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

MODEL IMPLEMENTATION AND QUANTIFICATION OF THE EUTROPHICATION RISK ASSOCIATED TO THE USE OF PHOSPHATES IN DETERGENTS

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LAYMAN´S SUMMARY

OF FINAL STUDY REPORT

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This is a simplified summary of the final report of the study entitled: "**Development of an European Quantitative Eutrophication Risk Assessment of Phosphates in Detergents**" carried out by **Green Planet Research** and **INIA** (Spanish National Institute for Agricultural and Food Research and Technology) for CEEP**, a Cefic sector group** (European detergent phosphate industry joint research association) in the context of the EU Detergent Regulation.

Objectives

The objective of the study was to develop, with expert peer review of the methodology, a (quantitative) risk assessment model for eutrophication, allowing the comparative assessment of different sources of phosphates and particularly the contribution from Phosphorus-based detergents.

The model was based on:

- A simplified generic exposure assessment model, allowing the identification of the expected total contribution of phosphates in a river basin, based on the catchment characteristics.
- The development of criteria for eutrophication risk based on the proposals from Water Framework Directive (WFD) and its application to a database of published field studies.
- The combination of both proposals for producing quantitative estimations of the likelihood for eutrophication in sensitive water bodies within the river basin.

In all cases, the definition for "eutrophication occurring" is that the most sensitive part of a water system should fail to achieve WFD "good quality" status because of eutrophication criteria. The model has been developed for large river basins and assumes that the risk for the whole basin should be quantified through the risk for its sensitive areas, such as shallow lakes or still water conditions.

The probabilistic distributions derived can then be used to assess, for generic river basins, the change in the risk of eutrophication occurring for different scenarios of use of phosphates in household detergents (as additional to other phosphates loads from sewage, agriculture …).

Although based on the same principles, the proposed probabilistic risk assessment model is significantly different from the standard industrial chemical risk assessment methodology developed by the European Chemicals Bureau (ECB) for assessing the risk of industrial chemicals. This is because:

a) the assessed substance, phosphorus (P), is widely distributed in the natural environment and there are many different anthropogenic sources;

b) eutrophication is a complex biological (ecosystem) phenomenon, because of synergistic or antagonistic effects with other substances (in particular other nutrients) or ecosystem modifications, climate variations, ecosystem adaptation mechanisms, storage and cycling of nutrients in aquatic ecosystems.

The study methodology and exposure scenarios were examined and confirmed at a peer-review Workshop, bringing together risk assessment scientists and eutrophication scientists, organised at INIA in Madrid in November 2005.

Effect assessment

The following field data was used to derive the probabilistic distributions of the risk of eutrophication occurring /not occurring for given surface water phosphate concentrations:

- 303 European data items on sensitive zones (lakes and reservoirs) from published literature were used, selected as appropriate and adequately informed out of over 500 initially examined;

- data points were assessed for : eutrophication status (using a proposal based on the WFD criteria without considering P concentration), and information on the annual average total phosphorus concentration;

- each site was assessed for each calendar year. The lack of fulfilment of the criteria for good status for eutrophication at any time of the year lead to classification as less-than-good status

The reliability of the assessments was verified by comparison with additional criteria including the Morphoedaphic Index for addressing the role of anthropogenic contributions (developed by Vighi et al., 1985). Potential inconsistencies were evaluated and a final decision adopted case-by-case.

The derived probabilistic distributions enable the estimation of the eutrophication risk based on the probabilistic distribution of P in water bodies with good and less-than-good status.

The use of probabilistic distributions effectively takes into account the variations in ecosystem complex reaction to phosphorus outlined above.

As proposed by the expert workshop peer-review, the effect assessment treated separately two eco-regions (Mediterranean region and the rest of Europe) and for the non-Mediterranean systems, two ecosystem types, deep and shallow lakes. Thus, three generic ecoregion / ecosystem types were considered as adequate to cover (sensitive water bodies) in Europe: Atlantic-North-Central Europe shallow lakes, Atlantic-North-Central Europe deep lakes, Mediterranean lakes and reservoirs. That is, the data points from each of these ecoregion / ecosystem types were analysed separately and a distinct probability distribution derived for each type. The number of data points for Atlantic-North-Central Europe deep lakes was not enough and therefore this class was not further considered in the assessment.

