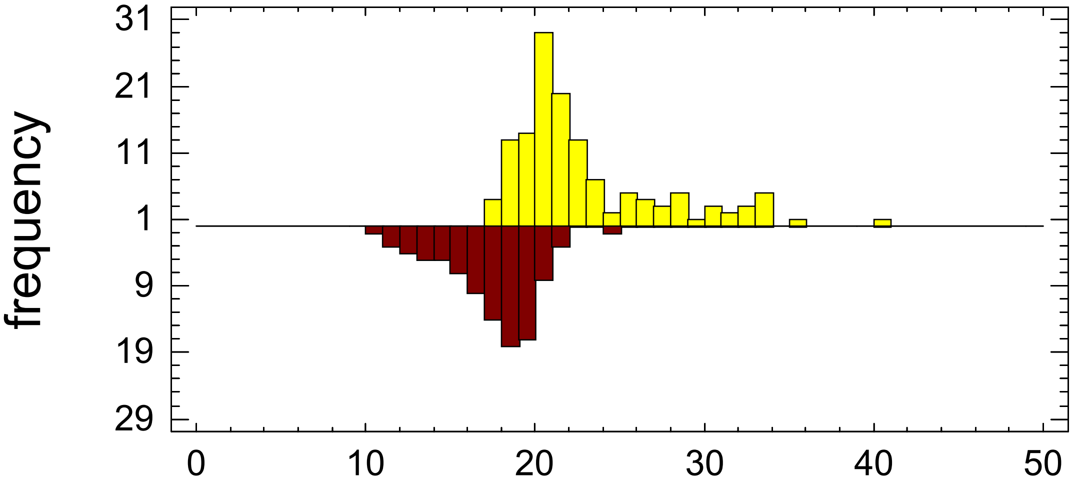


Figure 5.12. Frequency histograms describing the concentration of Total Nitrogen (µM) in sites with good (brown) and less than good (yellow) status.

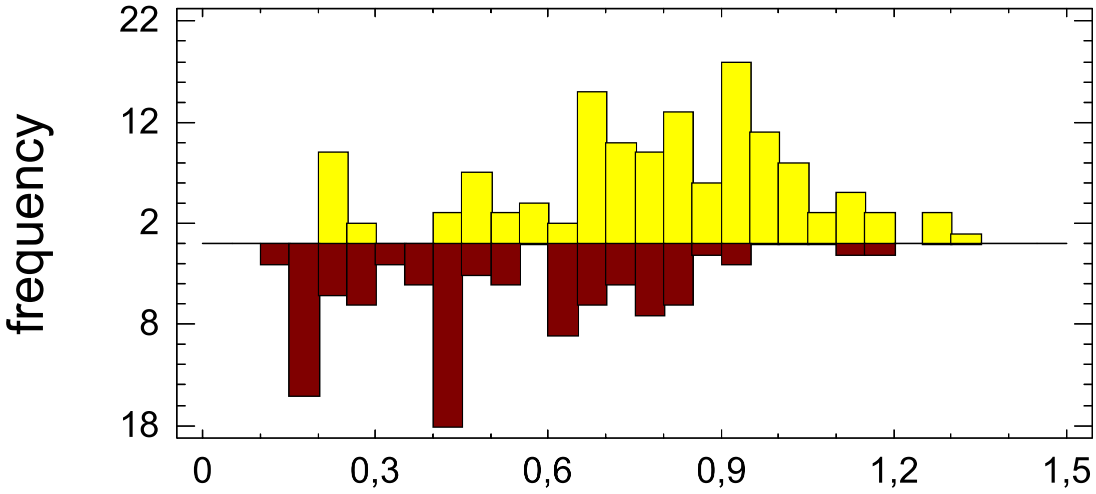


Figure 5.13. Frequency histograms describing the concentration of Total Phosphorous (µM) in sites with good (brown) and less than good (yellow) status.

Basically, the data indicate that TN can explain a significant part of the eutrophication status; rounding the values, sites with a TN value below 17 µM (or 245 µg N/l) are expected to be in good status, while sites with a TN value above 22 µM (or 305 µg N/l with one outlier at 338) are expected to be in less than good status.

Within the 17-22 µM (or 245-305 µg N/l) TN range, both situations are observed. Figure 14 presents the scatter plot of TN versus TP for this specific range. No clear influence of TP can be visually observed, as the tendency of red dots (sites in less than good status) is clearer from the bottom to the top than from the left to the right of the figure.

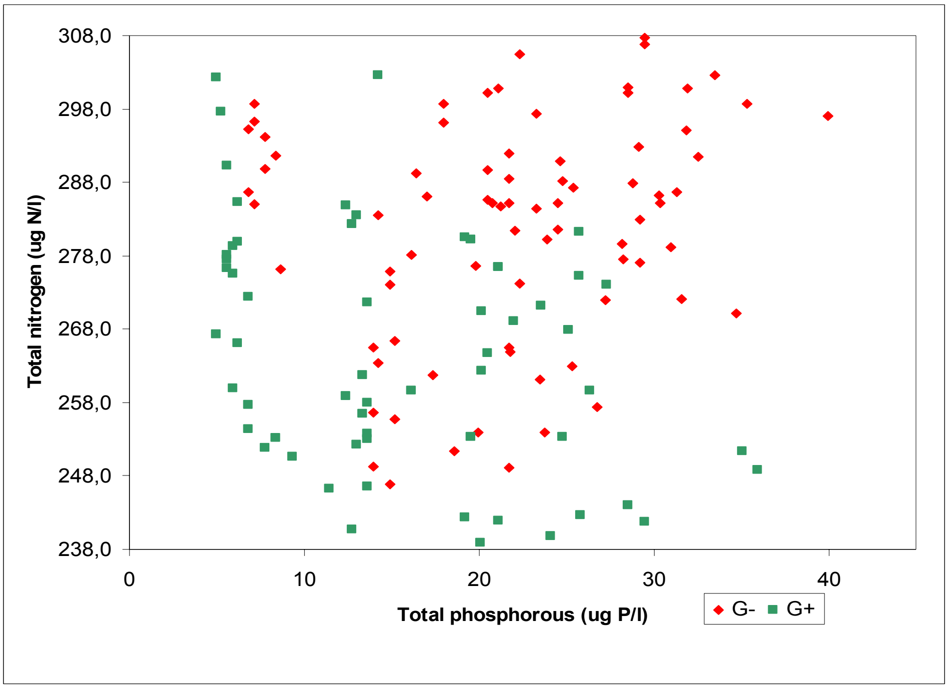


Figure 5.14. Scatter plot of TN vs TP concentrations in Baltic Sea sites with a TN concentration between 17 and 22 µM (equivalent to 238-308 µg N/l). Sites with good (green squares) and less than good (red triangles) eutrophication status are identified.

DISCRIMINANT ANALYSIS

The discriminant analysis capacity of STATGraphics was used to develop models for predicting the eutrophication status of Baltic sites on the basis TP and TN. The analysis was conducted for each nutrient and for a combination of both nutrients. The results are summarised in Table 5.1.

Table 5.1. Results of the discriminant analysis for predicting the eutrophication status of Baltic sites on the basis TP and TN

	Percent of cases correctly classified	Standardized Coefficient TP	Standardized Coefficient TN
TP and TN	80,95%	0,494	0,739
TP	73,59%	1	--
TN	81,82%	--	1
TP and TN for 17<TN<22	71,01%	0,629	0,824
TP for 17<TN<22	63,04%	1	--
TN for 17<TN<22	70,29%	--	1

Similar results were obtained using normalized data, and through the Tshuprow test after categorization of TP in four categories. The results confirm that for both, the total data set and the critical TN range, total nitrogen is a better predictor of the eutrophication status than total phosphorous.

MULTIPLE REGRESSION FOR SECCHI DISK VALUES

The eutrophication status classification proposed by the Baltic Nest Institute is based on the Secchi disk data. Thus, a multiple regression analysis has been conducted as a complementary tool for assessing the capability of TP and TN for predicting the eutrophication status. The

Predicted versus Observed plots for TP, TP+TN and TN are presented in Figure 5.15. The Observed versus Predicted graphics plots the observed values versus the predicted values for the dependent variable. The plot includes a line with slope equal to 1. If all the predictions are perfect, all the points should be on the line. The figure indicates that TN offers a better capability for predicting the Secchi disk value than TP.

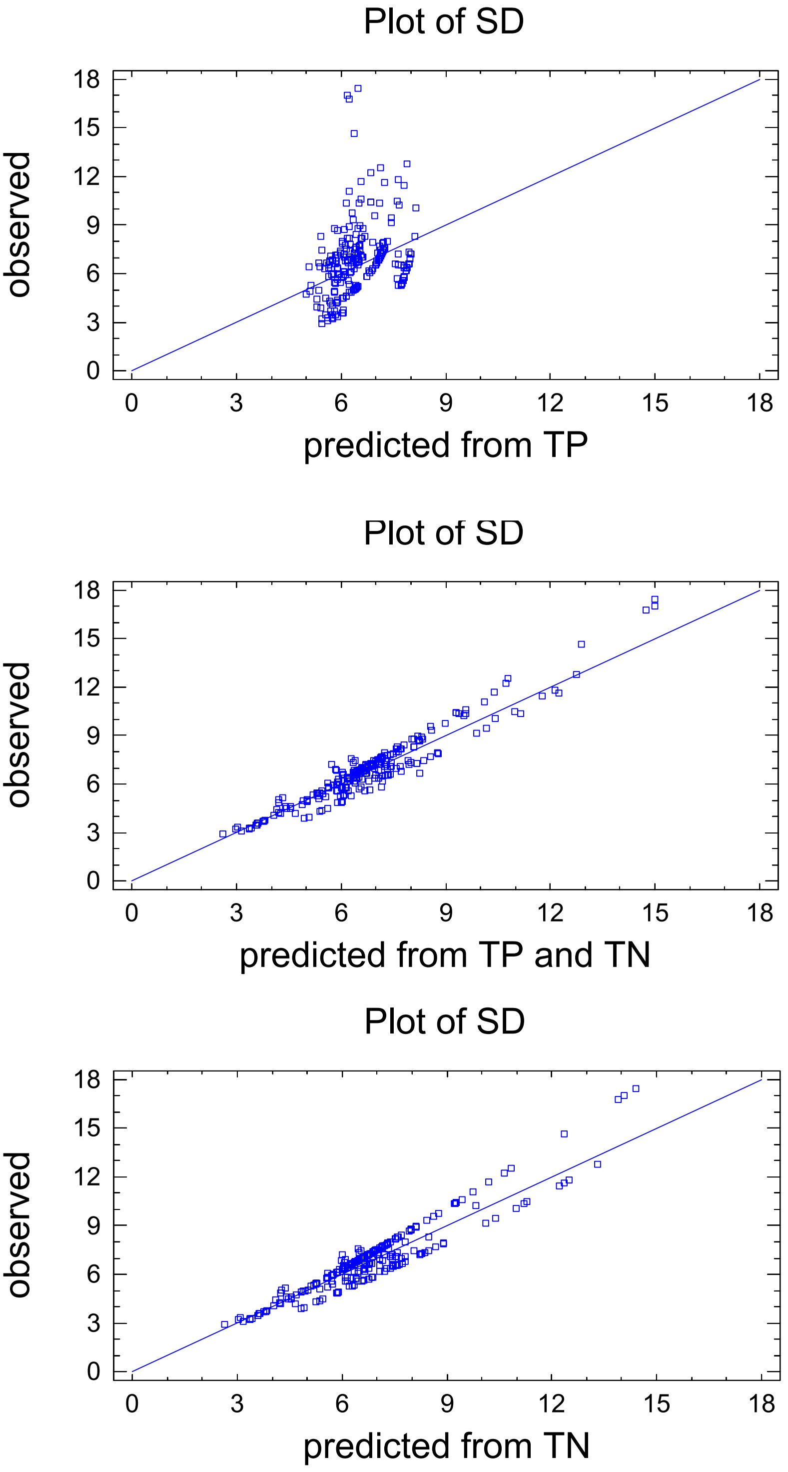


Figure 5.15. Secchi disk Predicted versus Observed values obtained from TP, TP+TN and TN.

The summary results for this analysis are presented below:

```
Multiple Regression Analysis
-----------------------------------------------------------------------------
Dependent variable: SD
Box-Cox transformation applied:  power = 1,0 shift = 0,0
-----------------------------------------------------------------------------
                                 Standard          T
Parameter          Estimate         Error       Statistic       P-Value
-----------------------------------------------------------------------------
CONSTANT              15,0043      0,347832       43,1367        0,0000
TP                1,22429      0,311615       3,92885        0,0001
TN              -0,431938     0,0188447      -22,9209        0,0000
-----------------------------------------------------------------------------

                       Analysis of Variance
-----------------------------------------------------------------------------
Source           Sum of Squares    Df  Mean Square    F-Ratio      P-Value
-----------------------------------------------------------------------------
Model                  840,99       2      420,495     298,82       0,0000
Residual               320,836    228      1,40717
-----------------------------------------------------------------------------
Total (Corr.)          1161,83    230

R-squared = 72,3852 percent
R-squared (adjusted for d.f.) = 72,143 percent
Standard Error of Est. = 1,18624
Mean absolute error = 0,782614
Durbin-Watson statistic = 0,527841 (P=0,0000)
Lag 1 residual autocorrelation = 0,647782
```

It should be noticed that the inclusion of TP in the model increases the R-squared from 70.4% (obtained for TN alone) to 72.4%; while the inclusion of TN in the model increases the R-squared from 8.75% (obtained for TP alone) to 72.4%.

DISCUSSION AND PROPOSAL FOR FURTHER ASSESSMENT

The analysis of the submitted data, representing mean values for each region within the Baltic Sea, suggests that the main contributor to the eutrophication risk in the Baltic Sea is TN, while TP plays a minor, although statistically significant, role. For a proper interpretation of these results, the basic conditions in the Baltic Sea should be considered. The first seasonal peak in primary production occurs all over the Baltic in the spring phytoplankton bloom that is driven by improving light conditions and high availability of nutrients following winter mixing. This bloom is terminated when inorganic nitrogen becomes limiting. The excess dissolved inorganic phosphorous left from the spring bloom is available to promote the mid-summer blooms of *Cyanobacteria* that are not limited by lack of nitrogen (Boesch et al., 2006). As the status is based on turbidity, and does not consider specifically the concerns on *Cyanobacteria,* the role of nitrogen may have been overestimated in this preliminary assessment.

It is suggested to check these results using a selection of non-averaged values. The proposal, under discussion with the BNI, is to select a random sample of raw data, and check the capability of the different alternatives for quantifying the eutrophication risk presented in this report, in particular:

- The eutrophication risk models (range and most likely value) for TP and TN respectively.
- The models for predicting the eutrophication status based on TP, TN and TN+TP obtained through the discriminant analysis
- The models for predicting the Secchi Disk value based on TP, TN and TN+TP obtained through the multi-regression analysis.

In addition, it is suggested to conduct a similar set of estimations using cyanobacterial blooms as the parameter for defining the eutrophication status; this estimation may identify the complementary roles of TN and TP in the assessment of the Baltic Sea situation.

UPDATED RESULS FOR SELECTED RIVER BASINS

The previous report (De Madariaga et al., 2007) included specific risk estimations for selected sites of the Tajo and Ebro Rivers in Spain and for the Danube River, based on public information and monitoring data.

For the development of the Tajo and Ebro scenarios basic information on the catchments characteristics was collected. This information was available at the public websites of the Water authorities of Tajo and Ebro rivers (Tajo Hydrographical Confederation (Confederación Hidrográfica del Tajo, C.H.T., www.chtajo.es) and Ebro Hydrographical Confederation (Confederación Hidrográfica del Ebro, C.H.E., www.chebro.es). Main river basin characteristics are presented in the following table (Table 5.2).

Table 5.2. Main river basin characteristics of Tajo and Ebro rivers.

	Tajo River[a]	**Ebro River[b]**
Catchment area (ha)	5,581,000[c]	8,553,420[d]
Population (inhabitants)	6,094,000	2,955,238
Mean annual discharge (Hm^3/y)	12,230 (356 m^3/s)	18,217 (578 m^3/s)
Arable land[e] (%)	33	41

a Information from the website of the Tajo Hydrographical Confederation (Confederación Hidrográfica del Tajo, C.H.T.). Available at www.chtajo.es.

b Information from the website of the Ebro Hydrographical Confederation (Confederación Hidrográfica del Ebro, C.H. E.). Available at www.chebro.es.

c Catchment area in Spain. The risk results and calculations are referred to the Spanish part of the river, which covers 69.2% of the total catchment area.

d Total catchment area. A small part (< 2%) of the catchment is located in Andorra and France. The risk results and calculations are referred to the total catchment area.

e Percentages of land uses were estimated from public data on Spanish agricultural annual census(MAPYA, 2003).

The case study of the Danube river basin scenario is developed using monitoring data for two river stations at the mouth of the Danube, and the UBA (Schreiber et al. 2003) estimation of detergents contributions in the catchment calculated with the MONERIS model. The contribution of P from detergents to the overall emission in the UBA report is presented for the whole river basin, and therefore, can be applied to the sampling stations located in the final part of the river basin.

The information was obtained from the International Commission for the Protection of Danube River (ICPDR), which commissioned the EU-project called “Danubs” and produced the report on “Harmonised inventory of point and diffuse emissions of nitrogen and phosphorus for a transboundary river basin” (Schreiber et al. 2003). The information was based on estimations and measures obtained with the GIS-based MONERIS model. The ICPDR set up the Trans National Monitoring Network (TNMN), whose annual reports are published in their website (www.icpdr.org).

Real monitoring TP values were used, as in the former catchment examples, using the stations located in the final part of the Danube river, because the contribution of P-based detergents is only reported for the whole river basin. A 12% contribution of detergents over the total emission of P for the entire catchment, and being diffuse sources one half of the total emission to the Black Sea, these are the values to estimate the percentages of TP concentrations from each source. Two river stations were selected to run the risk model (see Table 5.3).

Table 5.3. Summary of main characteristics of selected Danube river stations.

River-Station	TP conc. (µg/l)	River flow (m^3/s)	Upstream Area (ha)	Pop. Den. (inh/ha)	Arable land (%)
Pristol-Novo Selo	90	3825	80578300	0.92	38
Reni-Chilia arm	120	5021	115437200	0.96	42.5

Table TP conc. = Total Phosphorus annual average concentration monitored in 2003 (TNMN Yearbook 2003).

TP concentrations from detergents, other than point and diffuse sources are estimated by applying the percentages, 12, 38 and 50% respectively to the annual average concentration measured in each sampling station.

The estimations presented in the 2007 report have been updated using the recalibrated risk-response curves for the Mediterranean (Tajo and Ebro Rivers) and the Central/Baltic (Danube River) ecoregions. The results are summarised in Table 5.4.

Table 5.4 . Summary of the results obtained for the different River Basin scenarios.

Catchment/Station	Detergent contribution		TP conc.	Risk contribution from detergents			
	Laundry	Dishwashing		Laundry		Dishwashing	
	%	%	µg/l	p(TP|G+)	p(TP|G-)	p(TP|G+)	p(TP|G-)
Tajo – Trillo	2.5	2.4	36	0.8	0.7	0.8	0.7
Tajo – Aranjuez	1.9	1.9	98	0.1	0.6	0.1	0.6
Tajo – Polan	4.1	4.1	1370	0	0	0	0
Tajo – Alcantara	5.6	5.5	295	0.4	1.1	0.4	1.1
Ebro – Miranda	1.3	1.3	36	0.4	0.4	0.4	0.4
Ebro – Mendavia	3.4	3.3	166	0.2	0.7	0.2	0.6
Ebro – Zaragoza	3.2	3.2	173	0.2	0.6	0.2	0.6
Ebro - Tortosa	2.9	2.9	129	0.2	0.9	0.2	0.9
Danube - Pristol	6	6	90	0.4	2.9	0.4	2.9
Danube - Reni	6	6	120	0.4	2.9	0.4	2.9

DISCUSSION OF THE RESULTS AND CONCLUSIONS

The results presented in this report confirm the capability of the new conceptual model for assessing the potential eutrophication risk associated to nutrient emissions and, in particular, to phosphorous, that has been developed in this project. The development is based on generic risk analysis concepts as applied to chemical substances: the independent assessments of exposure and effects are combined in a risk characterization phase (ECB, 2003; SSC, 2003); however, a new conceptual model has been required for quantifying the eutrophication risk.

