green planet research

MINISTERIO DE EDUCACIÓN Y CIENCIA

INIA Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria

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

Barbara M. de Madariaga;

M. José Ramos,

José V. Tarazona

BACKGROUND

- CEEP, within the voluntary initiative HERA, presented a risk assessment report on polyphosphates in detergents
- The risk estimation was based on a toxicity assessment following the TGD; the RAR stated that it was not possible to estimate the eutrophication risk.
- The CSTEE considered that **the environmental risk of polyphosphates should be related to its contribution to the eutrophication risk** and that the available information should be sufficient for conducting such assessment.
- This study is a follow up of this consideration, and has been funded by CEEP and conducted by Green Planet (a technological base spin-off company) and INIA (a Spanish public research institute)

THE STUDY WORK PLAN

- Green Planet and INIA developed the initial proposal
- The proposal was presented for discussion at an *ad hoc* international expert workshop (Nov 2005)
- The proposal was adapted to consider the experts' opinions and has been used for a quantitative eutrophication risk estimation
- The draft report was distributed for comments and peer review by the experts
- The final report was submitted
- Additional scenarios have been considered

RISK ASSESSMENT

- CONCEPTUAL MODEL
- EXPOSURE ASSESSMENT
- EFFECT ASSESSMENT
- RISK CHARACTERIZATION
- RISK COMMUNICATION

- MATHEMATICAL IMPLEMENTATION
- RESULTS FOR THE PAN-EUROPEAN ASSESSMENT
- RESULTS FOR NATIONAL SCENARIOS

CONCEPTUAL MODEL

- REGIONAL (LARGE RIVER BASINS)
- BASIN RISK = RISK FOR SENSITIVE AREAS
- POTENTIAL RISK (= PEC/PNEC IN TGD)

- RISK OF PHOSPHATES IN DETERGENTS
  - CURRENT USE PATTERNS
  - INDICATED BY CEEP/AISE

EXPOSURE

- NEEDS:
  - ANNUAL AVERAGE TOTAL PHOSPHOROUS CONCENTRATION
  - CONTRIBUTION OF THE SOURCE TO BE EVALUATED (E.G. DETERGENTS) AS CONCENTRATION OR PERCENTAGE

- OPTIONS
  - GENERIC MODEL FOR LARGE RIVER BASINS
  - SPECIFIC MODELS
  - MONITORING DATA

THE SIMPLIFIED MODEL

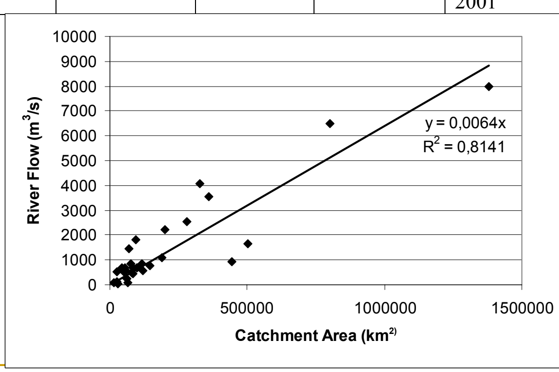
PAN-EUROPEAN ASSESSMENT

- GENERIC (NOT GIS) MODEL
- BASED ON AVERAGE EXPORT COEFFICIENTS
- APPLICABLE TO LARGE RIVER BASINS
- DISCRIMINATE THE CONTRIBUTIONS FROM DETERGENTS, OTHER POINT SOURCES AND DIFFUSE SOURCES
- VALIDATED FOR THE DANUBE RIVER BASIN
- **CAN BE REPLACED BY SITE-SPECIFIC MODELS AND/OR MONITORING DATA**