Exposure assessment and scenarios

Estimated P concentrations in water bodies (PEC = Predicted Environmental Concentration, as annual mean total phosphorus) were calculated for a generic river basin from the following catchment characteristics:

- river flow;
- agricultural intensity and land-use pattern;
- per hectare P run-off coefficients for different land-use types;
- population density and per capita emissions through sewage (human metabolism);
- different scenarios of reduction of P (P-removal from sewage) systems at the STPs;
- P emissions, per person, from P-based domestic detergents.

Data on consumption of P in domestic detergents were provided for each of the 25 EU member states by AISE, the International Association for Soaps, Detergents and Maintenance Products, giving a total of 61,500 tonnes P per year (2004 data), that is 0.36 gP/person/day. This was somewhat lower than the estimate for EU sales provided by the detergent phosphates industry (9 companies), at 95.000 tonnes P, or 0.56 gP/person/day. The difference may correspond to detergents manufactured in the EU and exported. The EU average (0.36 gP/person/day) and highest national figure (0.84gP/person/day) from AISE data, excluding one outlier, were used as model scenario inputs.

The estimations, based on average emission coefficients, were considered appropriate for large river basins. The capability of the model was established through comparisons of modelled data with Danube river basin monitoring data.

Thus estimated (modelled) P concentrations, with or without phosphates-based detergents, were derived for a number of different generic river basin models based on variations of the above factors (high / low population density, agricultural intensity, …). Additionally, contributions from point and diffuses sources were also compared.

It should be noted that the exposure assessment estimates P concentrations in the in-flow water, and does not consider in-lake phosphorous processes. Depending on lake characteristics (such as depth, residence time, etc.) lake concentrations can be even orders of magnitude lower than the concentrations in inflowing rivers. The same river concentration will not produce the same concentration in shallow ponds (mean depth of a few meters) than in a deep alpine lake (mean depth higher than 100 meters). Following the discussions at the expert workshop, it was decided to use the worst-case exposure conditions related to the concentration in the river and equivalent to the inflow phosphorous concentration for sensitive areas. For lakes, the estimations represent the eutrophication potential of the inflow water, which constitute an unrealistic worst-case estimation particularly for deep lakes.

Risk characterization

The eutrophication risk is defined as the likelihood of a sensitive site, susceptible to be affected by eutrophication, to be in less-than-good eutrophication status. This value is obtained using the probability distributions described in the effect assessment part. The value must be corrected by the percentage of sensitive sites in the considered land area (with potential for suffering eutrophication problems if enough amounts of nutrients are provided). This correction provides a risk value ranging from 0 to 1 (or 0% to 100% when expressed as percentage). The risk does not cover non-sensitive water bodies. For example, when 40% of the water bodies have potential for eutrophication in a given area, the risk value refers exclusively to this 40%, not to all water bodies in the area. Thus a risk value of 50% means that half of this 40% sensitive water bodies are expected to be in less-than-good status conditions.

Due to the complexity of the eutrophication process, the inherent biological variability and the uncertainty in the assessment, the risk is not presented as a single value but as a range (i.e. the eutrophication risk is between this and that value). In addition, the most likely value within the range is calculated. However, this calculation requires an estimation of the percentage of sensitive zones in the area which currently does not fulfil the conditions of good status; as proper values for this parameter are still not available, this estimation includes an additional level of uncertainty.

Several generic river basins with different phosphates emission management scenarios were modelled, including combinations of domestic detergent phosphates consumption (European average and highest national value), river flow (European average and twice the average),

population density (European average and one third the average), agricultural intensity (European average (26% arable soil, 26% pasture and 38% forest) and low intensity, based on 10% arable soil, 30% pasture and 50% forest), and level of P-removal at the Sewage Works. For the latter, a basic scenario of 20% P-removal in the sewage system (representing P-removal without tertiary treatment, this value is approximately equivalent to EU average collection and P-removal rates, 1999 figures) was compared to a scenario of 60% of removal, corresponding to estimated expectations after full implementation of directive EEC/1991/271, that is with nutrient removal widely installed in sensitive areas.