The original exposure assessment was a simplified generic river basin model. Diffuses P sources where estimated from emission coefficients (Lasevils and Berrux, 2000; Hilton et al., 2002; Hanrahan et al., 2001; De Wit and Bendoricchio, 2001). The use of these generic (average) export coefficients is only appropriate for relatively large river basins. The use of generic factors for relatively small river basins requires the inclusion of a “slope factor” to differentiate export coefficients accounting for differences due to erosive processes (see Vighi et al., 1991); or alternatively, the use of GIS based models with coefficients adapted to the land characteristics, the approach used in several recent models such as MONERIS (Schreiber et al., 2003). These approaches have not been required for the calculations conducted within this generic and pan-European study which focus on large river basins, but should be implemented if the approach is extended to lower scale assessments.

The main point source, human metabolisms, was addressed using a generic default value of 1.5 g per person and day (Lasevils and Berrux, 2000; Zessner and Lindtner, 2005). The contribution of P-based laundry and dishwashing detergents has been estimated from the data provided by the International Association for Soaps, Detergents and Maintenance Products (AISE, www.aise-net.org) (See Annex 1).

The European Rivers Network (ERN) website (ERN, 2006), the WISE portal (WISE, 2009) and EUROSTAT (2009), were used for getting information on river basins, river flow, population densities and land uses.

As demonstrated in the previous report (De Madariga et al., 2007), the simplified model overestimated the TP concentration, as the sedimentation process is not included in the estimations. Thus, the simplified model has been used exclusively for assessing the relative contribution of P-based detergents versus other P sources. Obviously, the consumption of P-based detergents represents the main factor for assessing this relative contribution, seconded by the ratio between point and diffuse sources which depends on different factors (Djodjic et al., 2002; Ulen and Jakobsson, 2005; Bowes et al. 2005).

The effect assessment has been based on the principles established by the Water Framework Directive. The classification of “G+” is assigned to situations fulfilling the criteria for Good eutrophication status conditions under the WFD. If the conditions were not fulfilled, the water body was classified in the Less than good status category “G-“. For the INIA database, the classification was based in the ECOSTAT (2004) criteria, combining all reported information available on the conditions of the biological community. The assignments were confirmed by a set of complementary assessments, including the Morphoedaphic index (MEI) method (Vighi and Chiaudiani, 1985). In the WFD IC dataset provided by the JRC, the status was assigned using boundaries established for the different ecoregions and ecotypes (Poikane, 2008).

The effect assessment phase aims to establish the relationship between the phosphorous concentration and the eutrophication response. Due to the large number of variables and factors influencing the eutrophication status, probabilistic approaches were selected; therefore, the aim of the effect assessment was to develop relationships between TP and the likelihood for being in less than good status. These relationships were developed from the conditional probabilities p(TP|G+) and p(TP|G-) describing the distribution of TP in sites with good and less than good status respectively. Conditional probability distributions describing the opposite situation, e.g. p(G-|TP) have been proposed for setting eutrophication thresholds (Paul and McDonald, 2005; Paul and Zheng, 2008); these approaches were unfeasible in this study as the databases could not be considered a random representation of the overall population.

The proposed conceptual model and its methodological application can be used for very different purposes. This report presents the application to generic assessment at the Pan-European level. In addition, the model can be used for a comparative assessment of different management options, analysing different alternatives resulting in a variety of medium and long-term future scenarios.

The model has been implemented using Monte Carlo analysis for covering the variability and uncertainty. As the model has been developed using an Excel datasheet, the probabilistic implementation for one and two dimensions Monte Carlo Analysis can be easily obtained from commercially available software tools such as Crystal Ball.

The risk communication exercise confirmed that the results of these risk estimations should be presented in a proper way for avoiding misunderstandings. The preferences and requirements identified in the expert consultation indicate that the risk characterization should present as much information as possible including the information on the uncertainty, even if the overall amount of information requires the use of complex approaches.

An additional element for the risk communication strategy is associated to the perception of the magnitude of the risk. The use of relative percentages has been recommended by some authors (e.g. Windhorst et al., 2004; Kannen et al., 2004).

UPDATED ESTIMATIONS OF THE CONTRIBUTION OF DETERGENTS TO THE EUTROPHICATION RISK

The examples presented for the specific estimations offer a quantitative estimation of the relative contribution of P-based detergents using average conditions and three pre-selected levels of TP. A summary of the results is presented in Table 6.1.

Table 6.1. Results obtained for the different generic scenarios. The table shows the detergent contribution in percentage to the total P load in the catchment; the three selected levels of annual average total P concentration, and the difference between the total risk and the risk without P-based detergents.

(This difference is presented as a range covering the upper and lower bounds of the risk estimations).

Example	Ecoregion	Detergent contribution		TP conc.	Risk contribution from detergents		
		Laundry	Dishwash		Laundry	Dishwash	Both
		%	%	µg/l	%	%	%
1	Atlantic	5.8	6.4	50	0.7-1.8	0.8-1.9	1.5-3.8
2	Atlantic	5.8	6.4	150	0.4-1.8	0.5-1.9	0.9-3.8
3	Atlantic	5.8	6.4	300	0.4-1.2	0.5-1.3	0.9-2.5
4	Central/Baltic	6.3	6.7	50	3.0-3.1	3.2-3.3	6.4-6.6
5	Central/Baltic	6.3	6.7	150	0.4-3.1	0.4-3.3	0.9-6.6
6	Central/Baltic	6.3	6.7	300	0.1-1.0	0.1-1.1	0.3-2.2
7	Northern	4.9	6.7	50	0.0-3.2	0.0-4.5	0.1-7.9
8	Northern	4.9	6.7	100	0.0-0.1	0.0-0.2	0.0-0.5
9	Northern	4.9	6.7	150	0.0-0.1	0.0-0.2	0.0-0.3
10	Mediterranean	4.8	3.8	50	0.6-1.6	0.4-1.1	1.1-2.8
11	Mediterranean	4.8	3.8	150	0.4-1.6	0.3-1.1	0.7-2.8
12	Mediterranean	4.8	3.8	300	0.4-1.0	0.3-0.8	0.7-1.8

Complementary results are obtained through the probabilistic assessments conducted for each ecoregion. The results are summarised in Table 6.2. For facilitating the comparison of the results obtained for each ecoregion, the table presents the outcome of the estimations conducted for the concentration-risk curves obtained for the whole ecoregion using the chlorophyll a boundaries for establishing the ecological status. As presented in section 4, minor differences are observed when using the available alternative concentration-risk curves: the ecotype specific curves for the Central/Baltic and Northern ecoregions, and the curve obtained using the macrophytes boundary for the Northern ecoregion. These differences do not modify the proposed conclusions. The comparison of the estimations obtained for the different ecotype concentration-risk curves obtained for each ecoregion offers an estimation of the expected uncertainty of the results associated to the fitting of raw data to the conditional distributions. As the concentration-risk curves have an "*S*" shape, with the slope increasing and then decreasing along the phosphorous concentration gradient, the use of a more or less sensitive risk-response curve may either increase or decrease the relative contribution of detergents to the eutrophication risk, depending on the TP concentration for which the risk contribution is estimated. For example, in the case of the Northern ecoregion, the use of the ecotype concentration-risk curves slightly increases the detergents contribution, while the use of the macrophytes concentration-risk curve slightly decreases this contribution. For the central estimations, for which the uncertainty reaches minimum values, all estimations are close, with maximum differences of about 1 unit in the percentage of the eutrophication risk assigned to the detergent contribution.

Table 6.2. Summary results for the contribution of detergents to the eutrophication risk in the four ecoregions. Values are presented as percentages of the eutrophication risk.

ATLANTIC ECOREGION				
Risk Contribution	**Mean**	**Median**	**10th Percentile**	**90th Percentile**
Laundry	1.5	1.6	0.5	2.3
Dishwashing	1.6	1.8	0.6	2.5
Laundry & Dishwash	3.2	3.5	1.2	4.9
CENTRAL/BALTIC ECOREGION				
Risk Contribution	**Mean**	**Median**	**10th Percentile**	**90th Percentile**
Laundry	3.1	0.8	0.0	9.6
Dishwashing	2.7	3.1	0.6	4.8
Laundry & Dishwash	5.8	4.5	2.0	10.4
NORTHERN ECOREGION (Chlorophyll a boundaries)				
Risk Contribution	**Mean**	**Median**	**10th Percentile**	**90th Percentile**
Laundry	2.0	1.9	0.3	3.2
Dishwashing	3.3	3.6	0.6	4.9
Laundry & Dishwash	5.3	5.7	1.0	8.0
MEDITERRANEAN ECOREGION (Excluding Cyprus and Malta)				
Risk Contribution	**Mean**	**Median**	**10th Percentile**	**90th Percentile**
Laundry	1.2	0.9	0.0	3.2
Dishwashing	1.1	1.1	0.0	1.9
Laundry & Dishwash	2.3	1.7	0.5	4.5

The results indicate that within each ecoregion, the contribution of P-based detergents to the eutrophication risk mostly depends on three main factors: a) the use patterns of P-based detergents in the area; b) the relative contribution of point and diffuse sources; and c) the total phosphorous concentration.

Factors a) and b) depends on a combination of variables, including total use of detergents (laundry and dishwashing), relative contributions of P-based and P-free formulations, population density, level of removal of phosphorous at the sewage treatment plants, and land uses.

For the perspective of this study all these variables can be combined in a single number which aggregates factors a) and b): the overall detergent contribution to the emission of phosphorous. The estimation for the Danube River Basin is that 42% of phosphorous emissions are related to point sources with and estimated detergents contribution of 12% (Schreiber et al., 2003; 2005). Different authors have quantified the contribution of point sources in several European river basins; published values include 70% for the Vistula River (Kowalkowski and Buszewski, 2004); 40% for the Odense River (Kronvang et al., 2003); 37% for the Krka River (Drolc et al., 2007); 33% for the Lake Peipsi/Chudskoe drainage basin (Mourad et al., 2006), or 23% for the Weser River (Hirt et al., 2008). It should be noted that in diffuse-dominated river basins, large seasonal variations are expected, with an increase in the relative contribution of point sources during the plant and algae growing period (Bowes et al., 2008).

The scenarios selected for this study covers the highest values within the range, with a point source contribution of 60-70%, and therefore represents a realistic worst case estimation regarding the contribution of P-based detergents.

Regarding factor c), the selected TP ranges (deterministic scenarios) and TP distributions (probabilistic approaches) represents measured TP concentrations for each ecoregion. Thus, a realistic estimation is guaranteed.

The combination of the deterministic and probabilistic approaches offers a coherent assessment of the expected contribution of P-based detergents on the eutrophication risk at the Pan-European Level. The general averaged contribution to the eutrophication risk from each type of detergent (laundry or dishwashing) is estimated to be below 5%; and the combined contribution around 4-6%. Only under extreme conditions, the contribution of detergents to the eutrophication risk may exceed the 10%, using realistic worst case assumptions in terms of point versus diffuse emissions, these extreme conditions could occur rarely at the Pan-European level: about one case every tenth in the Central/Baltic and Northern ecoregions; and with an even lower frequency in the Atlantic and Mediterranean ecoregions. The results obtained for the selected river basins (Tajo, Ebro and Danube) are also in agreement with these conclusions.

This model, validated and re-calibrated using the WFD IC data, can be applied for identifying these extreme circumstances, and for estimating the expected outcome of different risk management options.

REFERENCES

Boesch D, Hecky R, O'Melia C, Schindler D & Seitzinger S (2006) Eutrophication of Swedish Seas, Report 5509, Stockholm 13 March 2006, 72pp.

Bowes MJ, Hilton J, Irons GP, Hornby DD. The relative contribution of sewage and diffuse phosphorus sources in the River Avon catchment, southern England: implications for nutrient management. Sci Total Environ. 344:67-81.

Bowes MJ, Smith JT, Jarvie HP, Neal C. 2008. Modelling of phosphorus inputs to rivers from diffuse and point sources. Sci Total Environ. 395:125-38.

CIS-WFD (2003). Guidance on establishing reference conditions and ecological status class boundaries for inland surface waters. REFCOND Guidance Final Version.

CIS-WFD (2006). "Towards a Guidance Document on Eutrophication Assessment in the context of European Water Policies", March 2006

CSTEE (2003). Opinion of the Scientific Committee on Toxicity, Ecotoxicity and the Environment (CSTEE) on "The environmental impact (reduction in eutrophication) that would result from banning sodium tripolyphosphate (STPP) in household detergents". EUROPEAN COMMISSION HEALTH & CONSUMER PROTECTION DIRECTORATE-GENERAL. Brussels, C7/GF/csteeop/P/12-131103 D(03). Available at: http://europa.eu.int/comm/health/ph_risk/committees/sct/documents/out202_en.pdf

De Madariaga BM; Ramos MJ & Tarazona JV (2007) Model implementation and quantification of the eutrophication risk associated to the use of phosphates in detergents. Amended and expanded final study report. April 2007; 176pp.

De Wit M., Bendoricchio G (2001) Nutrient fluxes in the Po basin. Sci Tot Environ. 273:147-161.

Djodjic F, Montas H, Shirmohammadi A, Bergstrom L, Ulen B. 2002. A decision support system for phosphorus management at a watershed scale. J Environ Qual. 31:937-45.

Drolc A, Koncan JZ, Tisler T. 2007. Evaluation of point and diffuse sources of nutrients in a river basin on base of monitoring data. Environ Monit Assess. Jun;129(1-3):461-70. Epub 2006 Oct 21.

EC (2004). REPORT FROM THE COMMISSION TO THE COUNCIL, THE EUROPEAN PARLIAMENT, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Implementation of Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment, as amended by Commission Directive 98/15/EC of 27 February 1998. COM(2004) 248 final Brussels, 23.4.2004

ECOSTAT (2003). Overall Approach to the Classification of Ecological Status and Ecological Potential. CIS of WFD. WG 2A Ecological Status. November 2003

ECOSTAT (2004) ECOSTAT Discussion paper on WFD eutrophication (v7) 25-08-2004.

ECOSTAT (2005) Draft Guidance on Eutrophycation assessment in the context of European water policies (v7) 04-03-2005.

ECB 2003, Technical Guidance Document in support of Commission Directive 93/67/EEC on Risk Assessment for new notified substances, Commission Regulation (EC) No 1488/94 on Risk Assessment for existing substances and Directive 98/8/EC of the European Parliament and of the Council concerning the placing of biocidal products on the market.

European Chemicals Bureau, Ispra, Italy. Available at: http://ecb.jrc.it/index.php?CONTENU=/Technical-Guidance-Document/sommaire.php

ERN (2006) European Rivers Network website: http://www.rivernet.org/rivers.htm

EUROSTAT (2009) Statistical Office of the European Communities. http://epp.eurostat.ec.europa.eu

Hanrahan G, Gledhill, M., House W.A., Worsfold, P.J. (2001) Phosphorus loading in the Frome catchment, UK: Seasonal refinement of the coefficient modelling approach. J. Environ Qual. 30:1738-1746.

Hilton J., Buckland P., Irons G.P. (2002) An assessment of a simple method for estimating the relative contributions of point and diffuse sources phosphorus to in-river phosphorus loads. Hydrologia 472:77-83.

Hirt U, Venohr M, Kreins P, Behrendt H. 2008. Modelling nutrient emissions and the impact of nutrient reduction measures in the Weser river basin, Germany. Water Sci Technol.;58(11):2251-8.

Human & Environmental Risk Assessment on ingredients of European household cleaning products. Sodium Tripolyphosphate (STPP) CAS: 7758-29-4 DRAFT June 2003. Available at: http://www.heraproject.com/files/13-F-04-%20HERA%20STPP%20full%20web%20wd.pdf

ICPDR, 2001. WATER QUALITY in the Danube River Basin. TNMN Yearbook 2001. Vienna, 76pp.

ICPDR, 2002. WATER QUALITY in the Danube River Basin. TNMN Yearbook 2002. Vienna, 38pp.

Jiang, F., Beck, M.B., Cummings, R.G., Rowles, K., Russell, D. (2004) Estimation of Costs of Phosphorus Removal in Wastewater Treatment Facilities:Construction De Novo. Water Policy Working Paper #2004-010. Georgia Water Planning and Policy Center.

Kannen A, Windhorst W, Lenhart H & Nunneri GC. (2004) Assessing catchment-coast interactions for the Elbe by linking scenarios, indicators and modelling: Schernewski und T. Dolch (Hrsg.): Geographie der Meere und Küsten Coastline Reports 1 (2004), pp 225 – 237.

Kowalkowski T, Buszewski B. 2004. Modeling of past, present and future state of nutrient emission into the Vistula river system. Implementation of MONERIS model to the Vistula river catchment. EUROCAT Report http://www.cs.iia.cnr.it/EUROCAT/Reports%20from%20Regional%20Studies/VistulaCatchment-Coast/KOWALKOWSKI&BUZEWSKI_2003.PDF

Kronvang, B., Larsen, S.E., Jensen, J.P. & Andersen, H.E., 2003. Catchment report: River Odense, Denmark. Trend analysis, retention and source apportionment, EUROHARP report 2-2003, NIVA report SNO 4740-2003, Oslo, Norway, 29 pp.

Lasevils, JF & Berrux, D. 2000. Sources of phosphorus to surface waters: comparing calculated with measured P loadings for three French rivers. Geoplus Study July 2000 for CEEP-CEFIC

Mourad DS, Van Der Perk M, Piirimäe K. 2006. Changes in nutrient emissions, fluxes and retention in a north-eastern European lowland drainage basin. Environ Monit Assess. Sep;120(1-3):415-48.

Paul, J.F. and M.E. McDonald. 2005. Development of empirical, geographically specific water quality criteria: a conditional probability analysis approach. Journal of the American Water Resources Association 41:1211-1223

Paul MJ and Zheng L., 2008. Development of Nutrient Endpoints for Allegheny Plateau and Ridge and Valley Ecoregions of Pennsylvania: TMDL Application. United States Environmental Protection Agency Region 3 Philadelphia, 34pp.

Poikane S (ed) 2008. Water Framework Directive intercalibration technical report. Part 2: Lakes. JRC Scientific and Technical Reports. http://circa.europa.eu/Public/irc/jrc/jrc_eewai/library?l=/intercalibration/intercalibration_2/technreport_combinedpdf/_EN_1.0_&a=d

Schreiber et al., (2003). Harmonised Inventory of Point and Diffuse Emissions of Nitrogen and Phosphorus for a Transboundary River Basin. Environmental Research of the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety Water Research Project. Research Report 200 22 232.

Schreiber H, Behrendt H, Constantinescu LT, Cvitanic I, Drumea D, Jabucar D, Juran S, Pataki B, Snishko S, Zessner M. 2005. Nutrient emissions from diffuse and point sources into the River Danube and its main tributaries for the period of 1998-2000--results and problems. Water Sci Technol., 51:283-90.

SSC (2003) the future of risk assessment in the European Union. The second report on the harmonisation of Risk Assessment Procedures. APPENDIX 5: Report On Ecological Risk Assessment On Chemicals. EUROPEAN COMMISSION HEALTH & CONSUMER PROTECTION DIRECTORATE-GENERAL., Brussels, 57pp Available at: http://europe.eu.int/comm/food/fs/sc/ssc/out361_app5_en.pdf

Ulen B, Jakobsson C. (2005). Critical evaluation of measures to mitigate phosphorus losses from agricultural land to surface waters in Sweden. Sci Total Environ. 344:37-50.

Vighi M, Chiaudani G (1985) A simple method to estimate lake phosphorus concentrations resulting from natural, background, loadings. Water Res. 19:987-991.

