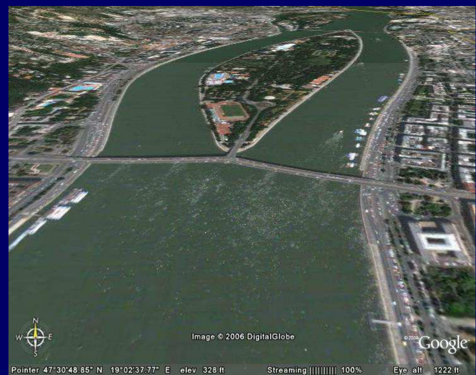
Katalin Gruiz

Ecological Risk Assessment of Inorganic and Organic Micropollutants in the Danube Sediment



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2006

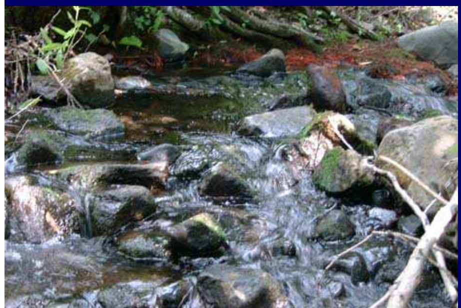
SEDIMENTS

1. Suspended matter in surface waters, with large specific surface for physico-chemical and biological processes.

- 2. Able to rescu the water phase from the harm of pollutants.
- 3. After piling up at sedimentation areas it represents a low value habitat.
- 4. Has long term potential for releasing the accumulated pollution into water and/or soil.
- 5. Threatens the ecosystem and humans as a chemical time bomb.

SENTIMENTS

1. Scientist: extremely high importance in aquatic structures, element cycles, transport pathways
2. Human being: sediments' time bomb fate endangers humans and human land uses, e.g. flooded areas.
3. Environmental managers: continuous maintenance is necessary to keep river and lake bed quality, special waste-treatment and waste-utilising technologies are required for the management of dredged sediment.
4. Ecosystem: the damaged aquatic ecosystem cannot fulfil its role in global element cycles and in the keeping of ecological equilibrium.



INTRODUCTION

Aim

Introduction of the results of two former research projects on

Risk Based managemenet of Danube sediment

Methodology and results

A 3-step tiered Risk Assessment methodology was developed and applied

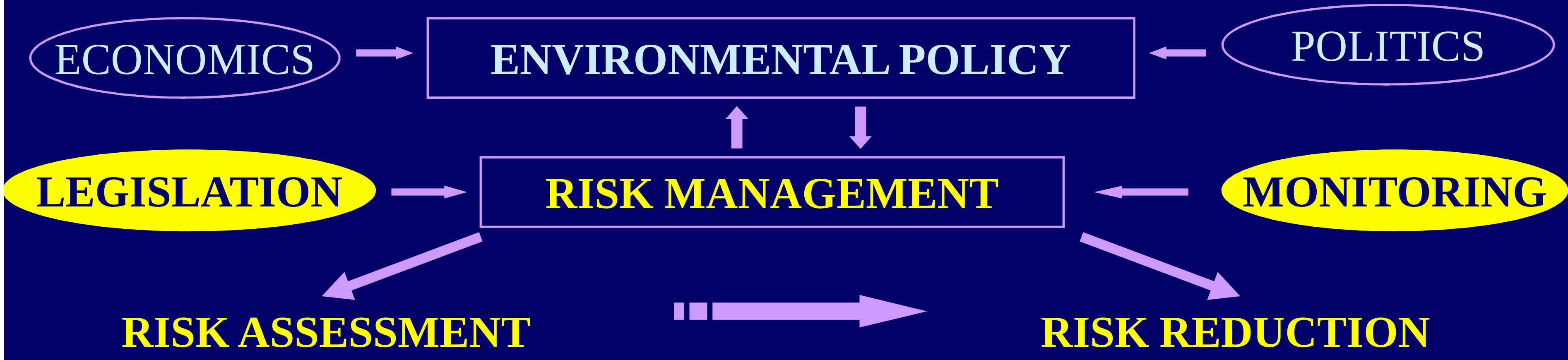
1. All chemicals produced and used in Danube catchment were collected
2. Tier 1.: Initial hazard assessment (qualitative RA): first ranking
3. Tier 2.: Hazard Assessment (Generic Qualitataive RA): ranking by RQ
4. Tier 3.: Site specific Risk Assessment: local risk value
5. Evaluation, interpretation and use of data
6. Validation calculated risk with measured data.