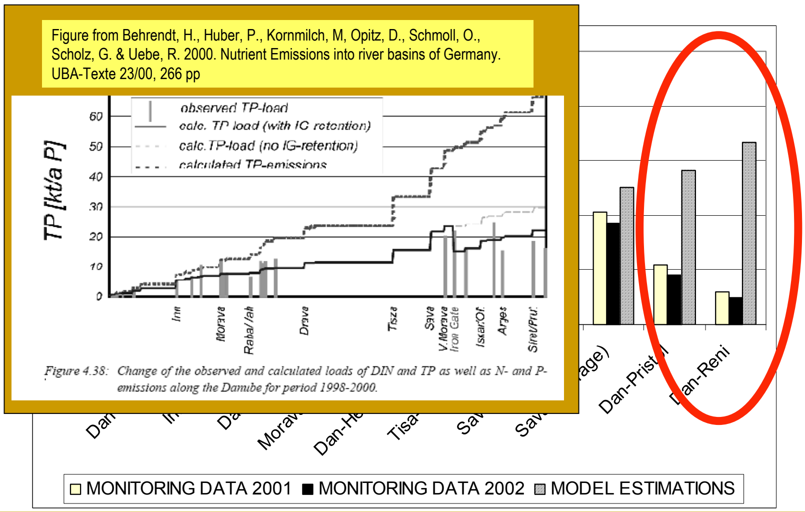
VALIDATION

Table 1. Export coefficients selected for the simplified model and reported range in the literature.

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



DANUBE RIVER BASIN



POINT EMISSION SOURCES

- HUMAN METABOLISM
  - 1.5 gP/person and day
- DETERGENTS
  - EU average 0.36 gP/person and day
  - Maximum (Hungary): 0.84 gP/person and day
- STP/WWTP REDUCTION
  - 20%
  - 60%

EFFECTS ASSESSMENT

- CRITERIA ADAPTED FROM WATER FRAMEWORK DIRECTIVE
- APPLIED TO A 303 FIELD CASES DATABASE
- ESTIMATES RELATIONSHIPS BETWEEN PHOSPHOROUS CONCENTRATION AND EUTROPHICATION POTENTIAL

EFFECT ASSESSMENT FOR PHOSPHATES DOSE/RESPONSE RELATIONSHIPS

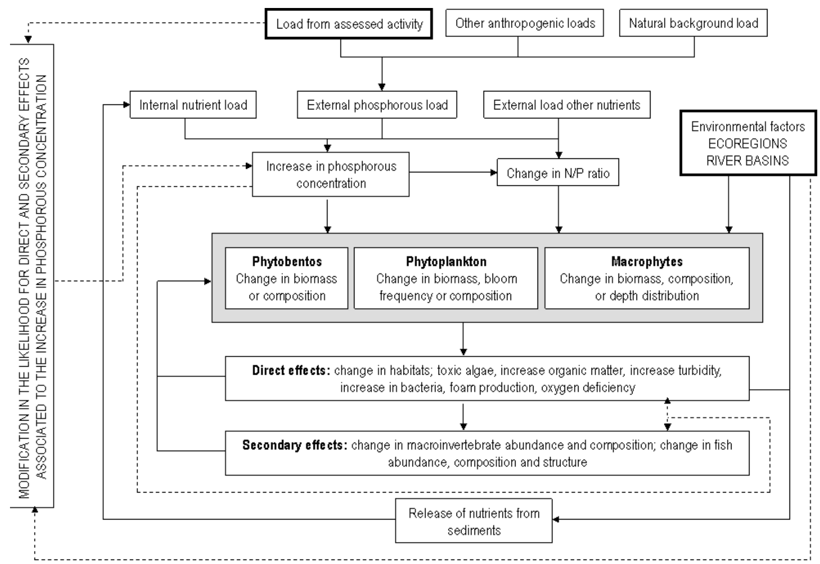
- ADVERSE CONSEQUENCES AS DEFINED BY THE WFD
- RESPONSE DEPENDS ON A LARGE VARIETY OF VARIABLES
  - EVEN FOR THE SAME ECOSYSTEMS AND UNDER CONTROLLED CONDITIONS
- ALTERNATIVE
  - **FIELD OBSERVATIONS COVERING THE NATURAL VARIABILITY**
  - **PROBABILITY ESTIMATIONS FOR EFFECTS**