For comparative purposes, the model also estimates three specific contributions:

- the contribution of all sources expect P-based detergents.
  - estimating the risk without detergents (risk for zero STPP use in detergents);
- the contribution of all point sources only
  - estimating the hypothetical risk for zero contribution from diffuse sources (basically agricultural and background P run-off);
- the contribution of all diffuse sources only
  - estimating the hypothetical risk for zero contribution from point sources (human metabolism plus P-based detergents).

Summarising, for each river basin model, the model generates an expected phosphorus concentration for each comparative scenario and a “probability” of eutrophication occurring (eutrophication risk). In fact, as indicated above, the model gives a probability range from minimum to maximum and a “most likely probability” value.

A specific consultation of scientific experts concluded that they would prefer that each of these three values be included in the presentation of the final results (rather than only a calculated combination of them), and so this is done in the graphs used to represent the model results for different generic water basin scenarios.

Results and conclusions

The above scenarios generated a total of 20 graphs, reproduced in the full final report.

Of these, the following are reproduced below:

- typical situations:
  - EU average situation for Atlantic, Northern & Central European shallow lakes (Figs. A and C);
  - EU average situation for Mediterranean lakes and reservoirs (Figs. B and D)

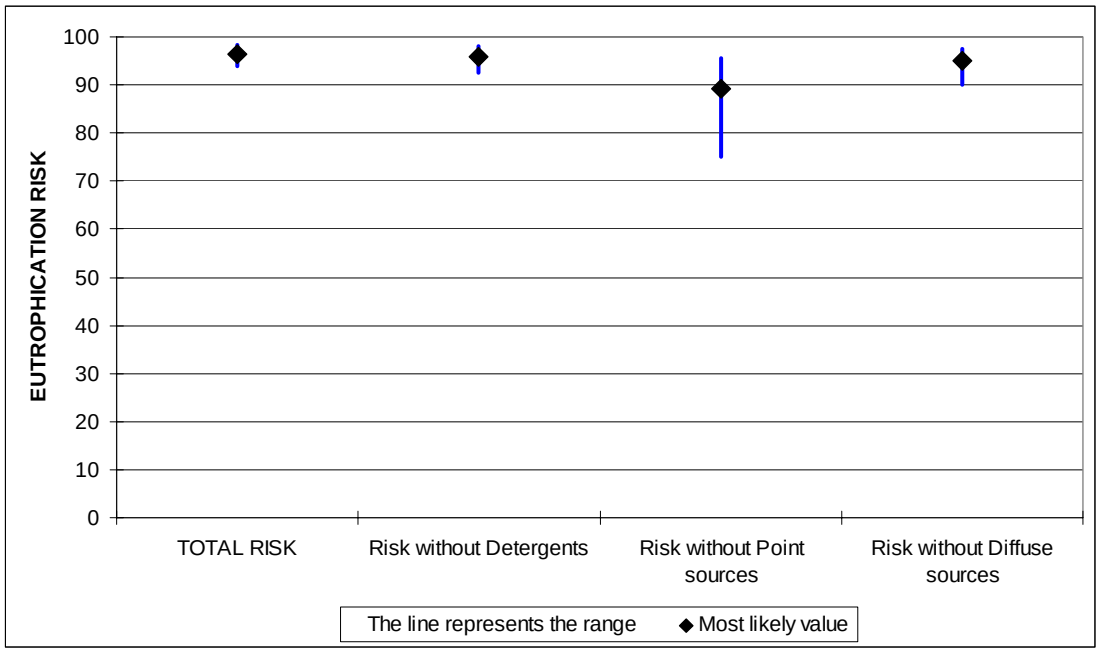

Figure A. Generic risk estimations for Atlantic, Northern & Central European shallow lakes using European average conditions