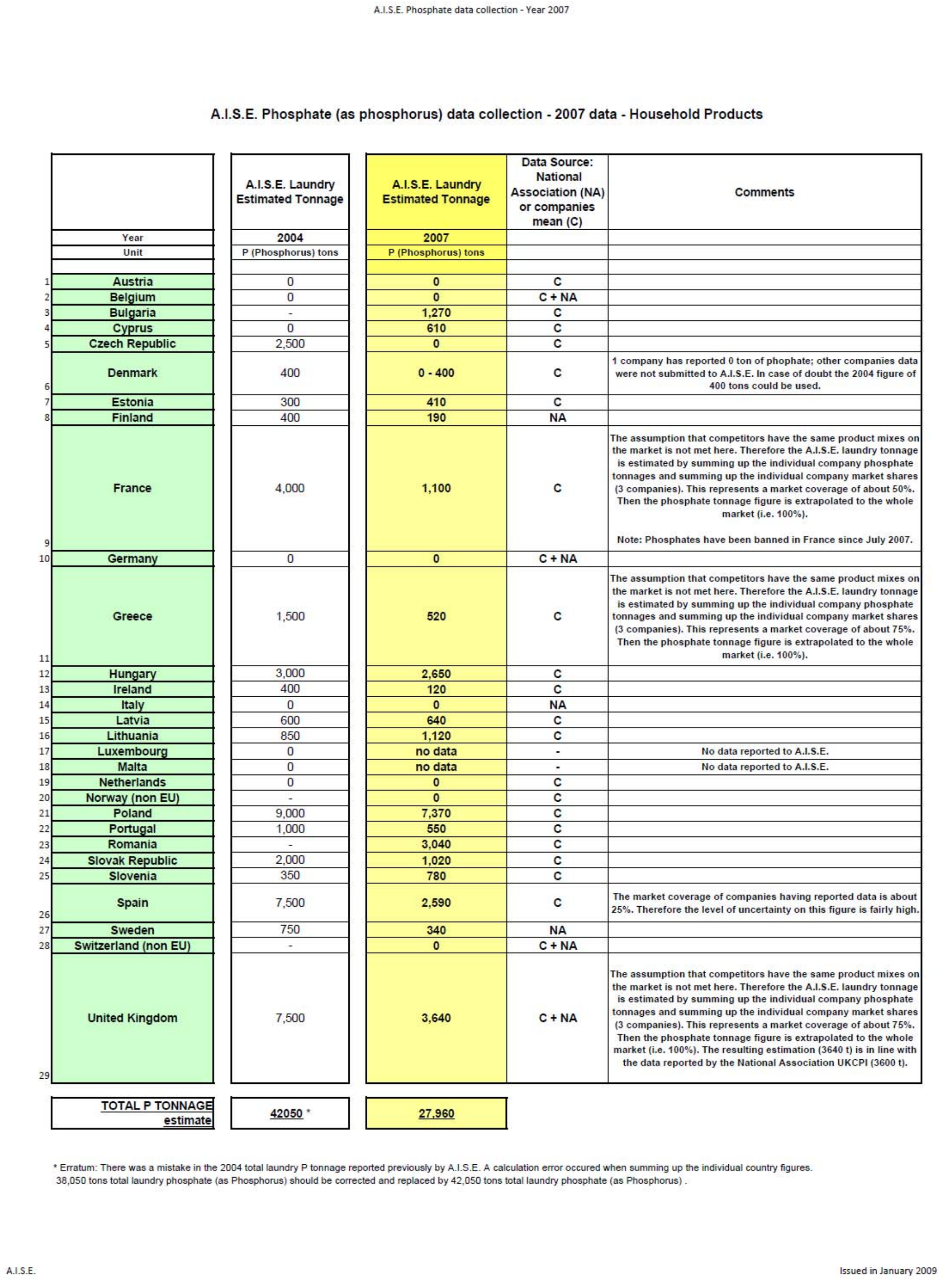
Vighi M., Soprani S., Puzzarini P., Menghi G. (1991). Phosphorus loads from selected watersheds in the drainage area of the North Adriatic Sea. J. Environ Qual. 20: 439-444.

Windhorst, W., Colijn, F., Kabuta, S., Laane, R., Lenhart, H. (2004) Defining a good ecological status of coastal waters - A case study for the Elbe Plume. In: Ledoux, L, Vermaat, JE, Bouwer, R, Salomons, W, Turner, RK (Eds.) Managing European coasts: past, present and future (Contribu-tions of the ELOISE BtB Workshop, 2-5 June 2003, Springer Verlag submitted).

WISE (2009) Water Information System for Europe. http://water.europa.eu/

Zessner, M., Lindtner, S. 2005. Estimations of municipal point source pollution in the context of river basin management. Water Science & Technology 52:175–182.

ANNEX 1. UPDATED CONSUMPTION PATTERNS OF P-BASED LAUNDRY AND DISHWASHING DETERGENTS PROVIDED BY AISE



A.I.S.E. Phosphate data collection - Year 2007

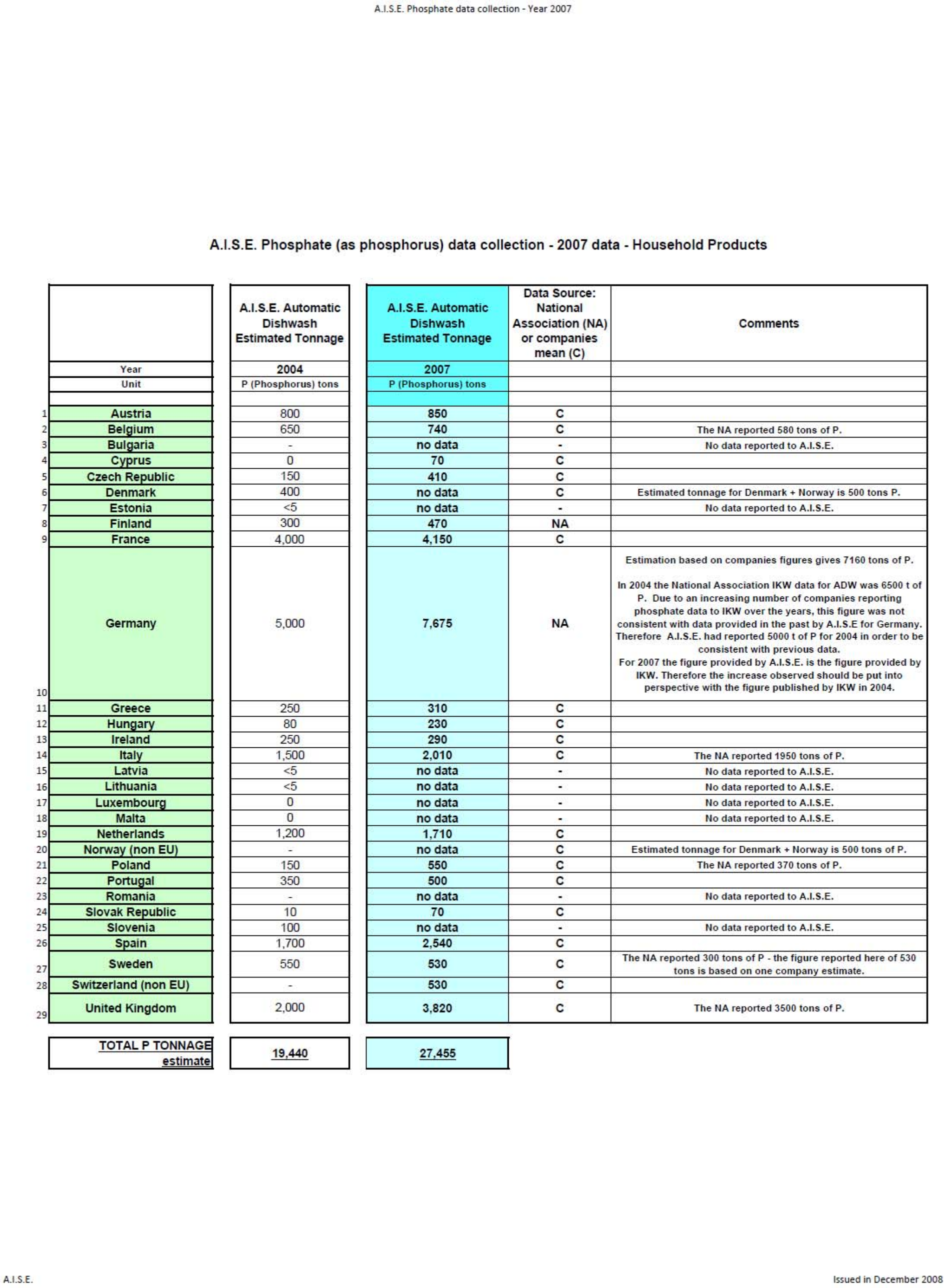
A.I.S.E. Phosphate (as phosphorus) data collection - 2007 data - Household Products

		A.I.S.E. Laundry Estimated Tonnage	A.I.S.E. Laundry Estimated Tonnage	Data Source: National Association (NA) or companies mean (C)	Comments
	Year	2004	2007		
	Unit	P (Phosphorus) tons	P (Phosphorus) tons		
1	**Austria**	0	**0**	**C**	
2	**Belgium**	0	**0**	**C + NA**	
3	**Bulgaria**	-	**1,270**	**C**	
4	**Cyprus**	0	**610**	**C**	
5	**Czech Republic**	2,500	**0**	**C**	
6	**Denmark**	400	**0 - 400**	**C**	1 company has reported 0 ton of phophate; other companies data were not submitted to A.I.S.E. In case of doubt the 2004 figure of 400 tons could be used.
7	**Estonia**	300	**410**	**C**	
8	**Finland**	400	**190**	**NA**	
9	**France**	4,000	**1,100**	**C**	The assumption that competitors have the same product mixes on the market is not met here. Therefore the A.I.S.E. laundry tonnage is estimated by summing up the individual company phosphate tonnages and summing up the individual company market shares (3 companies). This represents a market coverage of about 50%. Then the phosphate tonnage figure is extrapolated to the whole market (i.e. 100%). Note: Phosphates have been banned in France since July 2007.
10	**Germany**	0	**0**	**C + NA**	
11	**Greece**	1,500	**520**	**C**	The assumption that competitors have the same product mixes on the market is not met here. Therefore the A.I.S.E. laundry tonnage is estimated by summing up the individual company phosphate tonnages and summing up the individual company market shares (3 companies). This represents a market coverage of about 75%. Then the phosphate tonnage figure is extrapolated to the whole market (i.e. 100%).
12	**Hungary**	3,000	**2,650**	**C**	
13	**Ireland**	400	**120**	**C**	
14	**Italy**	0	**0**	**NA**	
15	**Latvia**	600	**640**	**C**	
16	**Lithuania**	850	**1,120**	**C**	
17	**Luxembourg**	0	**no data**	**-**	No data reported to A.I.S.E.
18	**Malta**	0	**no data**	**-**	No data reported to A.I.S.E.
19	**Netherlands**	0	**0**	**C**	
20	**Norway (non EU)**	-	**0**	**C**	
21	**Poland**	9,000	**7,370**	**C**	
22	**Portugal**	1,000	**550**	**C**	
23	**Romania**	-	**3,040**	**C**	
24	**Slovak Republic**	2,000	**1,020**	**C**	
25	**Slovenia**	350	**780**	**C**	
26	**Spain**	7,500	**2,590**	**C**	The market coverage of companies having reported data is about 25%. Therefore the level of uncertainty on this figure is fairly high.
27	**Sweden**	750	**340**	**NA**	
28	**Switzerland (non EU)**	-	**0**	**C + NA**	
29	**United Kingdom**	7,500	**3,640**	**C + NA**	The assumption that competitors have the same product mixes on the market is not met here. Therefore the A.I.S.E. laundry tonnage is estimated by summing up the individual company phosphate tonnages and summing up the individual company market shares (3 companies). This represents a market coverage of about 75%. Then the phosphate tonnage figure is extrapolated to the whole market (i.e. 100%). The resulting estimation (3640 t) is in line with the data reported by the National Association UKCPI (3600 t).
	TOTAL P TONNAGE estimate	**42050** *	**27,960**		

* Erratum: There was a mistake in the 2004 total laundry P tonnage reported previously by A.I.S.E. A calculation error occured when summing up the individual country figures. 38,050 tons total laundry phosphate (as Phosphorus) should be corrected and replaced by 42,050 tons total laundry phosphate (as Phosphorus) .

A.I.S.E.

Issued in January 2009



A.I.S.E. Phosphate data collection - Year 2007

A.I.S.E. Phosphate (as phosphorus) data collection - 2007 data - Household Products

		A.I.S.E. Automatic Dishwash Estimated Tonnage	A.I.S.E. Automatic Dishwash Estimated Tonnage	Data Source: National Association (NA) or companies mean (C)	Comments
	Year	2004	2007		
	Unit	P (Phosphorus) tons	P (Phosphorus) tons		
1	Austria	800	850	C	
2	Belgium	650	740	C	The NA reported 580 tons of P.
3	Bulgaria	-	no data	-	No data reported to A.I.S.E.
4	Cyprus	0	70	C	
5	Czech Republic	150	410	C	
6	Denmark	400	no data	C	Estimated tonnage for Denmark + Norway is 500 tons P.
7	Estonia	<5	no data	-	No data reported to A.I.S.E.
8	Finland	300	470	NA	
9	France	4,000	4,150	C	
10	Germany	5,000	7,675	NA	Estimation based on companies figures gives 7160 tons of P. In 2004 the National Association IKW data for ADW was 6500 t of P. Due to an increasing number of companies reporting phosphate data to IKW over the years, this figure was not consistent with data provided in the past by A.I.S.E for Germany. Therefore A.I.S.E. had reported 5000 t of P for 2004 in order to be consistent with previous data. For 2007 the figure provided by A.I.S.E. is the figure provided by IKW. Therefore the increase observed should be put into perspective with the figure published by IKW in 2004.
11	Greece	250	310	C	
12	Hungary	80	230	C	
13	Ireland	250	290	C	
14	Italy	1,500	2,010	C	The NA reported 1950 tons of P.
15	Latvia	<5	no data	-	No data reported to A.I.S.E.
16	Lithuania	<5	no data	-	No data reported to A.I.S.E.
17	Luxembourg	0	no data	-	No data reported to A.I.S.E.
18	Malta	0	no data	-	No data reported to A.I.S.E.
19	Netherlands	1,200	1,710	C	
20	Norway (non EU)	-	no data	C	Estimated tonnage for Denmark + Norway is 500 tons of P.
21	Poland	150	550	C	The NA reported 370 tons of P.
22	Portugal	350	500	C	
23	Romania	-	no data	-	No data reported to A.I.S.E.
24	Slovak Republic	10	70	C	
25	Slovenia	100	no data	-	No data reported to A.I.S.E.
26	Spain	1,700	2,540	C	
27	Sweden	550	530	C	The NA reported 300 tons of P - the figure reported here of 530 tons is based on one company estimate.
28	Switzerland (non EU)	-	530	C	
29	United Kingdom	2,000	3,820	C	The NA reported 3500 tons of P.
	TOTAL P TONNAGE estimate	19,440	27,455		

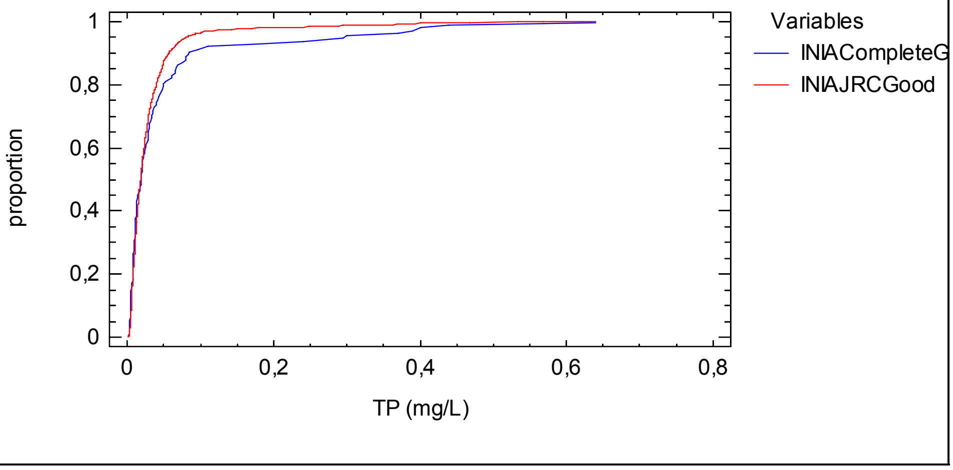
A.I.S.E.