Theoretical background

Risk of chemicals: scale of damage x probability of occurrence

- **Environmental Risk Assessment (ERA) methodologies: discursive, qualitative or quantitative risk assessment**
- **Kind of Generic ERA: calculates the quantity of risk with default (Danube) values**
- **Site Specific ERA: considers the characteristics of the site: environmen-tal elements, contaminants, interactions, land uses, reg+local exposures, etc.**
- **Quantitative ERA: RQ = PEC/PNEC and HQ = ADD/TDI**
- **Integrated Risk Model: unifies the transport- and the exposure model**
- **Aims of ERA**:
  - **to quantify risk**
  - **to define acceptable risk / environmental quality criteria**
  - **to compare risk to the acceptable risk,**
  - **to reduce risk to an acceptable level,**
  - **to determine site specific target value of remediation**

Environmental Risk Assessment:
a tool for environmental management



1. HAZARD IDENTIFICATION
2. RISK ASSESSMENT

Generic / site specific

Qualitative / quantitative

Ecological / human health risk

1. PREVENTION
2. REMEDIATION
3. RESTRICTION

Management of contaminated sediment

Principles

To prevent further pollution

Polluter should pay

Precaution

Risk based decision making,

Risk based management: RB priority setting, RB monitoring, RB remediation

Scientific basis

Tiered risk assessment

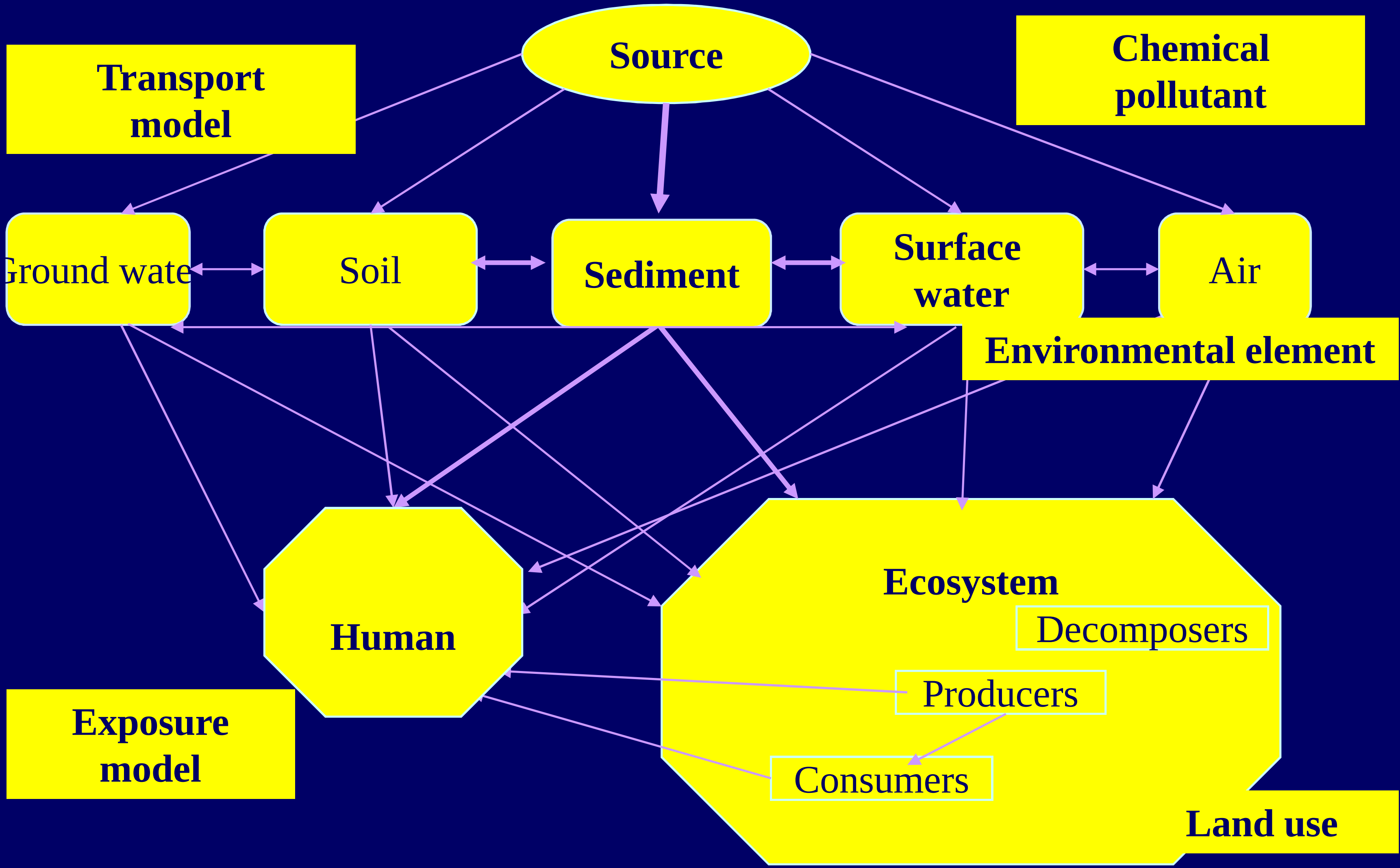
Qualitative and quantitative RA

Assessment of subsurface water and sediment: sampling, analyses, Triad approach

Exposure modeling

Ecotoxicology and toxicology

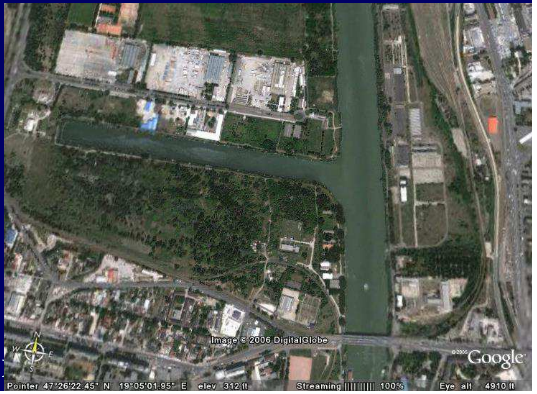
Integrated Risk Model



Tiered risk assessment of chemicals in Danube sediment

The methodology for risk characterisation has three steps (ECORISK, 1999):

1. **Initial hazard identification**: a qualitative risk assessment, aiming priority setting for those chemicals, which are produced and used in the Danube catchment.