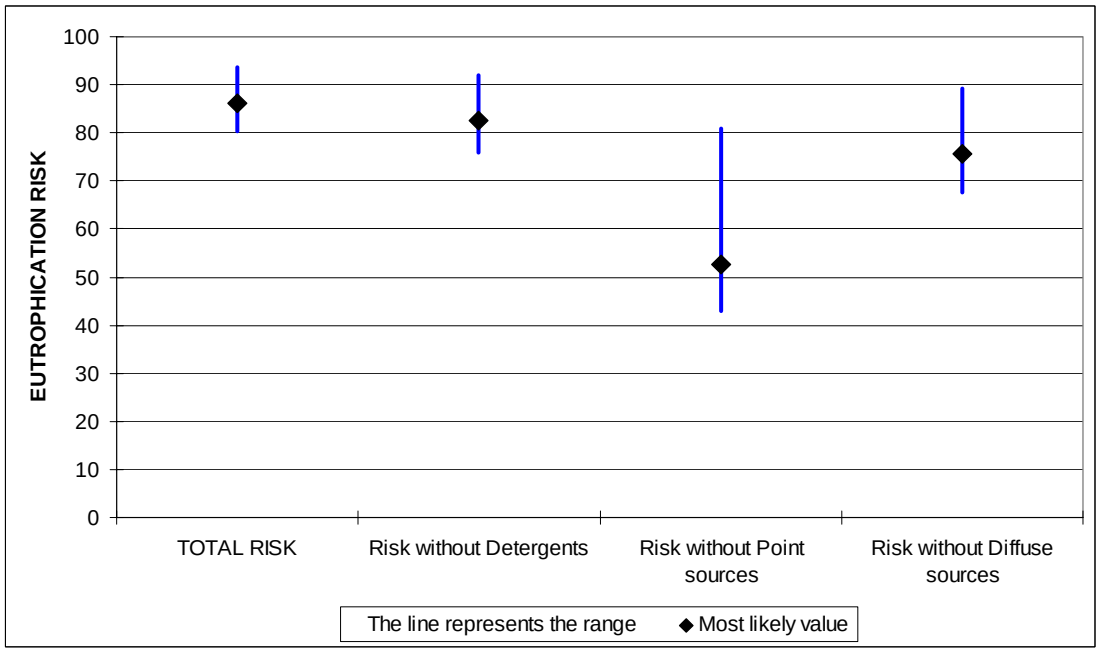

Figure B. Generic risk estimations for Mediterranean water bodies using European average conditions

The results indicate a large variability within the different regions. This variability can be covered by a probabilistic Pan European assessment comparing the eutrophication risk distributions with and without the contribution of detergents. The results are presented in graphic forms below.