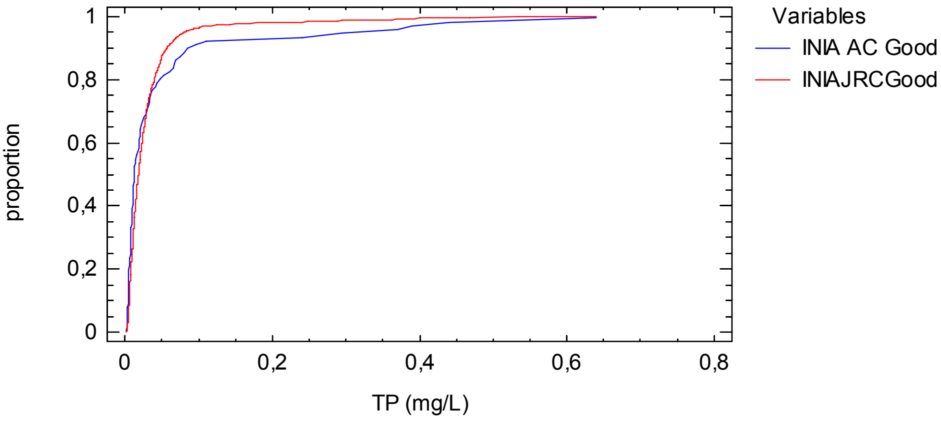
Issued in December 2008

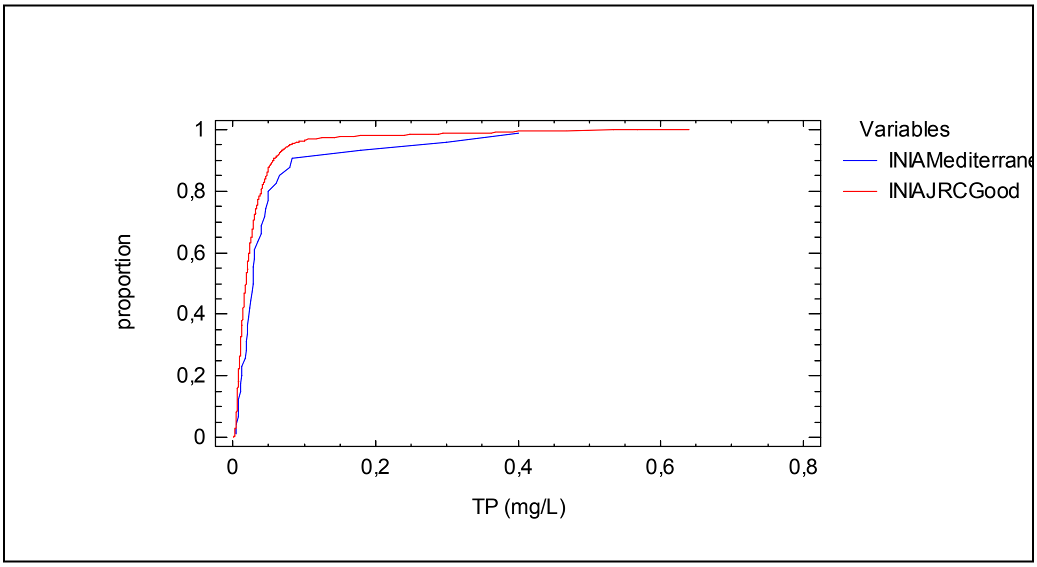
ANNEX 2. RESULTS OF THE STATISTICAL ANALYSIS

SUMMARY OF INIA vs. IC-WFD DATABASES COMPARISON

1. Quantile plots comparing two distributions



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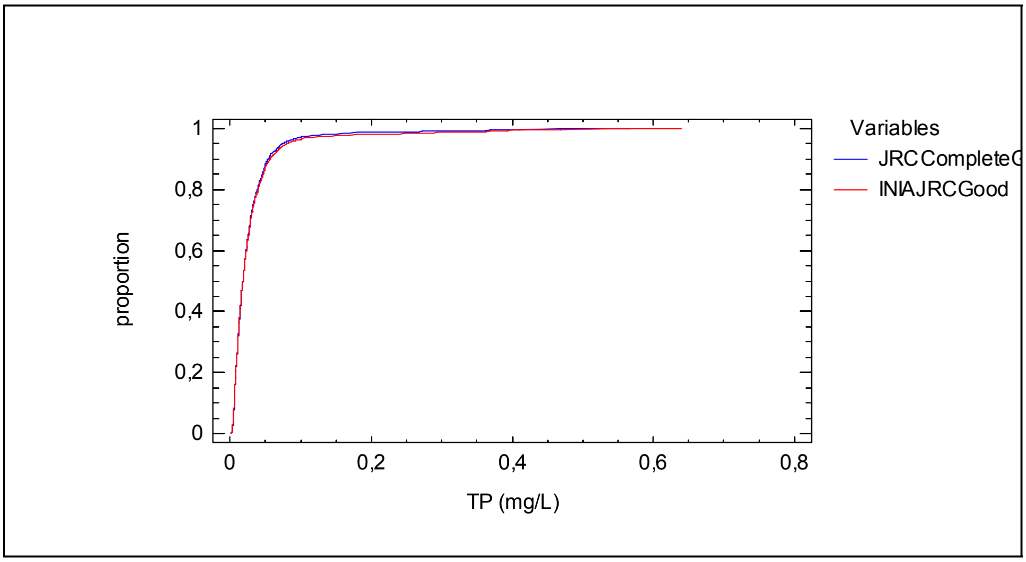
TP (mg/L)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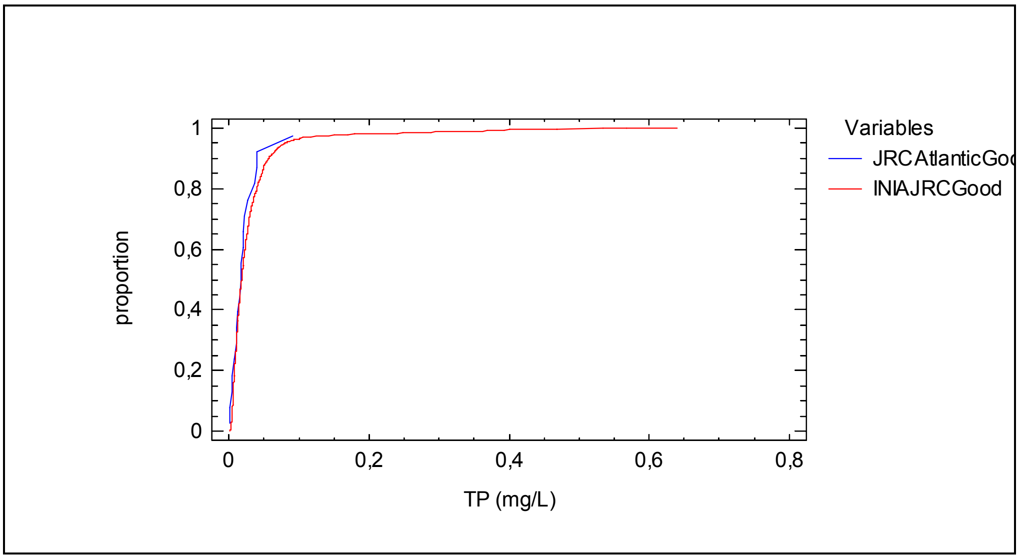
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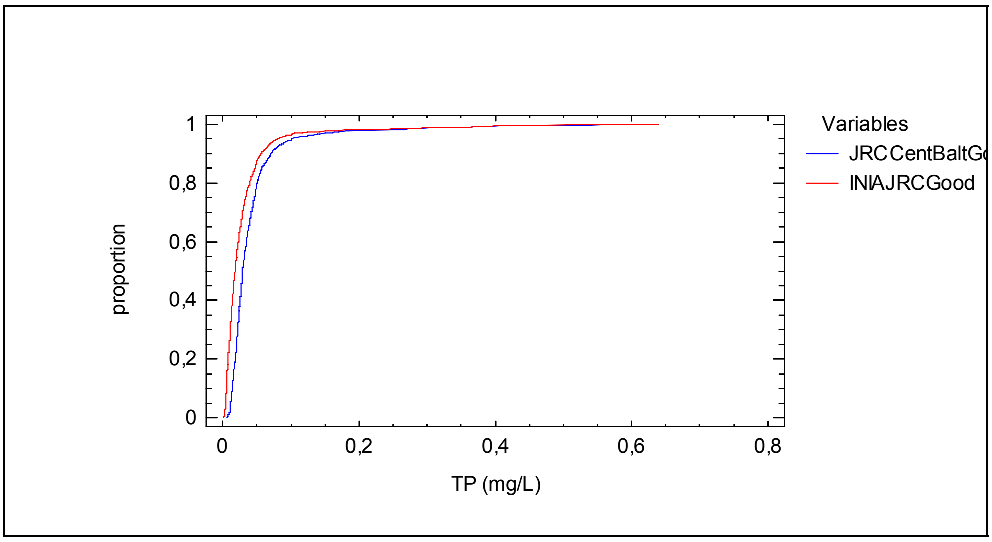
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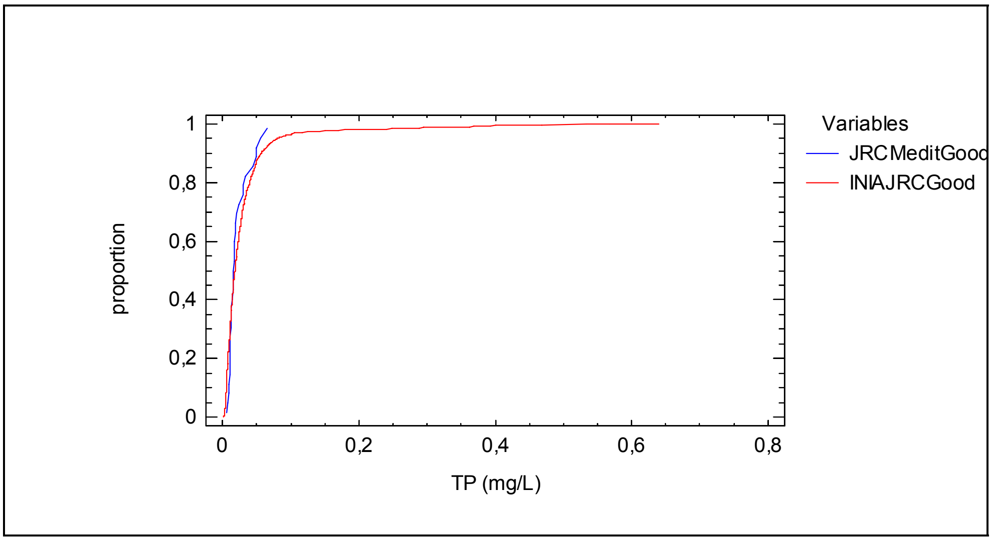
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Variables
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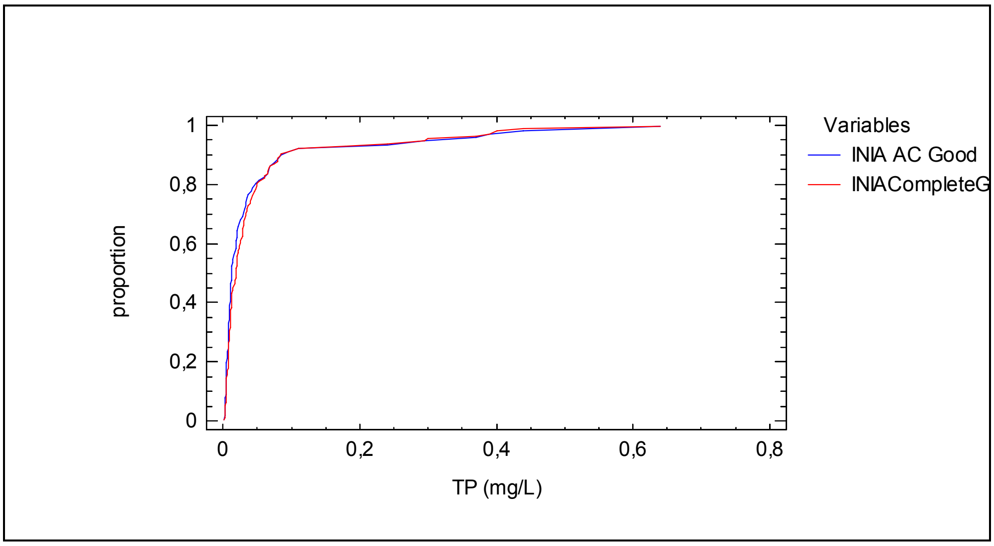
INIAJRCGood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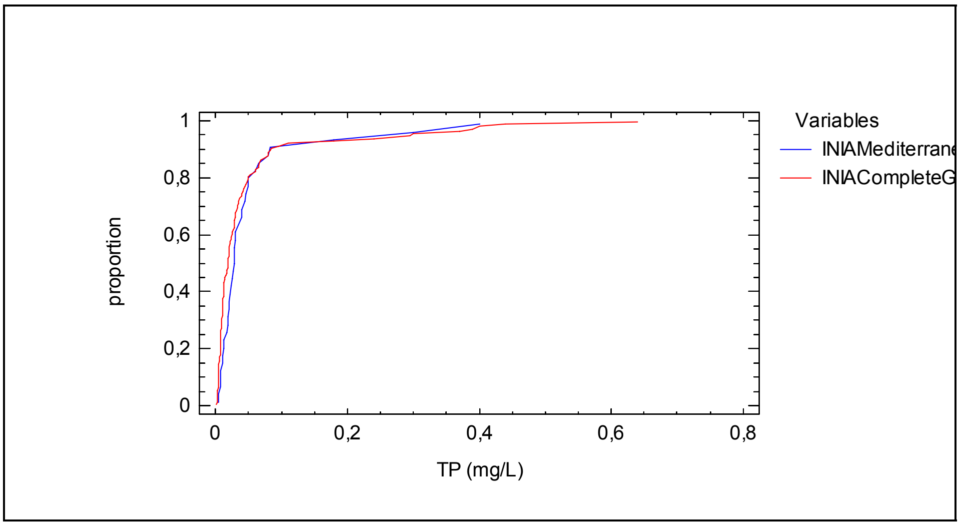
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TP (mg/L)
Variables
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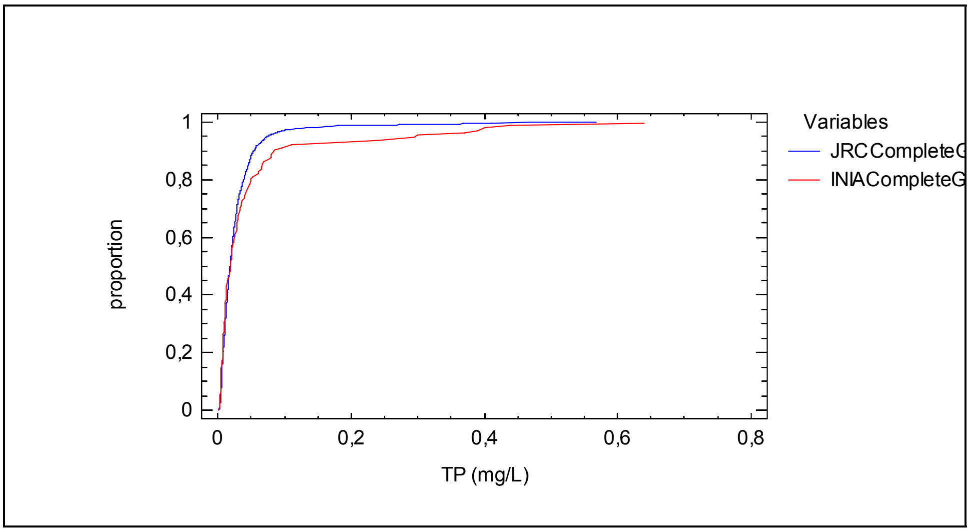
INIACompleteG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TP (mg/L)
Variables
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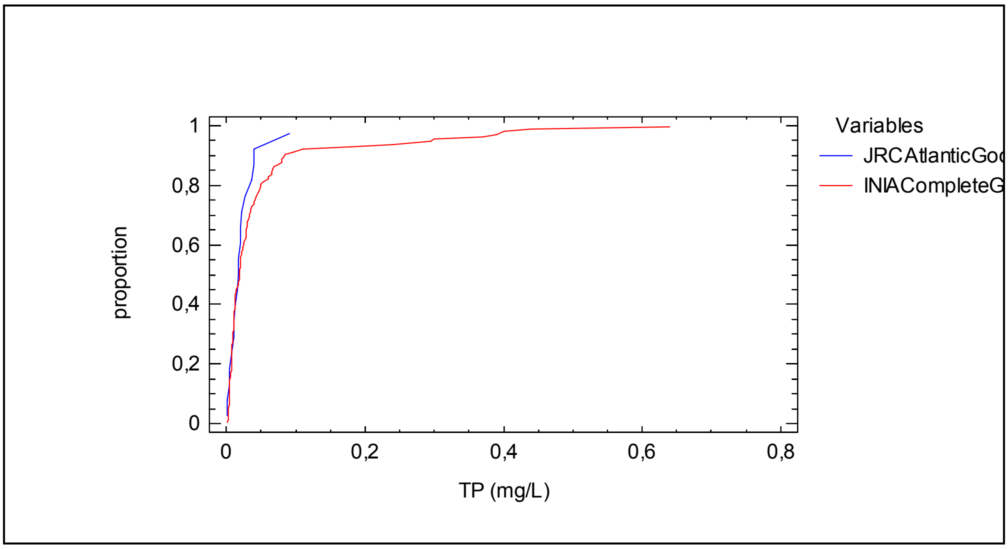
INIACompleteG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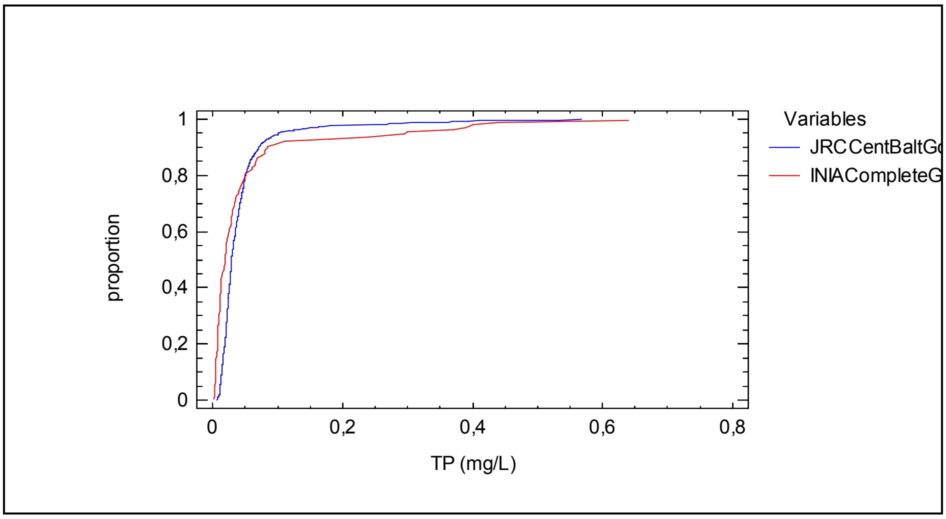
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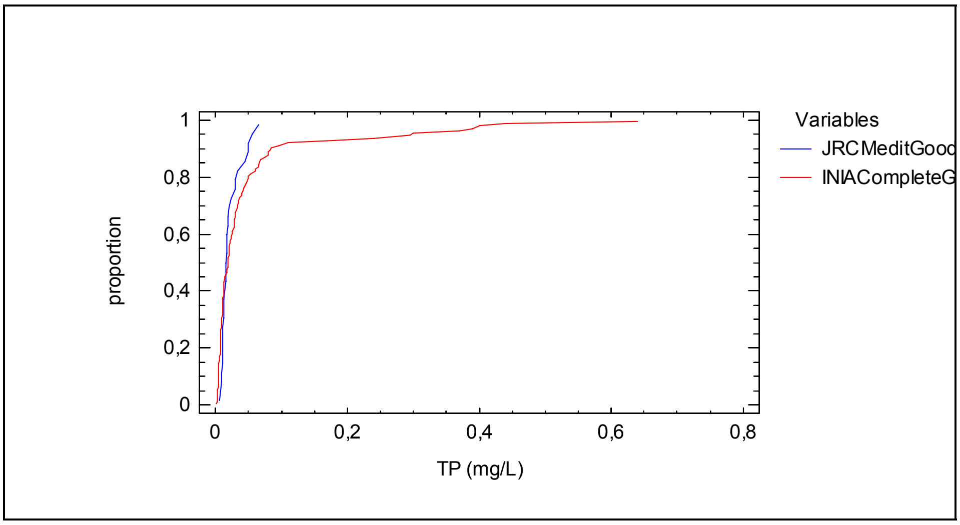
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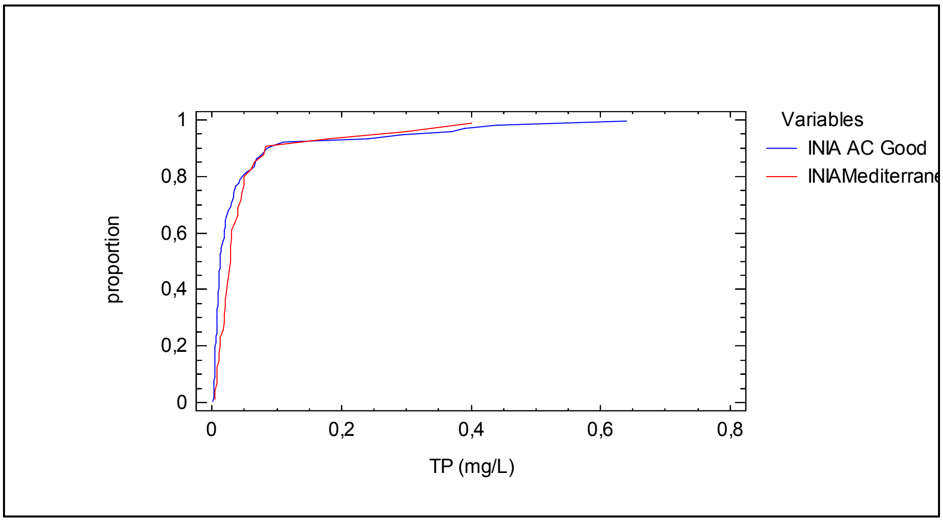
TP (mg/L)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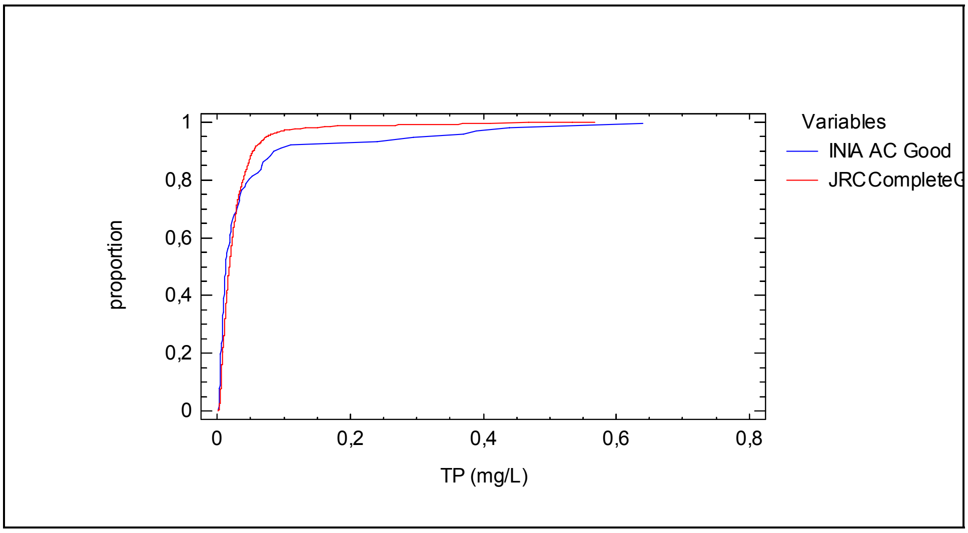
TP (mg/L)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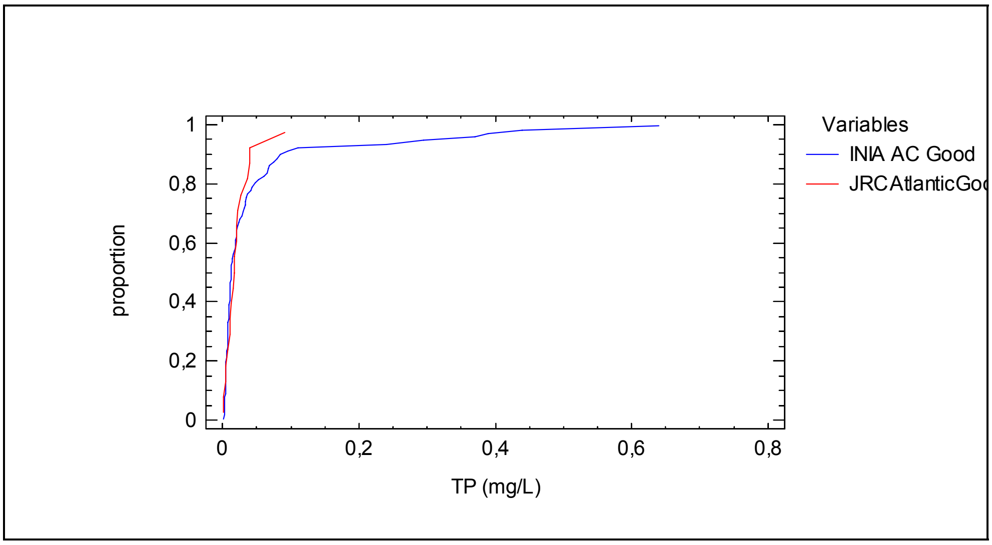
TP (mg/L)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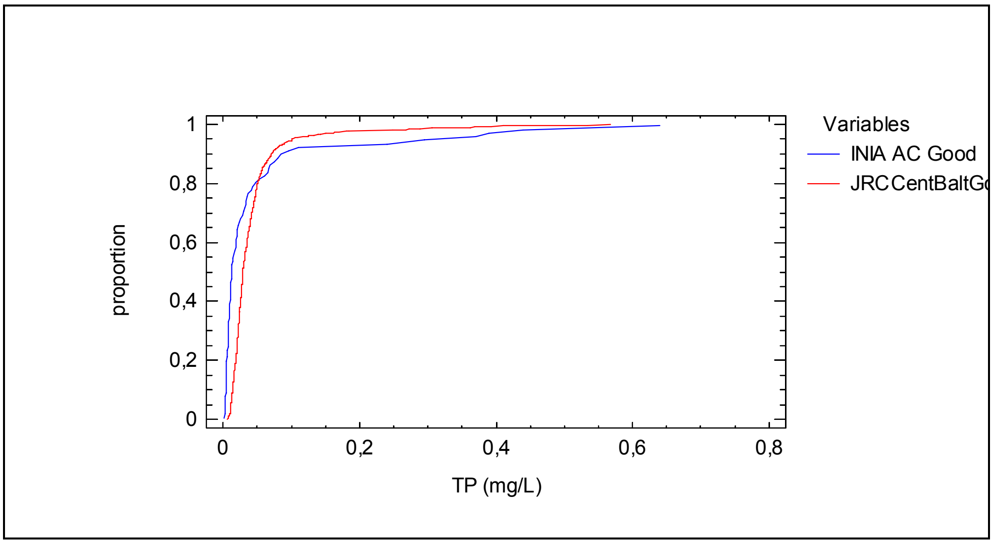
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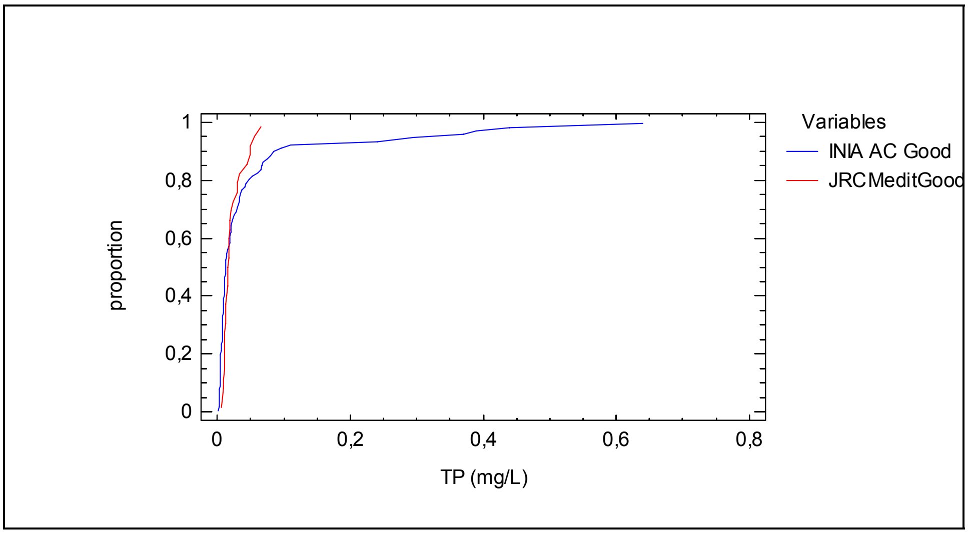
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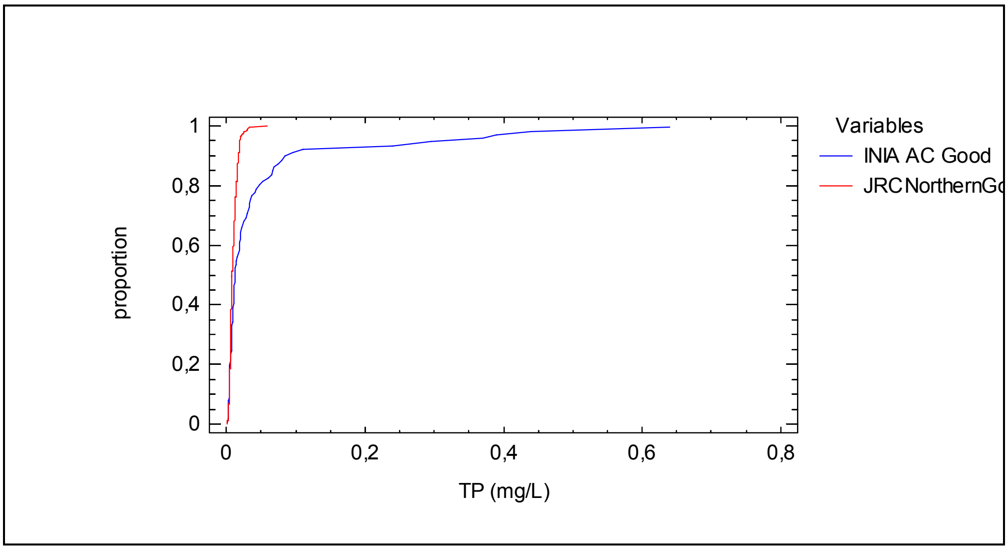
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TP (mg/L)
Variables
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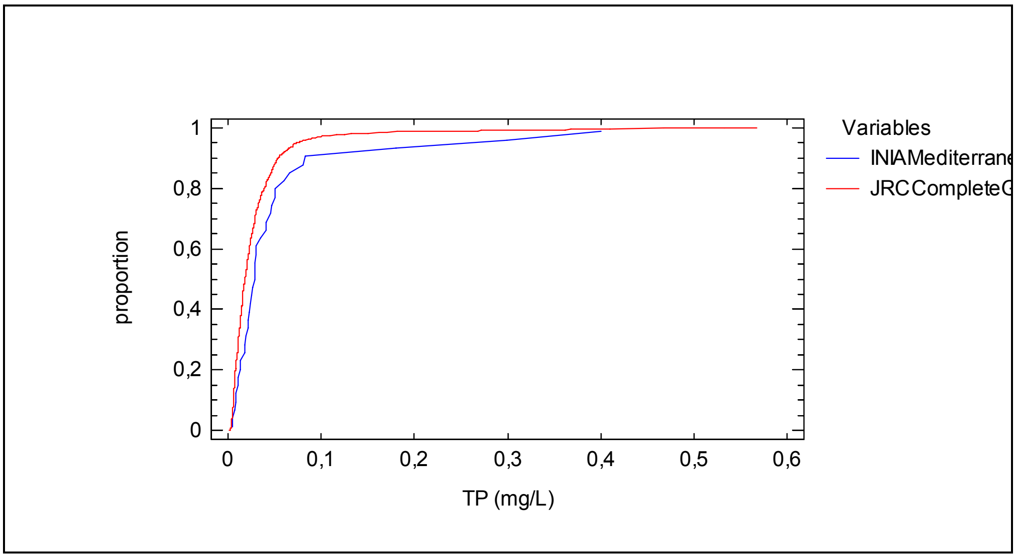
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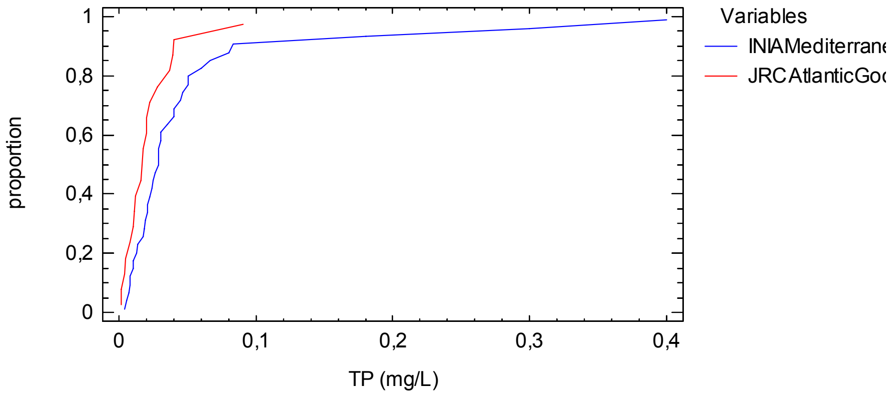
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Variables
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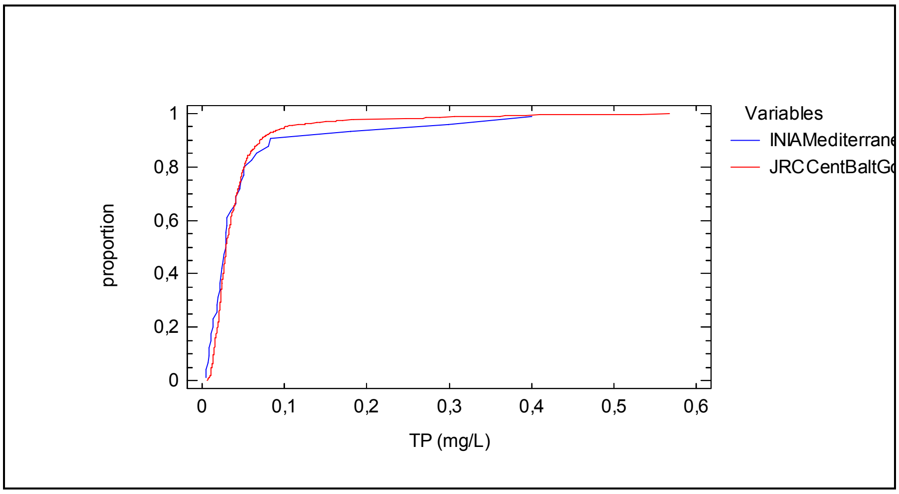
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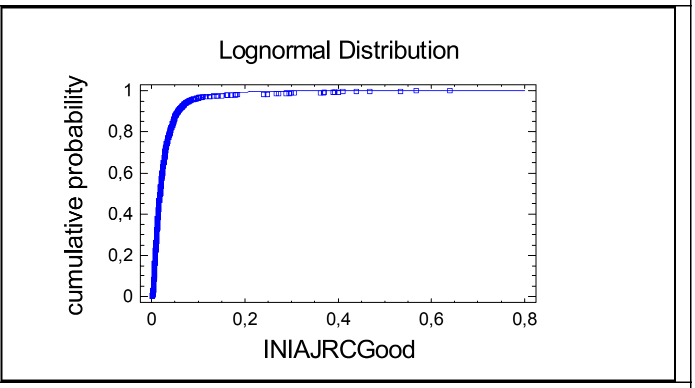
0,6
TP (mg/L)
Variables
INIAMediterrane
JRCCentBaltG