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

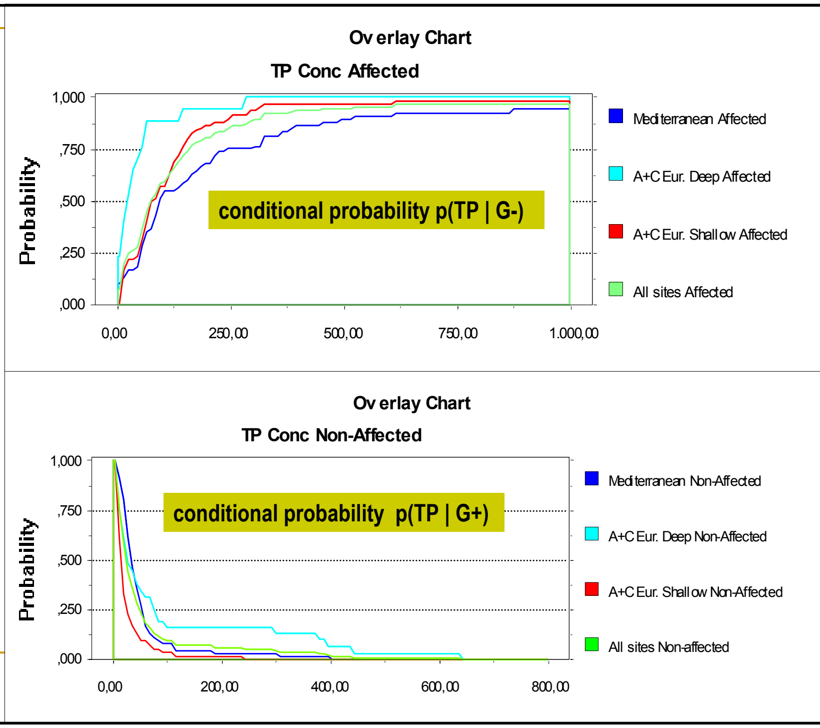
Table 1: Significant undesirable disturbances that may result from accelerated growth of phytoplankton, macroalgae, phytobenthos, macrophytes or angiosperms
(a)Causes the condition of other elements of aquatic flora in the ecosystem to be moderate or worse
(a)Causes the condition of benthic invertebrate fauna to be moderate or worse
(a)Causes the condition of fish fauna to be moderate or worse
(a)Compromises the achievement of the objectives of a Protected Area for economically significant species
(a)Compromises the achievement of objectives for a Natura Protected Area
(a)Compromises the achievement of objectives for a Drinking Water Protected Area
(a)Causes a change that is harmful to human health (e.g. shellfish poisoning)
(a)Causes a significant impairment of, or interference with, amenities and other legitimate uses of the environment
(a)Causes significant damage to material property

The condition of phytoplankton, phytobenthos, macrophytes, macroalgae or angiosperms would not be consistent with good ecological status where, as a result of anthropogenic nutrient enrichment, changes in the balance of taxa had occurred that are likely to adversely affect the functioning of the ecosystem

Table 2: Examples of ecologically significant undesirable changes to the balance of taxa
(a) An entire functional group of taxa, or a keystone taxon, normally present at reference conditions is absent;
(a) A nutrient-tolerant functional group of taxa not present under reference conditions is no longer rare
(a) A substantial change in the balance of functional groups of taxa has occurred;
(a) A group of taxa, or a taxon, of significant conservation importance normally present at reference conditions is missing



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
Eutrophication Assessment	Rationale Ecologically Relevant Effects (ERE) ERE - semi quantitative discrimination	Direct & indirect effects yes / no from -3 to +3
Data Validation	Trend in the semi-quantitative classification MorphoEdaphic Index (MEI based on conductivity) following Vighi, and Chiaudani, 1985.	



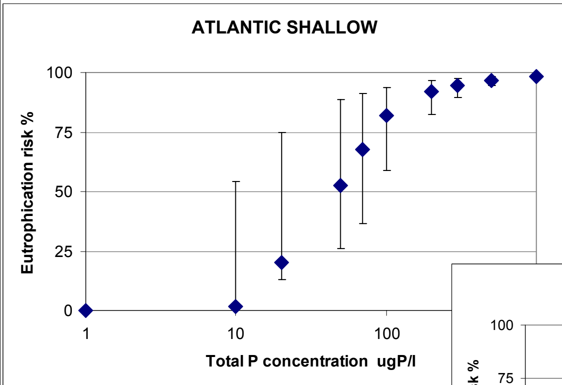
FROM FIELD DATA TO RISK CHARACTERIZATION

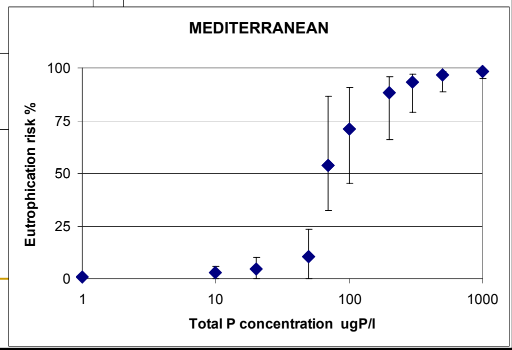
- Conditional probabilities p(TP | G+) and p(TP | G-) are used to define the eutrophication risk as
  Relative (0-100%) conditional probability of a water body to be in less than good status given a certain TP concentration
  - **p(G- | TP) corrected by maximum value of p(G-)**