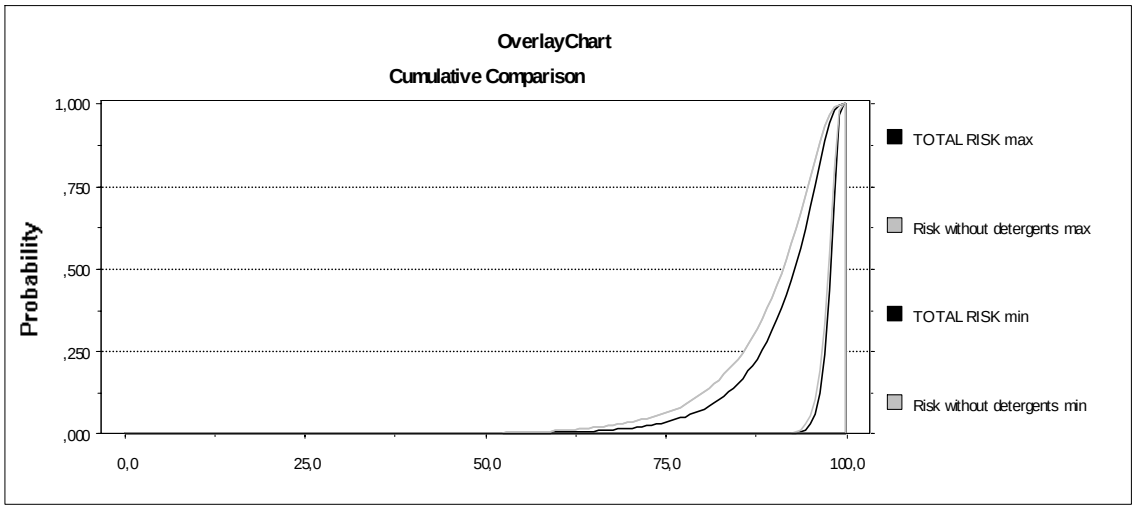

Figure C. Atlantic-N&Central shallow effects assessment scenario. Comparison between "Total Eutrophication Risk" (black lines) and "Eutrophication Risk without P-Detergent contribution" (grey lines) ranges. Max and min represents the upper and lower bounds respectively.

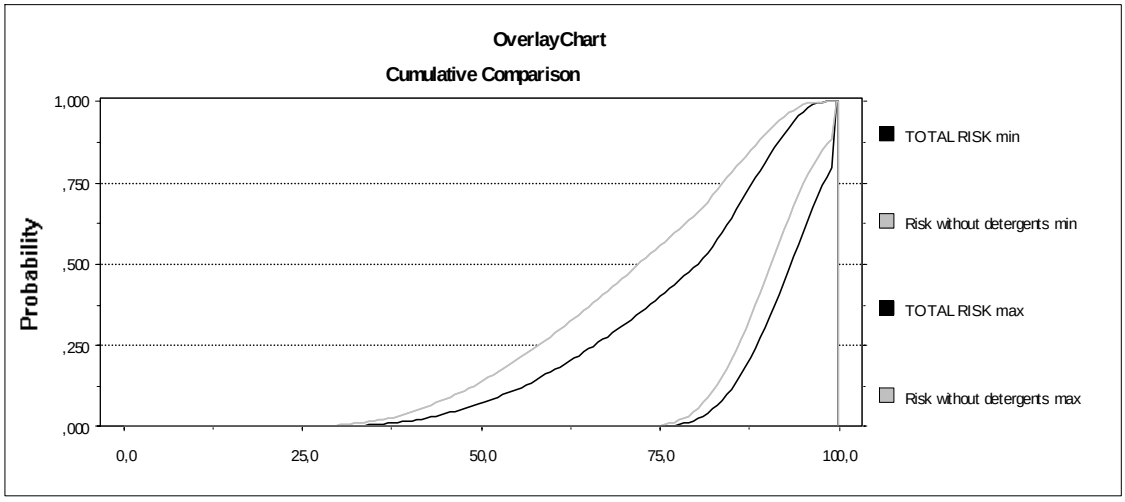

Figure D. Mediterranean effects assessment scenario. Comparison between "Total Eutrophication Risk" (black lines) and "Eutrophication Risk without P-Detergent contribution" (grey lines) ranges. Max and min represents the upper and lower bounds respectively.

The results of this study are subject to the following limitations:

- Insufficient and non-representative data points for Atlantic & Central European deep lakes. The probabilistic distributions derived from the data points available for this ecoregion / ecosystem type did not give meaningful results. The input of further data points into the model might resolve this. Additionally, the consideration of in-lake processes may be required for this class of sensitive ecosystems of very particular nature.
- High level of variability in the model results for Atlantic & Central European shallow lakes and Mediterranean lakes and reservoirs. This could be tested by inputting further data and seeing whether the variability is reduced. If the input of further data points do not reduce the variability, then the variability may be reflecting natural environmental variation (in particular dependence of eutrophication on a range of different factors). Data currently being collected by the European Union in the "Intercalibration" process of the WFD implementation would enable this.

It can be concluded from the results of this study, as illustrated in the graphs, that at an EU level, the estimated difference between the eutrophication risk (as a %) with and without P-based household detergents is typically around the range 2-8% based for Mediterranean ecosystem types and around the range 0.4-2% based on the Atlantic & Central European shallow lake effect assessment.

The eutrophication risks, and also the additional eutrophication risks related to detergent phosphates, are very variable in different regional situations as a result of the characteristics of hydrology, population density and agricultural intensity, among other factors.