2. Results of the data fitting process for the selected conditional distributions.

INIAJRC G+

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0288192
std dev = 0,0359736



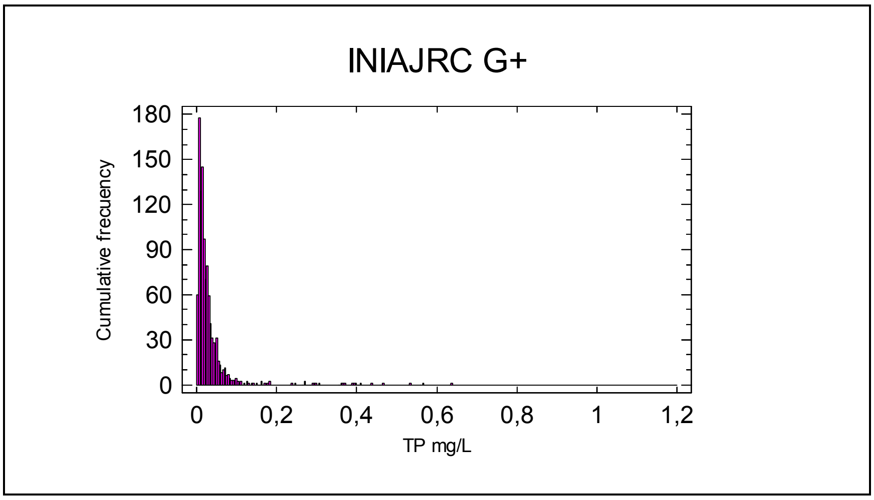
Goodness-of-Fit Tests

Chi-Square = 22,392 with 9 d.f.
P-Value = 0,00771624
Estimated Kolmogorov statistic DPLUS = 0,0238666
Estimated Kolmogorov statistic DMINUS = 0,0184611
Estimated overall statistic DN = 0,0238666
Approximate P-Value = 0,557924

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0238666	≥0.10
Anderson-Darling	1,53397	≥0.10

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.01, we can **reject** the idea that INIAJRC Good comes from a lognormal distribution with 99% or higher confidence.

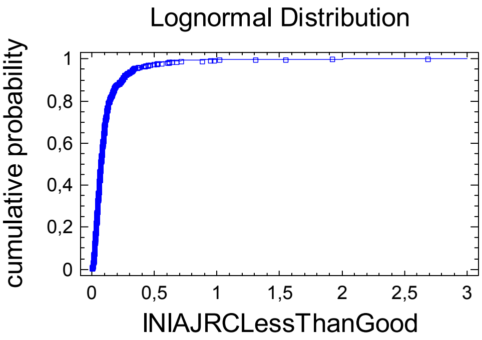
Selected distribution: Raw data distribution



INIAJRC G-

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,112452
std dev = 0,133667



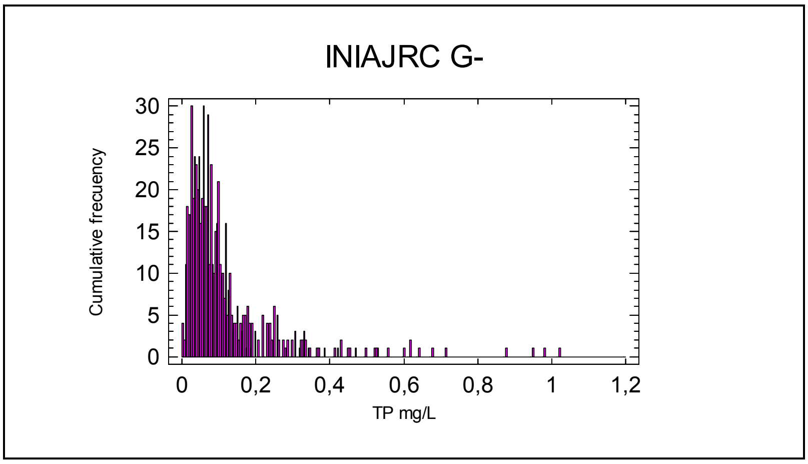
Goodness-of-Fit Tests

Chi-Square = 17,1795 with 8 d.f.
P-Value = 0,0282928
Estimated Kolmogorov statistic
DPLUS = 0,0486751
Estimated Kolmogorov statistic
DMINUS = 0,0317513
Estimated overall statistic DN = 0,0486751
Approximate P-Value = 0,0856115

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0486751	<0.10
Anderson-Darling	1,6705	≥0.10

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.05, we can **reject** the idea that INIAJRC LessThanGood comes from a lognormal distribution with 95% confidence.

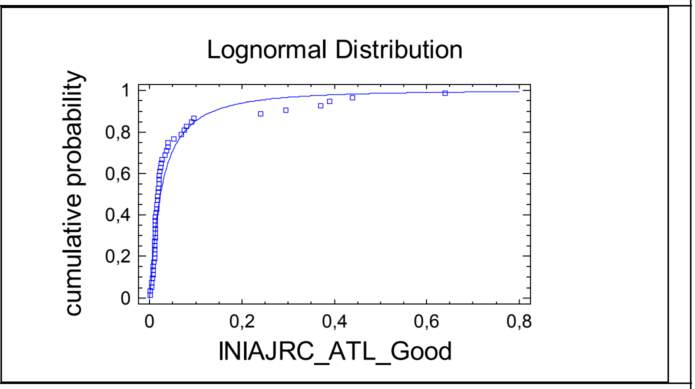
Selected distribution: Raw data distribution



INIAJRC ATLANTIC G+

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0606703
std dev = 0,145197



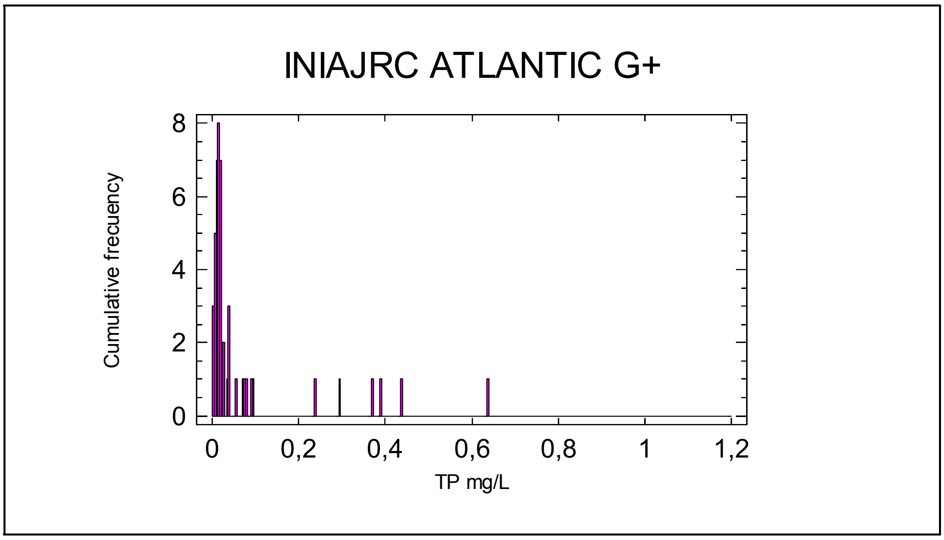
Goodness-of-Fit Tests

Chi-Square = 12,4399 with 4 d.f.
P-Value = 0,0143632
Estimated Kolmogorov statistic DPLUS = 0,145162
Estimated Kolmogorov statisticDMINUS=0,0943438
Estimated overall statistic DN = 0,145162
Approximate P-Value = 0,243371

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,145162	≥0.10
Anderson-Darling	1,35835	≥0.10

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.05, we can **reject** the idea that INIAJRC_ATL_Good comes from a lognormal distribution with 95% confidence.

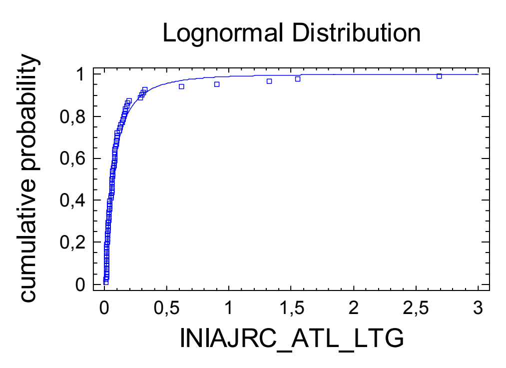
Selected distribution: Raw data distribution



INIAJRC ATLANTIC G-

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,132339
std dev = 0,235393



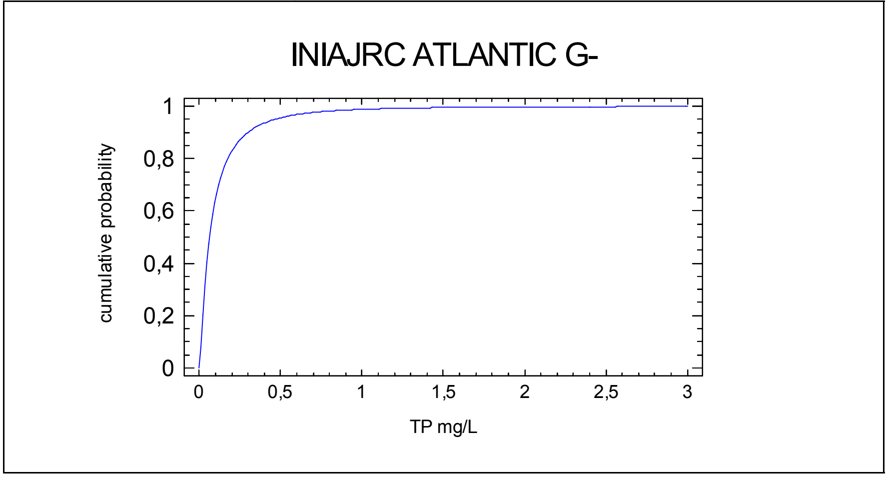
Goodness-of-Fit Tests

Chi-Square = 2,06478 with 5 d.f.
P-Value = 0,84011
Estimated Kolmogorov statistic DPLUS=0,0816039
Estimated Kolmogorov statistic DMINUS=0,068432
Estimated overall statistic DN = 0,0816039
Approximate P-Value = 0,684341

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0816039	≥0.10
Anderson-Darling	0,895513	≥0.10

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we can **not reject** the idea that INIAJRC_ATL_LTG comes from a lognormal distribution with 90% or higher confidence.