- Defined in the range:
  From 1- p(TP | G+) to p(TP | G-)

- With a most likely value of
  mlp(G- | TP) = p(TP | G-)mlp(G-) / p(TP)

RISK CHARACTERIZATION





MATHEMATIC IMPLEMENTATION

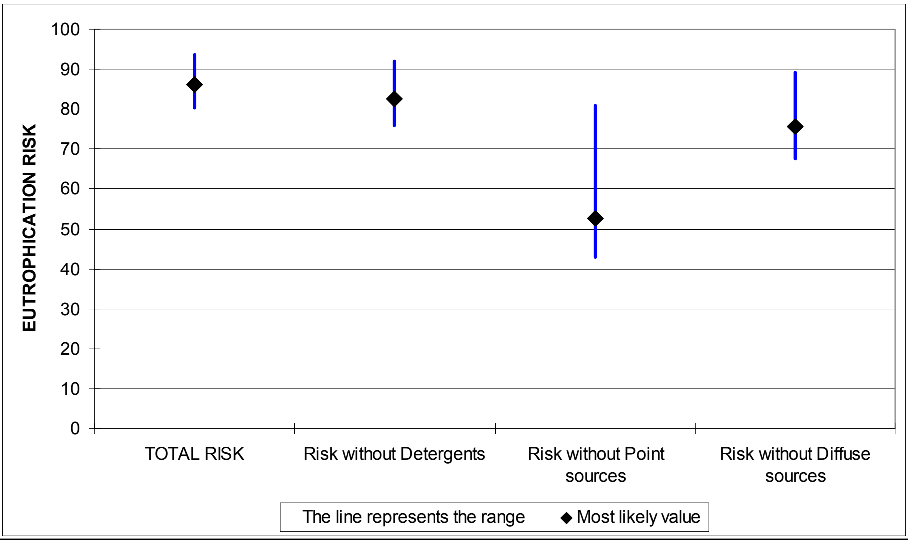
INPUTS		
	Units	Figures
Scenario	MEDITERRANEAN	
Effect assessment distribution		2
PopulationDensity	person/ha	1,17
CatchmentArea	ha	10000000
RiverFlow	m^3/s	640
LanduseArableLand	%	26
LandusePasture	%	26
LanduseForest	%	38
LanduseOther	%	10
ArableLand coefficient	kg/ha/year	0,66
Pasture coefficient	kg/ha/year	0,4
Forest coefficient	kg/ha/year	0,02
Other uses coefficient	kg/ha/year	0,2
P emission from Population	g/person/day	1,5
P emission from Detergents	g/person/day	0,36
Current P reduction at STP	%	20
Sites with non-good status	%	33

RESULTS

MEDITERRANEAN

PREDICTED EXPOSURE LEVELS		*Units*		*Units*
TP total concentration	**465,1**	µg P/l	100	%
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	%



RESULTS:

CONTRIBUTION OF DETERGENTS TO THE OVERALL RISK

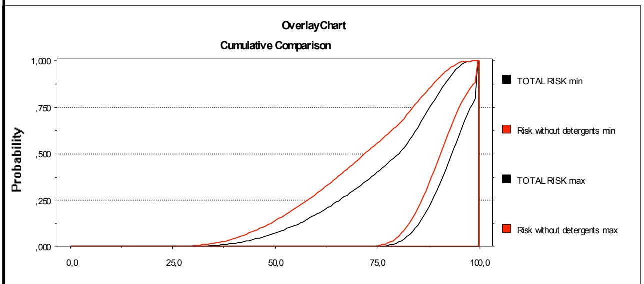
GENERIC EUROPEAN SCENARIOS

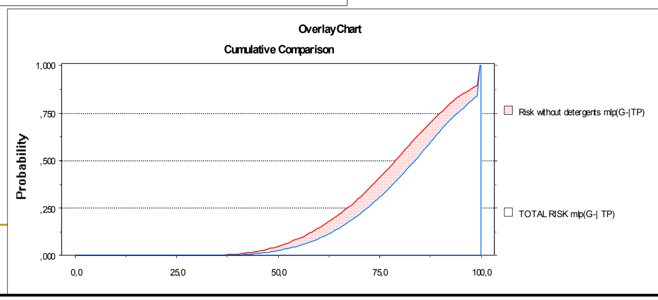
Scenario	Detergent contribution	TP conc.	Ecoregion&type Class	Difference between total risk and risk without detergents		
	%	µg/l		Upper bound 1-p(TP|G+)	Lower bound P(TP|G-)	mlp(G-|TP)
1a	13.1	465	Mediterranean	1.6	4.5	3.7
1b	13.1	465	At-N&C shallow	0.2	1.2	0.5
1c	26	546	Mediterranean	3.4	8.1	7.6
1d	26	546	At-N&C shallow	0.4	2.3	1
2a	13.1	232	Mediterranean	1.6	4.7	4.4
2b	13.1	232	At-N&C shallow	0.4	2.8	1.1
2c	26	273	Mediterranean	3.4	10.3	9.3
2d	26	273	At-N&C shallow	0.8	5.4	2
3a	8	255	Mediterranean	0.9	2.8	2.5
3b	8	255	At-N&C shallow	0.2	1.4	0.6
3c	16.8	282	Mediterranean	2	6.3	5.5
3d	16.8	282	At-N&C shallow	0.5	2.9	1.1
4a	9.6	212	Mediterranean	1.1	3.3	3.2
4b	9.6	212	At-N&C shallow	0.4	2.1	0.8
4c	19.8	239	Mediterranean	2.5	7.4	6.9
4d	19.8	239	At-N&C shallow	0.7	4.4	1.6
5a	9.9	154	Mediterranean	1.1	3	3.2
5b	9.9	154	At-N&C shallow	0.4	3.3	1.4
5c	20.4	174	Mediterranean	2.5	6.8	7.2
5d	20.4	174	At-N&C shallow	0.8	6.7	2.7

Table ES.2.. Median and arithmetic mean values obtained for the different generic scenarios.

Parameter	Detergent contribution	TP conc.	Difference between total risk and risk without detergents		
	%	µg/l	Upper bound 1-p(TP|G+)	Lower bound P(TP|G-)	mlp(G-|TP)
All scenarios					
Median	15	247	0.85	3.85	2.6
Arith mean	16	283	1.24	4.48	3.31
Mediterranean scenarios					
Median	15	247	1.80	5.50	4.95
Arith mean	16	283	2.01	5.72	5.35
Atlantic-N&Central shallow scenarios					
Median	15	247	0.40	2.85	1.10
Arith mean	16	283	0.48	3.25	1.28