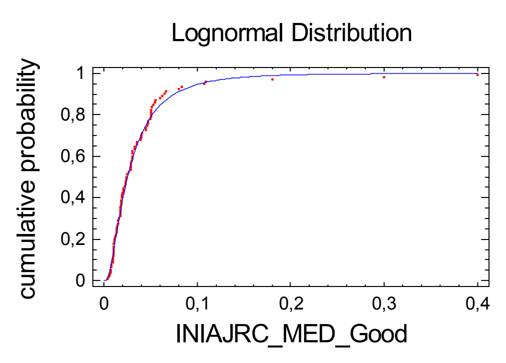
Selected distribution: Fitted lognormal distribution



INIAJRC MEDITERRANEAN G+

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,036324
std dev = 0,0375702



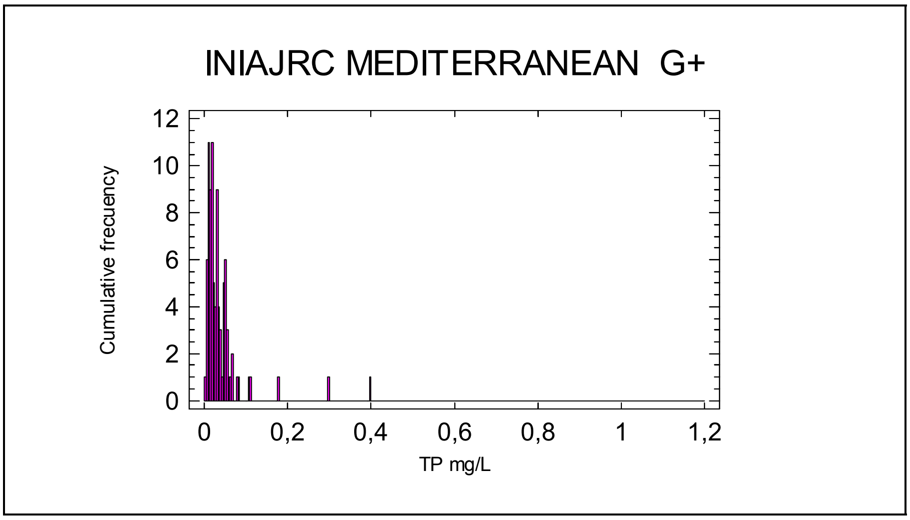
Goodness-of-Fit Tests

Chi-Square = 10,6855 with 5 d.f.
P-Value = 0,057984
Estimated Kolmogorov statistic DPLUS =0,0570632
Estimated Kolmogorov statistic DMINUS =0,036430
Estimated overall statistic DN = 0,0570632
Approximate P-Value = 0,934047

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0570632	≥0.10
Anderson-Darling	0,430379	≥0.10

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.10, we can **reject** the idea that INIAJRC_MED_Good comes from a lognormal distribution with 90% confidence.

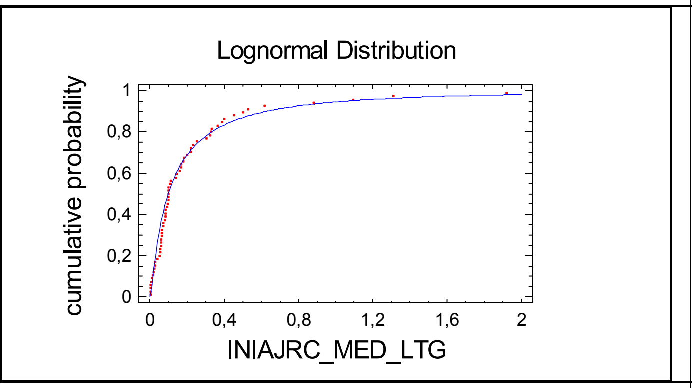
Selected distribution: Raw data distribution



INIAJRC MEDITERRANEAN G-

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,279691
std dev = 0,747355



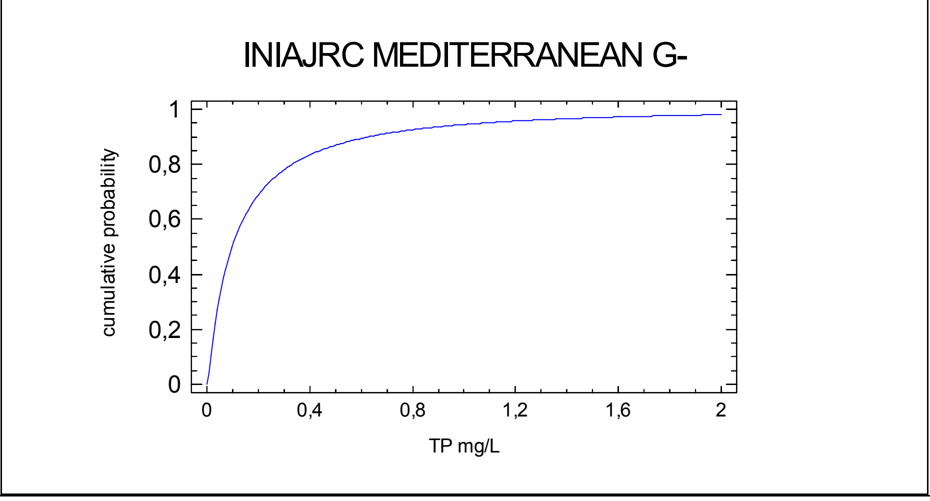
Goodness-of-Fit Tests

Chi-Square = 5,77733 with 4 d.f.
P-Value = 0,216406
Estimated Kolmogorov statistic DPLUS =0,0549579
Estimated Kolmogorov statistic DMINUS =0,135417
Estimated overall statistic DN = 0,135417
Approximate P-Value = 0,198508

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,135417	≥0.10
Anderson-Darling	0,941267	≥0.10

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we **can not reject** the idea that INIAJRC_MED_LTG comes from a lognormal distribution with 90% or higher confidence.

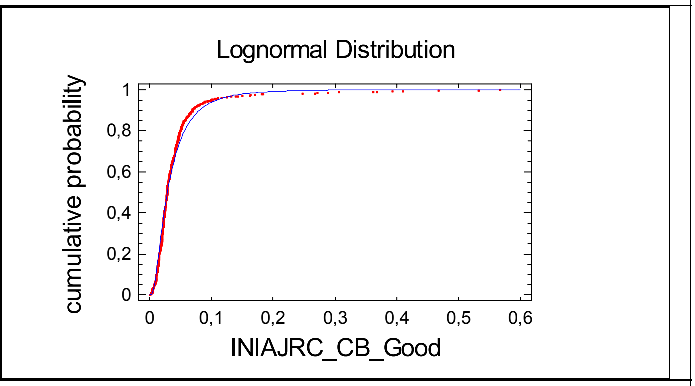
Selected distribution: Fitted lognormal distribution



INIAJRC CENTRAL/BALTIC G+

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,0397174
std dev = 0,0382788



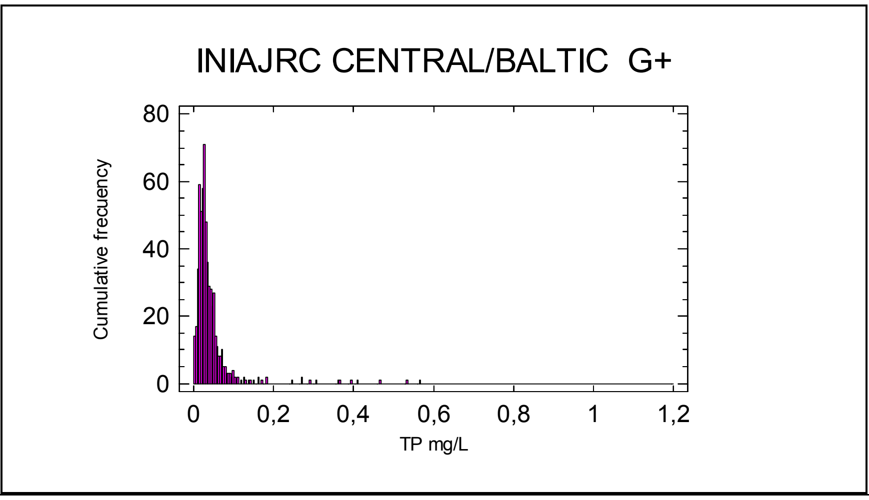
Goodness-of-Fit Tests

Chi-Square = 29,8217 with 8 d.f.
P-Value = 0,000227283
Estimated Kolmogorov statistic DPLUS =0,0565834
Estimated Kolmogorov statistic DMINUS =0,064536
Estimated overall statistic DN = 0,0645369
Approximate P-Value = 0,0135026

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0645369	<0.05
Anderson-Darling	4,17445	<0.01

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.01, we **can reject** the idea that INIAJRC_CB_Good comes from a lognormal distribution with 99% confidence.

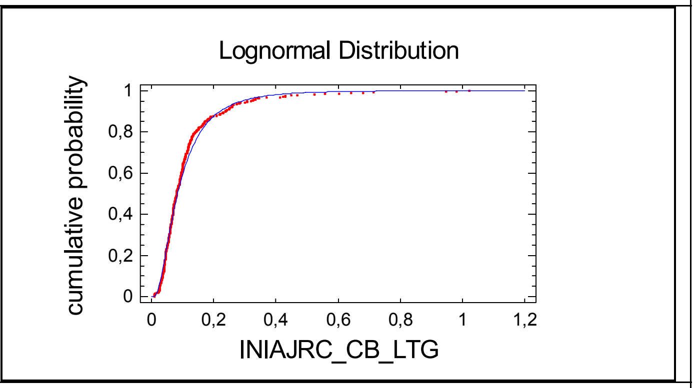
Selected distribution: Raw data distribution



INIAJRC CENTRAL/BALTIC G-

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,111161
std dev = 0,0976198



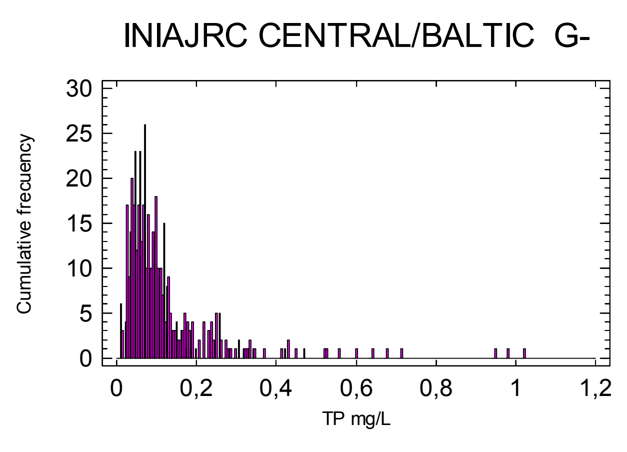
Goodness-of-Fit Tests

Chi-Square = 18,9579 with 7 d.f.
P-Value = 0,00832037
Estimated Kolmogorov statistic DPLUS =0,0562238
Estimated Kolmogorov statistic DMINUS=0,036736
Estimated overall statistic DN = 0,0562238
Approximate P-Value = 0,0897238

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0562238	<0.10
Anderson-Darling	1,97478	<0.10

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.01, we can **reject** the idea that INIAJRC_CB_LTG comes from a lognormal distribution with 99% confidence.

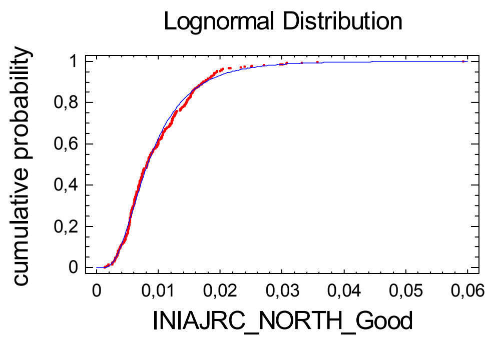
Selected distribution: Raw data distribution



INIAJRC NORTHERN G+

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,00982528
std dev = 0,0063473



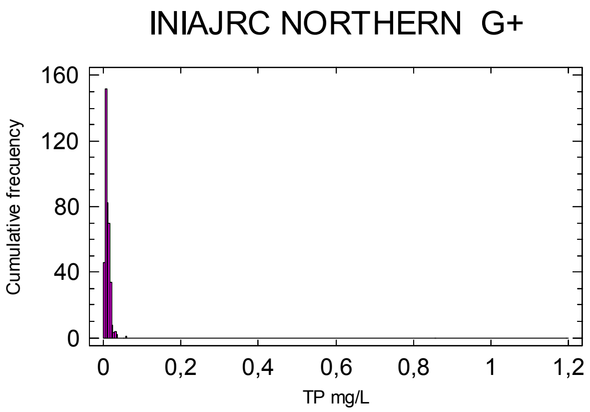
Goodness-of-Fit Tests

Chi-Square = 14,5186 with 7 d.f.
P-Value = 0,0426907
Estimated Kolmogorov statistic DPLUS =0,0382083
Estimated Kolmogorov statistic DMINUS=0,043476
Estimated overall statistic DN = 0,0434769
Approximate P-Value = 0,43982

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0434769	≥0.10
Anderson-Darling	0,89998	≥0.10

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.05, we can **reject** the idea that INIAJRC_NORTH_Good comes from a lognormal distribution with 95% confidence.

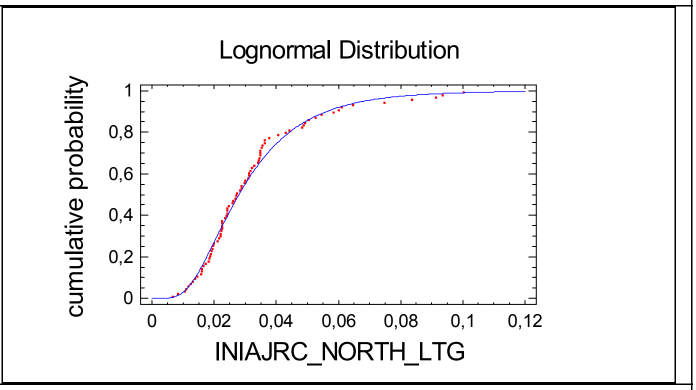
Selected distribution: Raw data distribution



INIAJRC NORTHERN G-

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,032396
std dev = 0,0189956



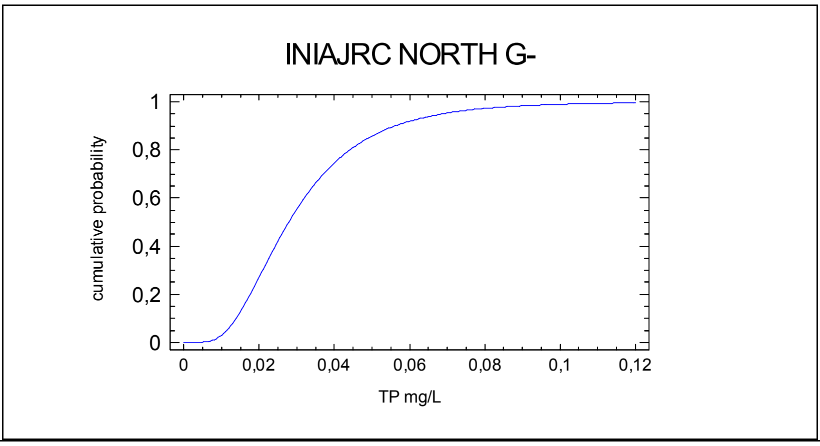
Goodness-of-Fit Tests

Chi-Square = 2,09753 with 5 d.f.
P-Value = 0,835492
Estimated Kolmogorov statistic DPLUS=0,0840336
Estimated Kolmogorov statistic DMINUS=0,045768
Estimated overall statistic DN = 0,0840336
Approximate P-Value = 0,608756

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0840336	≥0.10
Anderson-Darling	0,327128	≥0.10

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we **can not reject** the idea that INIAJRC_NORTH_LTG comes from a lognormal distribution with 90% or higher confidence.

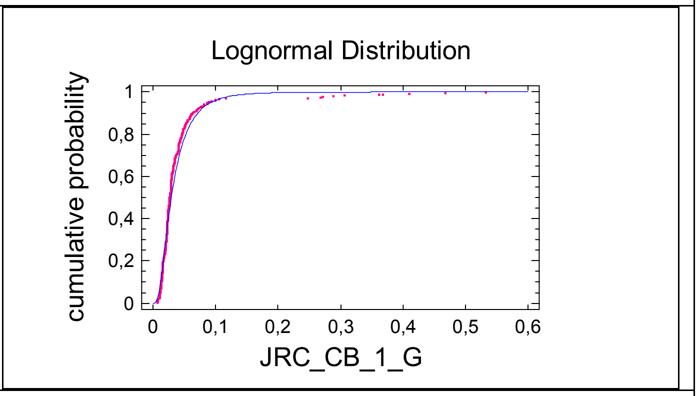
Selected distribution: Fitted lognormal distribution



JRC CENTRAL/BALTIC G+ Ecotype: CB1

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0370953
std dev = 0,0295912



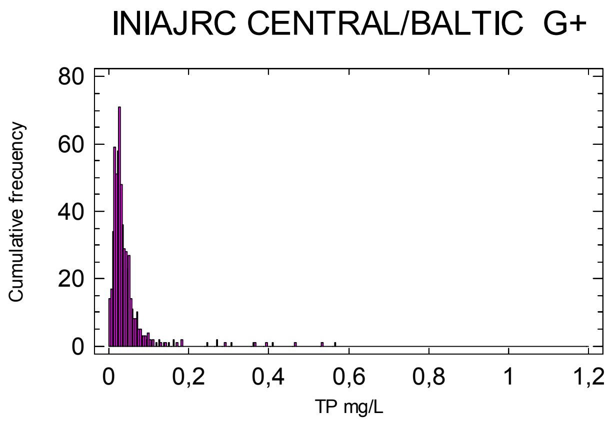
Goodness-of-Fit Tests

Chi-Square = 32,107 with 7 d.f.
P-Value = 0,0000388019
Estimated Kolmogorov statistic DPLUS =0,0944844
Estimated Kolmogorov statistic DMINUS =0,051607
Estimated overall statistic DN = 0,0944844
Approximate P-Value = 0,00514212

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0944844	<0.01
Anderson-Darling	4,5626	<0.01

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.01, we **can reject** the idea that JRC_CB_1_G comes from a lognormal distribution with 99% confidence.

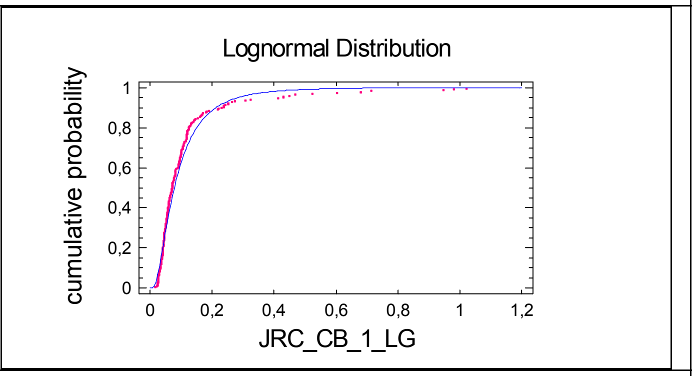
Selected distribution: Raw data distribution



JRC CENTRAL/BALTIC G- Ecotype: CB1

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,105657
std dev = 0,096935



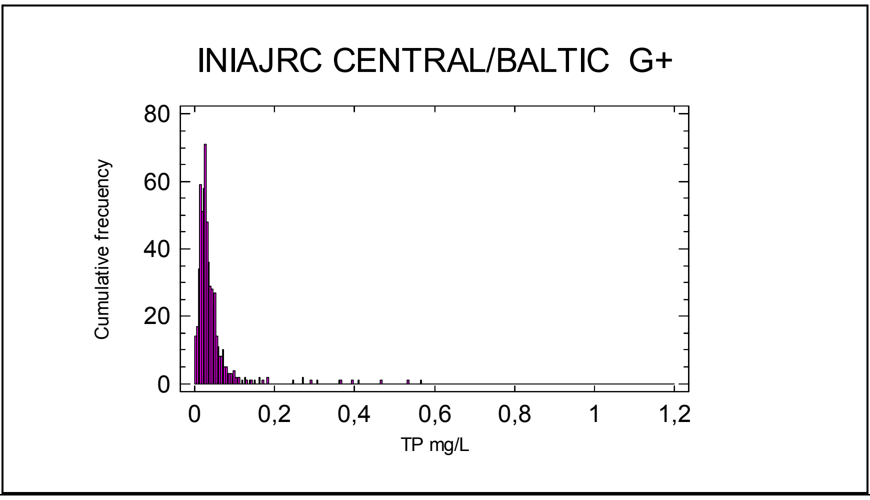
Goodness-of-Fit Tests

Chi-Square = 13.684 with 6 d.f.
P-Value = 0.0333725
Estimated Kolmogorov statistic DPLUS =0.0803774
Estimated Kolmogorov statistic DMINUS =0.049766
Estimated overall statistic DN = 0.0803774
Approximate P-Value = 0.124337

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0.0803774	≥0.1
Anderson-Darling	2.62293	<0.05

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.05, we **can reject** the idea that JRC_CB_1_LG comes from a lognormal distribution with 95% confidence.

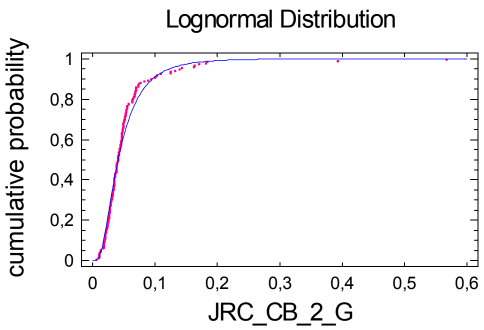
Selected distribution: Raw data distribution



JRC CENTRAL/BALTIC G+ Ecotype: CB2

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0509486
std dev = 0,0383776



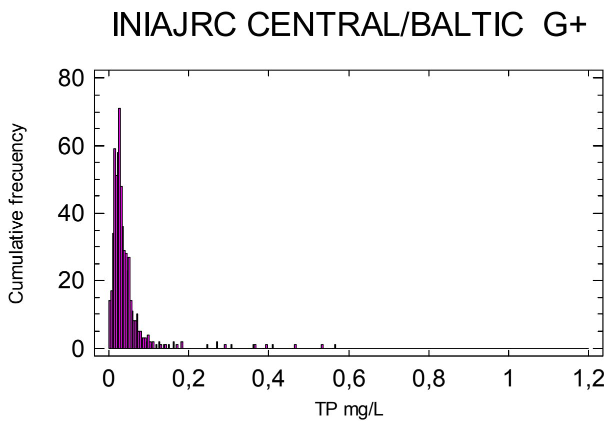
Goodness-of-Fit Tests

Chi-Square = 14,9449 with 6 d.f.
P-Value = 0,0206898
Estimated Kolmogorov statistic DPLUS =0,0933712
Estimated Kolmogorov statistic DMINUS =0,045913
Estimated overall statistic DN = 0.0803774
Approximate P-Value = 0,112617

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0933712	≥0.1
Anderson-Darling	1,42239	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.05, we **can reject** the idea that JRC_CB_2_G comes from a lognormal distribution with 95% confidence.

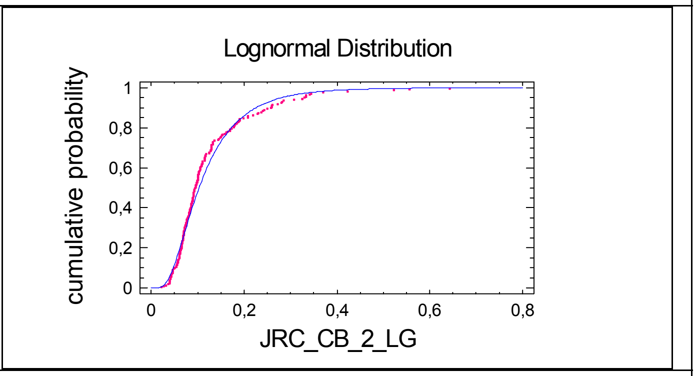
Selected distribution: Raw data distribution



JRC CENTRAL/BALTIC G- Ecotype: CB2

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,124145
std dev = 0,0830478



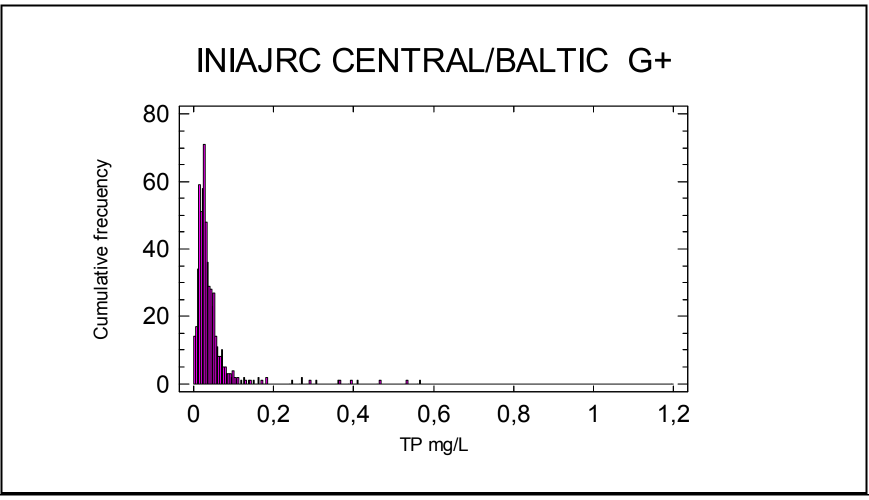
Goodness-of-Fit Tests

Chi-Square = 18,0098 with 6 d.f.
P-Value = 0,00620775
Estimated Kolmogorov statistic DPLUS =0,0921436
Estimated Kolmogorov statistic DMINUS =0,041989
Estimated overall statistic DN = 0,0921436
Approximate P-Value = 0,0741905

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,0921436	<0.1
Anderson-Darling	1,69924	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.01, we **can reject** the idea that JRC_CB_2_LG comes from a lognormal distribution with 99% confidence.

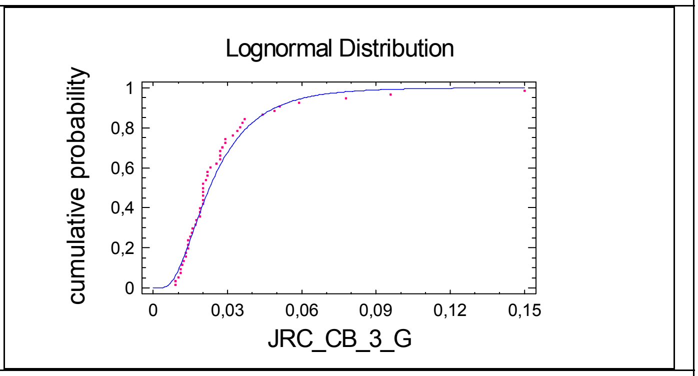
Selected distribution: Raw data distribution



JRC CENTRAL/BALTIC G+ Ecotype: CB3

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0272727
std dev = 0,017987



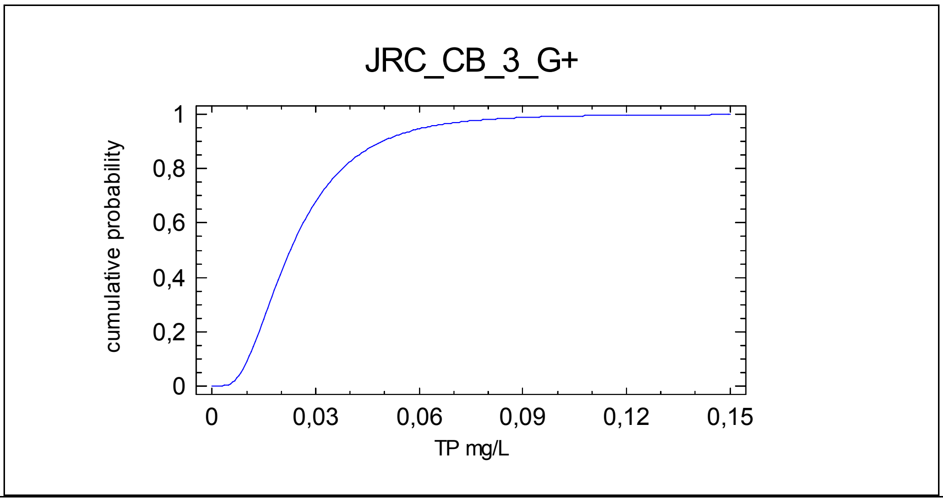
Goodness-of-Fit Tests

Chi-Square = 4,8574 with 4 d.f.
P-Value = 0,302245
Estimated Kolmogorov statistic DPLUS = 0,115975
Estimated Kolmogorov statistic DMINUS = 0,06125
Estimated overall statistic DN = 0,115975
Approximate P-Value = 0,540401

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,115975	≥0.1
Anderson-Darling	0,716048	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we **can not reject** the idea that JRC_CB_3_G comes from a lognormal distribution with 90% or higher confidence.

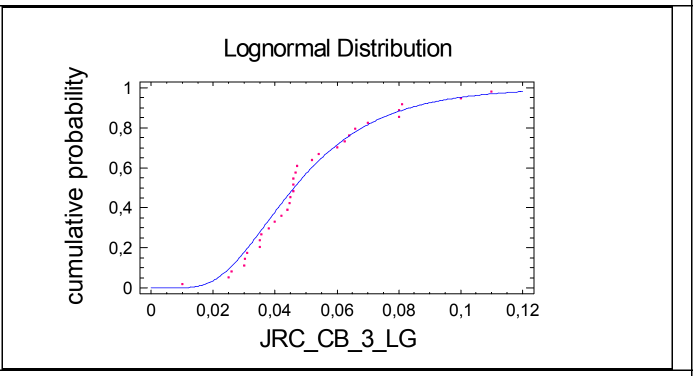
Selected distribution: Fitted lognormal distribution



JRC CENTRAL/BALTIC G- Ecotype: CB3

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,051362
std dev = 0,0253215



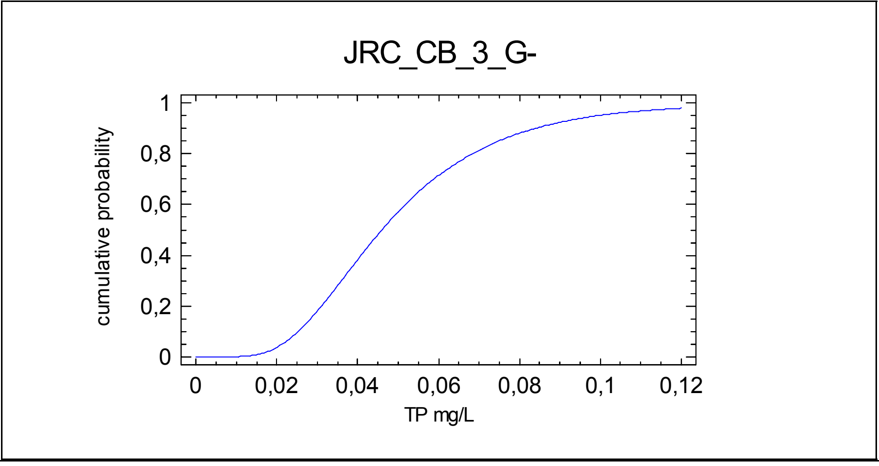
Goodness-of-Fit Tests

Chi-Square = 4,74958 with 4 d.f.
P-Value = 0,313971
Estimated Kolmogorov statistic DPLUS = 0,107869
Estimated Kolmogorov statistic DMINUS = 0,09040
Estimated overall statistic DN = 0,107869
Approximate P-Value = 0,850494

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,107869	≥0.1
Anderson-Darling	0,426925	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we **can not reject** the idea that JRC_CB_3_LG comes from a lognormal distribution with 90% or higher confidence.

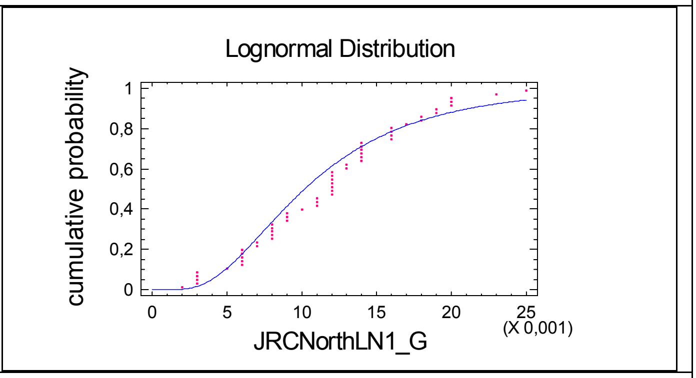
Selected distribution: Fitted lognormal distribution



JRC NORTHERN G+ Ecotype: LN1

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,0120039
std dev = 0,00748911



Goodness-of-Fit Tests

Chi-Square = 9,25957 with 4 d.f.
P-Value = 0,0549289
Estimated Kolmogorov statistic DPLUS = 0,082553
Estimated Kolmogorov statistic DMINUS = 0,14964
Estimated overall statistic DN = 0,149645
Approximate P-Value = 0,17817

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,149645	≥0.1
Anderson-Darling	1,24329	≥0.1

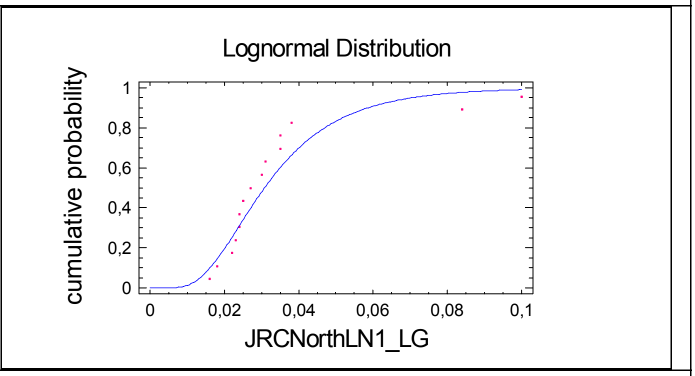
Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.10, we **can reject** the idea that JRC_Northern_LN1_G comes from a lognormal distribution with 90% confidence.

Selected distribution: Raw data distribution

JRC NORTHERN G- Ecotype: LN1

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0349143
std dev = 0,0188236



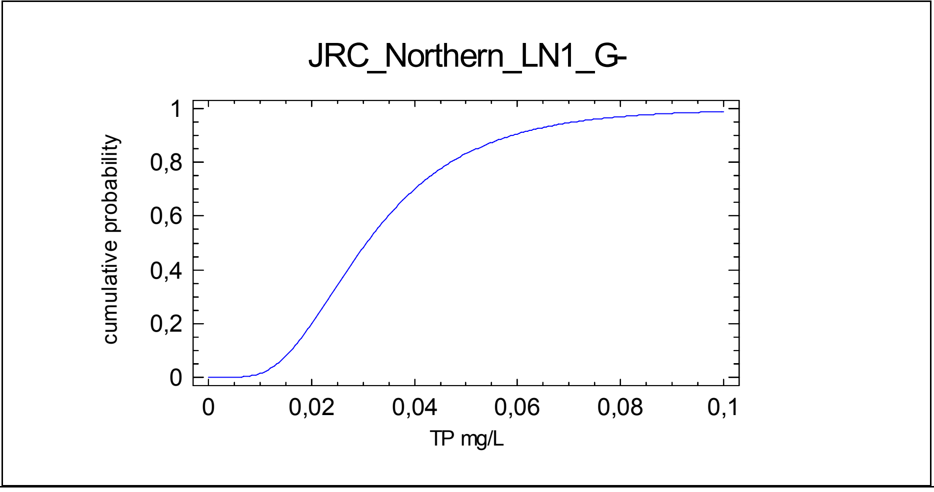
Goodness-of-Fit Tests

Chi-Square = 4,00007 with 2 d.f.
P-Value = 0,13533
Estimated Kolmogorov statistic DPLUS = 0,203827
Estimated Kolmogorov statistic DMINUS = 0,12072
Estimated overall statistic DN = 0,203827
Approximate P-Value = 0,561453

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,203827	≥0.1
Anderson-Darling	0,869286	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we **can not reject** the idea that JRC_Northern_LN1_LG comes from a lognormal distribution with 90% or higher confidence.

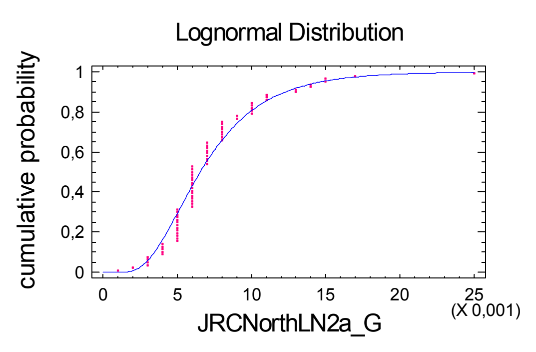
Selected distribution: Fitted lognormal distribution



JRC NORTHERN G+ Ecotype: LN2a

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0.00737995
std dev = 0.00388468



Goodness-of-Fit Tests

Chi-Square = 9.79956 with 5 d.f.
P-Value = 0.0811179
Estimated Kolmogorov statistic DPLUS = 0.101345
Estimated Kolmogorov statistic DMINUS = 0.14794
Estimated overall statistic DN = 0.14794
Approximate P-Value = 0.0750371

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0.14794	<0.1
Anderson-Darling	1.15288	≥0.1

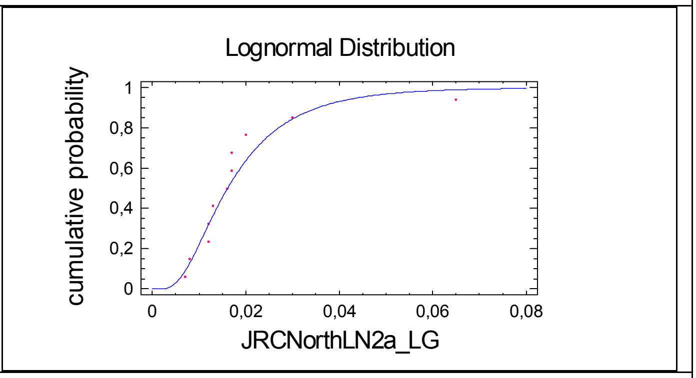
Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.10, we **can reject** the idea that JRC_Northern_LN2a_G comes from a lognormal distribution with 90% confidence.

Selected distribution: Raw data distribution

JRC NORTHERN G- Ecotype: LN2a

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0.0194646
std dev = 0,013212



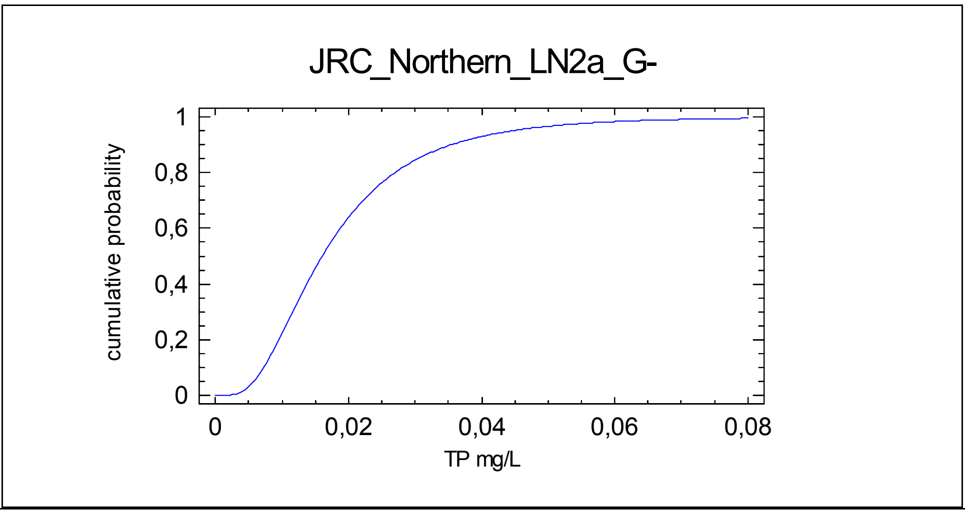
Goodness-of-Fit Tests

Chi-Square = 1,27267 with 2 d.f.
P-Value = 0,529229
Estimated Kolmogorov statistic DPLUS = 0.101345
Estimated Kolmogorov statistic DMINUS = 0,13451
Estimated overall statistic DN = 0,192266
Approximate P-Value = 0,810831

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,192266	≥0.1
Anderson-Darling	0,393319	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we **can not reject** the idea that JRC_Northern_LN2a_LG comes from a lognormal distribution with 90% or higher confidence.