PROBABILISTIC IMPLEMENTATION MONTE CARLO ANALYSIS



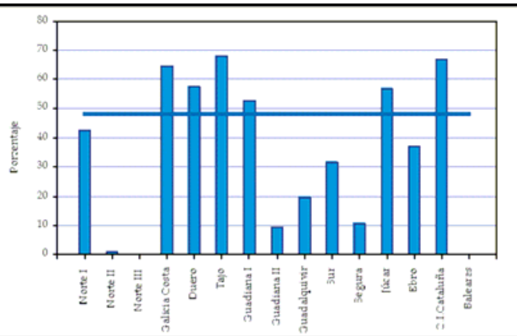


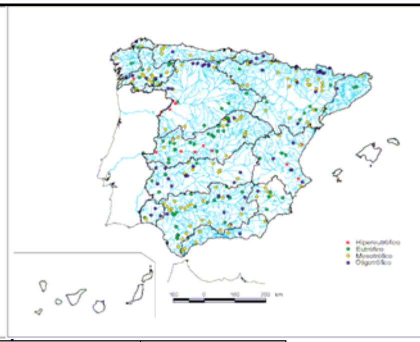
APPLICATION TO SPECIFIC/NATIONAL SCENARIOS

CALIBRATION OF EXPOSURE LEVELS

COMPARISON WITH OBSERVED EFFECTS

SPANISH SCENARIOS

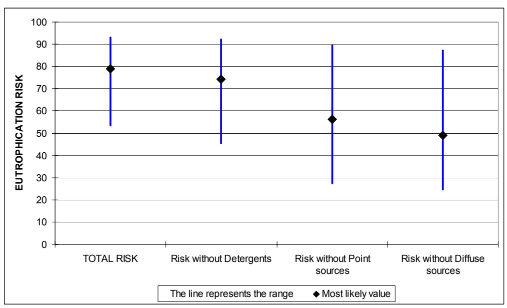




Example	TP conc. (μgP/l)	Upper bound 1-p(TP|G+) (%)	Lower bound P(TP|G-) (%)	mlp(G-|TP) (%)
1a–Tajo-Trillo	36	42.5	16.1	12.1
2a–Tajo-Aranjuez	98	76.2	31.9	39.82
3a–Tajo-Polan	1370	100	94.6	100
4a–Tajo-Alcantara	295	88.5	65.1	73.6
5a-Ebro-Miranda	36	42.4	16.1	12.1
6a-Ebro-Mendavia	166	82.09	46.01	55.8
7a-Ebro-Zaragoza	173	82.5	47.2	57.1
8a-Ebro-Tortosa	129	79.2	38.7	47.9

Example	Catchment/Station	Detergent contribution	TP conc.	Difference between total risk and risk without detergents		
		%	µg/l	Upper bound 1-p(TP|G+)	Lower bound P(TP|G-)	mlp(G-|TP)
1a	Tajo - Trillo	8.4	36	6	0.2	1.1
1b	Tajo - Trillo	5	36	3.4	0.1	0.6
2a	Tajo - Aranjuez	6.7	98	0.8	1.6	1.9
2b	Tajo - Aranjuez	3.8	98	0.4	0.9	1.1
3a	Tajo - Polan	13.9	1370	0	1	0
3b	Tajo - Polan	9.3	1370	0	0.6	0
4a	Tajo - Alcantara	18.3	295	2.2	7	6
4b	Tajo - Alcantara	13.7	295	1.6	5.2	4.4
5a	Ebro - Miranda	4.7	36	3.2	0.1	0.6
5b	Ebro - Miranda	2.6	36	1.7	0	0.3
6a	Ebro - Mendavia	11.4	166	1.4	3.6	3.9
6b	Ebro - Mendavia	7.2	166	0.8	2.2	2.4
7a	Ebro - Zaragoza	11	173	1.3	3.5	3.7
7b	Ebro - Zaragoza	6.9	173	0.8	2.2	2.3
8a	Ebro - Tortosa	9.4	129	1.1	2.6	3.01
8b	Ebro - Tortosa	5.7	129	0.6	1.5	1.8

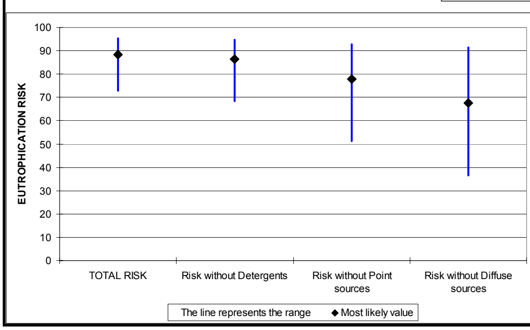
APPLICABILITY TO THE DANUBE RIVER BASIN



PRELIMINARY ESTIMATIONS

BASED ON UBA 2003
- **DETERGENTS CONTRIBUTION**
- **24% OF POINT SOURCES**

MONITORING DATA
- **90 and 140 ug P/l**



CONCLUSIONS

- THE STUDY HAS DEVELOPED A MODEL FOR A QUANTITATIVE ASSESSMENT OF THE EUTROPHICATION RISK ASSOCIATED TO PHOSPHOROUS EMISSIONS/CONCENTRATIONS
- THE MODEL CONSTITUTES A TOOL FOR ASSESSING THE CONTRIBUTION OF DIFFERENT SOURCES TO THE EUTROPHICATION RISK
- THE PAN-EUROPEAN ASSESSMENT FOR THE CURRENT SITUATION SUGGESTS THAT POLYPHOSPHATES IN DETERGENTS INCREASE THE EUTROPHICATION RISK BY:
  - 2-8% UNDER MEDITERRANEAN CONDITIONS
  - 0.4-2% UNDER ATLANTIC CONDITIONS

CONCLUSIONS cont.

- THE MODEL CAN BE ADAPTED TO SPECIFIC RIVER BASINS, THUS:
- **IF YOU HAVE PREDICTIONS OR MONITORING DATA FOR PHOSPHOROUS CONCENTRATIONS…..**
- **….THE MODEL BECOMES THE TOOL FOR MOVING FROM P CONCENTRATIONS TO EUTROPHICATION RISKS**.


THANK YOU