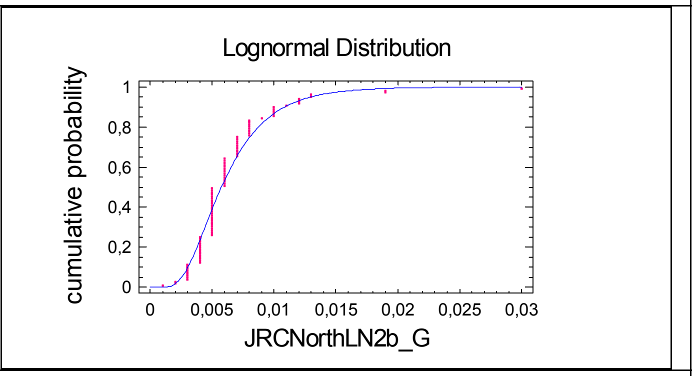
Selected distribution: Fitted lognormal distribution



JRC NORTHERN G+ Ecotype: LN2b

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0.00649706
std dev = 0.00342592



Goodness-of-Fit Tests

Chi-Square = 29.914 with 5 d.f.
P-Value = 0.0000153347
Estimated Kolmogorov statistic DPLUS = 0,114281
Estimated Kolmogorov statistic DMINUS = 0,13398
Estimated overall statistic DN = 0,133987
Approximate P-Value = 0,0684336

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,133987	<0.1
Anderson-Darling	1,51949	≥0.1

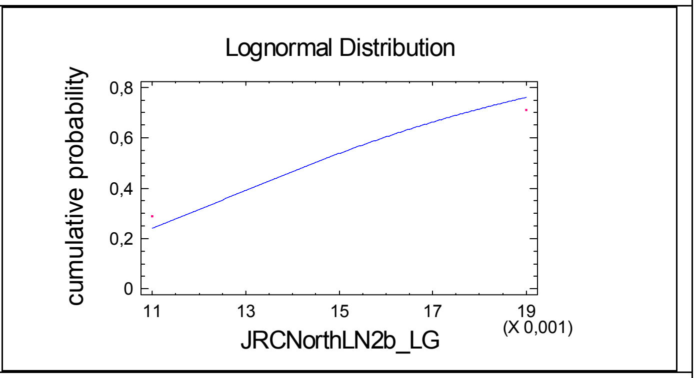
Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.10, we **can reject** the idea that JRC_Northern_LN2b_G comes from a lognormal distribution with 99% confidence.

Selected distribution: Raw data distribution

JRC NORTHERN G- Ecotype: LN2b

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0155778
std dev = 0,0062522



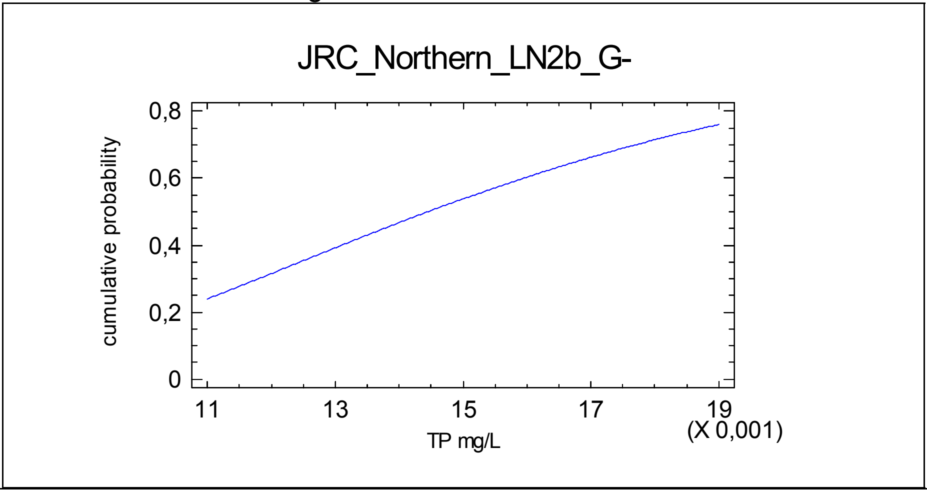
Goodness-of-Fit Tests

Insufficient data to conduct Chi-Square test.
Estimated Kolmogorov statistic DPLUS = 0,260251
Estimated Kolmogorov statistic DMINUS = 0,26025
Estimated overall statistic DN = 0,260251
Approximate P-Value = 0,999245

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,260251	≥0.1
Anderson-Darling	0,250483	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.10, we **can not reject** the idea that JRC_Northern_LN2b_LG comes from a lognormal distribution with 90% or higher confidence.

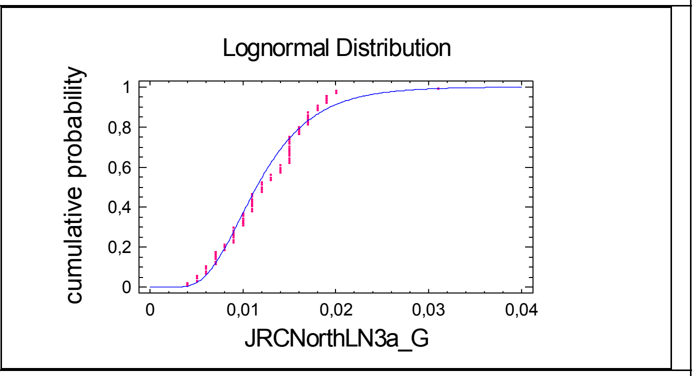
Selected distribution: Fitted lognormal distribution



JRC NORTHERN G+ Ecotype: LN3a

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0124503
std dev = 0,00538127



Goodness-of-Fit Tests

Chi-Square = 13,8678 with 5 d.f.
P-Value = 0,0164716
Estimated Kolmogorov statistic DPLUS = 0,076102
Estimated Kolmogorov statistic DMINUS = 0,12998
Estimated overall statistic DN = 0,129984
Approximate P-Value = 0,121061

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,129984	≥0.1
Anderson-Darling	1,28343	≥0.1

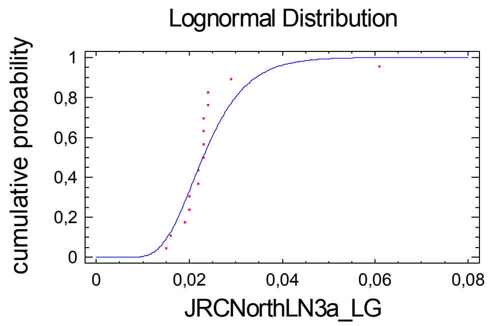
Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.05, we **can reject** the idea that JRC_Northern_LN3a_G comes from a lognormal distribution with 95% confidence.

Selected distribution: Raw data distribution

JRC NORTHERN G- Ecotype: LN3a

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0240888
std dev = 0,00781912



Goodness-of-Fit Tests

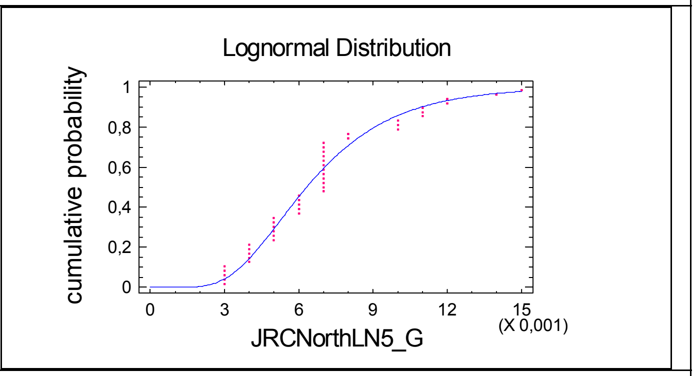
Chi-Square = 11,3328 with 2 d.f.
P-Value = 0,00346034
Estimated Kolmogorov statistic DPLUS = 0,308393
Estimated Kolmogorov statistic DMINUS = 0,14374
Estimated overall statistic DN = 0,308393
Approximate P-Value = 0,115331

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,308393	<0.1
Anderson-Darling	1,31729	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.01, we **can reject** the idea that JRC_Northern_LN3a_LG comes from a lognormal distribution with 99% confidence.

Selected distribution: Raw data distribution

JRC NORTHERN G+ Ecotype: LN5

Best fitting distribution: ***Lognormal*** Fitted lognormal distribution: mean = 0,00693389 std dev = 0,0031292	
Goodness-of-Fit Tests	Chi-Square = 11,778 with 4 d.f. P-Value = 0,0190811 Estimated Kolmogorov statistic DPLUS = 0,139538 Estimated Kolmogorov statistic DMINUS = 0,12712 Estimated overall statistic DN = 0,139538 Approximate P-Value = 0,347624

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,139538	≥0.1
Anderson-Darling	0,716025	≥0.1

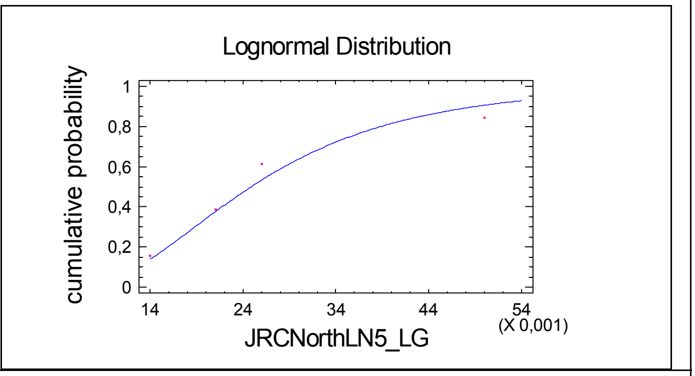
Conclusion:
Since the smallest P-value amongst the tests performed is less than 0.05, we **can reject** the idea that JRC_Northern_LN5_G comes from a lognormal distribution with 95% confidence.

Selected distribution: Raw data distribution

JRC NORTHERN G- Ecotype: LN5

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,0286409
std dev = 0,0163746



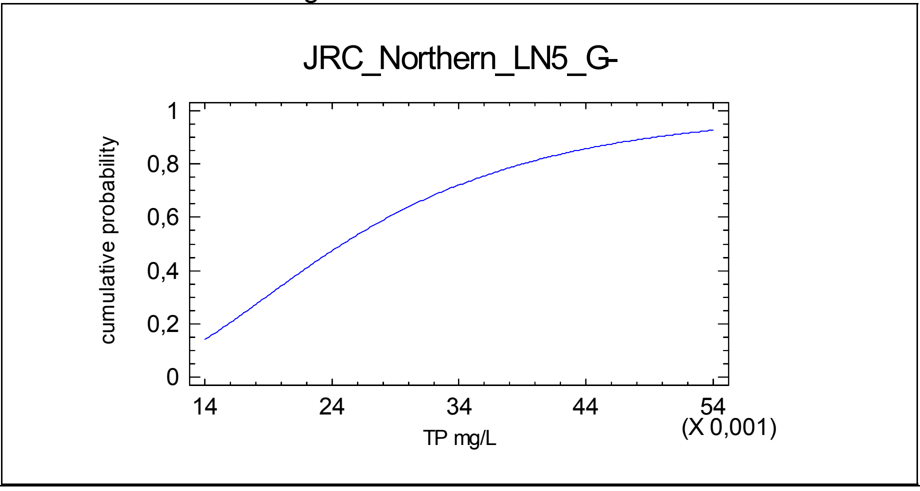
Goodness-of-Fit Tests

Insufficient data to conduct Chi-Square test.
Estimated Kolmogorov statistic DPLUS = 0,216526
Estimated Kolmogorov statistic DMINUS = 0,15551
Estimated overall statistic DN = 0,216526
Approximate P-Value = 0,991955

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,216526	≥0.1
Anderson-Darling	0,199392	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.1, we **can not reject** the idea that JRC_Northern_LN5_LG comes from a lognormal distribution with 90% or higher confidence.

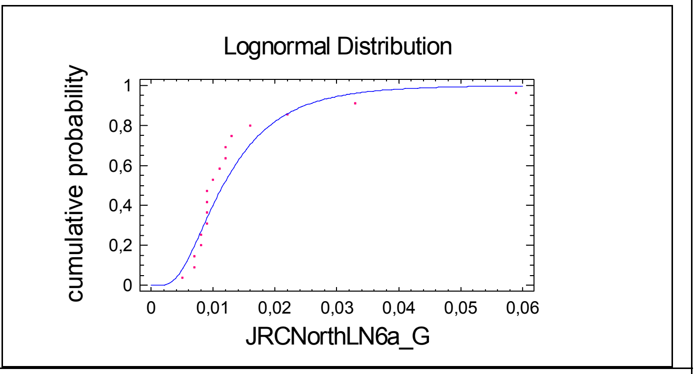
Selected distribution: Fitted lognormal distribution



JRC NORTHERN G+ Ecotype: LN6a

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,0138597
std dev = 0,00905607



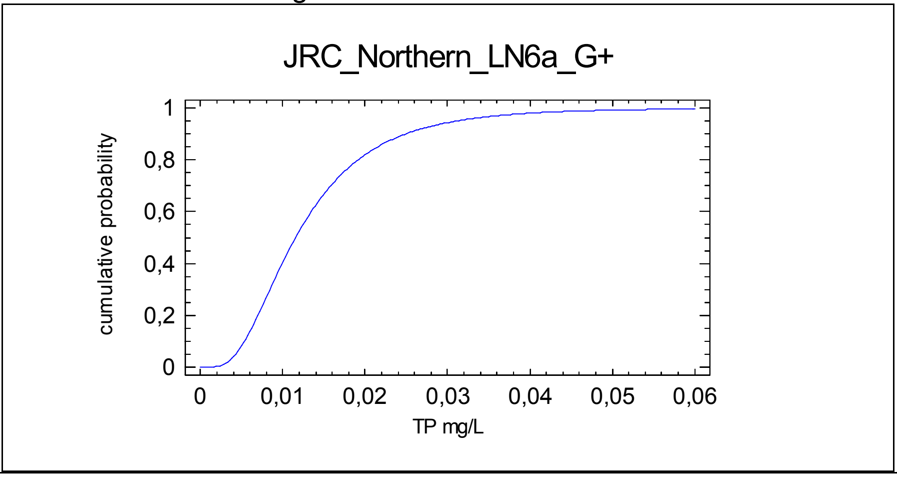
Goodness-of-Fit Tests

Chi-Square = 5,99985 with 3 d.f.
P-Value = 0,111615
Estimated Kolmogorov statistic DPLUS = 0,202142
Estimated Kolmogorov statistic DMINUS = 0,14281
Estimated overall statistic DN = 0,202142
Approximate P-Value = 0,46217

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,202142	≥0.1
Anderson-Darling	0,960402	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.1, we **can not reject** the idea that JRC_Northern_LN6a_G comes from a lognormal distribution with 90% or higher confidence.

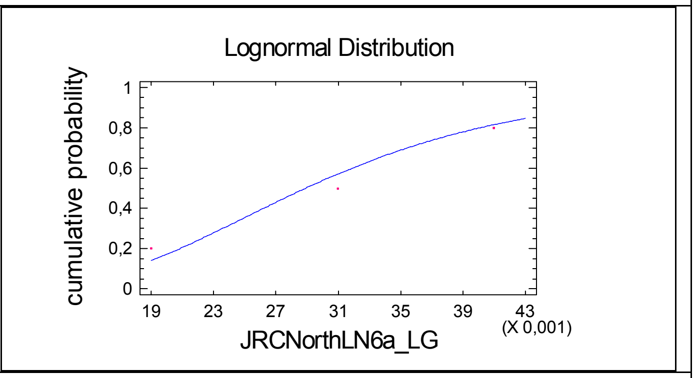
Selected distribution: Fitted lognormal distribution



JRC NORTHERN G- Ecotype: LN6a

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,0311802
std dev = 0,0126137



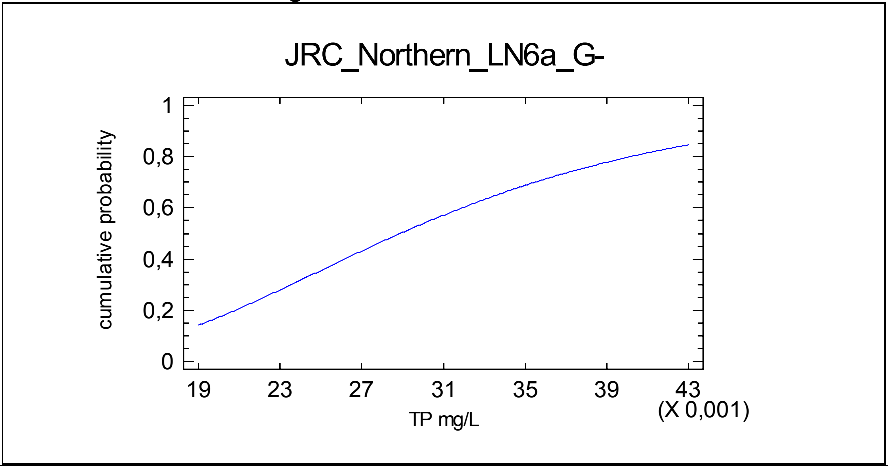
Goodness-of-Fit Tests

Insufficient data to conduct Chi-Square test.
Estimated Kolmogorov statistic DPLUS = 0,192748
Estimated Kolmogorov statistic DMINUS = 0,23800
Estimated overall statistic DN = 0,238003
Approximate P-Value = 0,995724

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,238003	≥0.1
Anderson-Darling	0,216665	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.1, we **can not reject** the idea that JRC_Northern_LN6a_LG comes from a lognormal distribution with 90% or higher confidence.

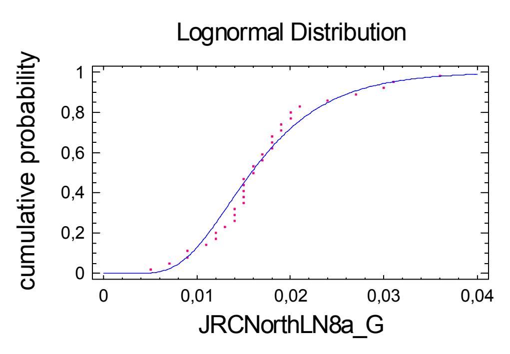
Selected distribution: Fitted lognormal distribution



JRC NORTHERN G+ Ecotype: LN8a

Best fitting distribution: ***Lognormal***

Fitted lognormal distribution:
mean = 0,01715
std dev = 0,00729771



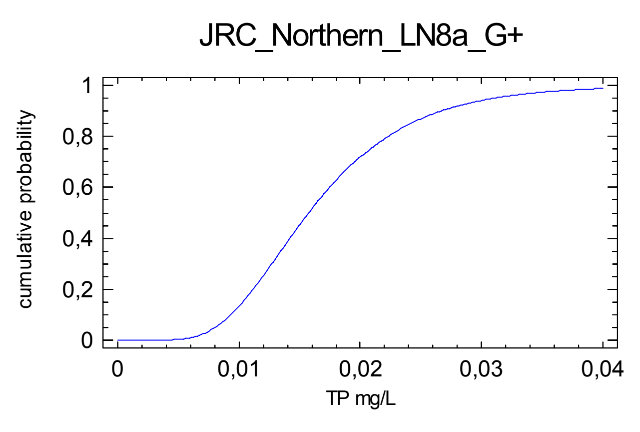
Goodness-of-Fit Tests

Chi-Square = 3,27247 with 4 d.f.
P-Value = 0,513306
Estimated Kolmogorov statistic DPLUS = 0,098861
Estimated Kolmogorov statistic DMINUS = 0,14214
Estimated overall statistic DN = 0,142144
Approximate P-Value = 0,531916

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,142144	≥0.1
Anderson-Darling	0,549855	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.1, we **can not reject** the idea that JRC_Northern_LN8a_G comes from a lognormal distribution with 90% or higher confidence.

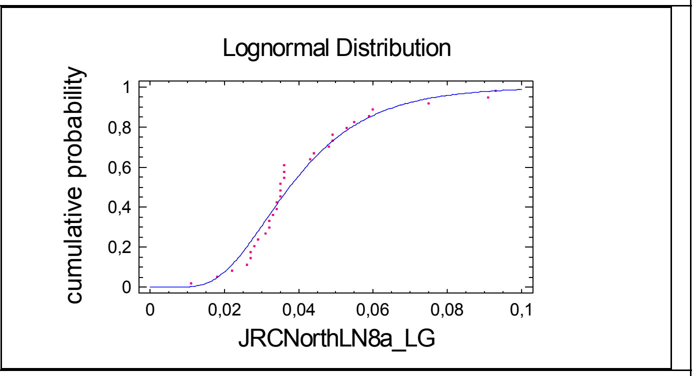
Selected distribution: Fitted lognormal distribution



JRC NORTHERN G- Ecotype: LN8a

Best fitting distribution:
Lognormal

Fitted lognormal distribution:
mean = 0,0413012
std dev = 0,0190898



Goodness-of-Fit Tests

Chi-Square = 2,12485 with 4 d.f.
P-Value = 0,712809
Estimated Kolmogorov statistic DPLUS = 0,161725
Estimated Kolmogorov statistic DMINUS = 0,10902
Estimated overall statistic DN = 0,161725
Approximate P-Value = 0,376261

EDF Statistic	Value	P-Value
Kolmogorov-Smirnov	0,161725	≥0.1
Anderson-Darling	0,533383	≥0.1

Conclusion:
Since the smallest P-value amongst the tests performed is greater than or equal to 0.1, we **can not reject** the idea that JRC_Northern_LN8a_LG comes from a lognormal distribution with 90% or higher confidence.

Selected distribution: Fitted lognormal distribution