2. **Generic Risk Assessment or Hazard Assessment:** quantitative risk assessment, the result is an RQ = PEC/PNEC, the European default values were used in the calculations.
3. **Site specific Risk Assessment:** used the PEC/PNEC approach too, but instead of default values the site specific measured concentrations and environmental parameters were used.



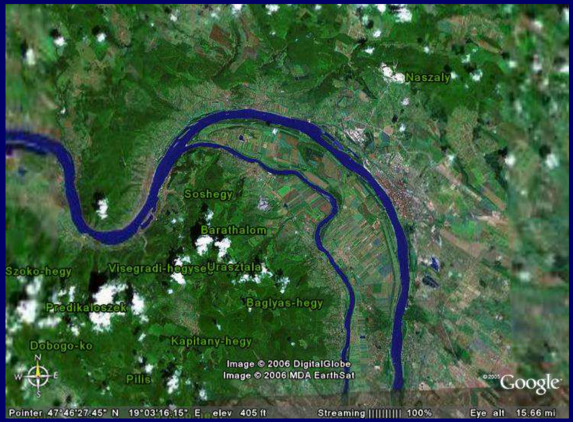
Gruiz, K. Risk Assessment of pollutants in Danube sedime

First tier of the risk assessment

Qualitative Environmental Risk Assessment and ranking of chemicals relevant to Danube sediment

CHARACTERISTICS OF QUALITATIVE ERA

- **Also called initial hazard assessment and relative risk assessment**
- **Characterizes risk with points or marks or %**
- **It is useful for priority setting and ranking in case of many existing contaminants**



First tier of the risk assessment

For initial hazard assessment and ranking of chemicals
Qualitative Environmental Risk Assessment

Suitable data: 1. production and use, 2. basic physico-chemical properties, 3. environmental nature and fate of the chemical substance, like K_{ow}, K_p: water solubility, degradability, 4. Biological/ecotoxicological properties, like biodegradability, toxicity, bioaccumulation.

To find the most risky chemicals in the Danube catchment, three properties were taken into account:

PARTITION

DEGRADABILITY

TOXICITY

First tier of the risk assessment: selection of the most risky contaminants for sediment

1. ***Partition*** between solid and liquid phase, which determines the sorption of the chemicals on the sediment particles.
   Criteria: more than 10 % of the contaminant is bound to the SS (suspended solid)
   For organics: *cut off value*: log $K_{ow} > 4.5$
   For inorganics: 1700 lit/kg.

2. ***Degradability*** biodegradation, hydrolyses and photo-degradation
   a.) readily degradable: (EU-TGD): half-life time 15 days;
   b.) not readily biodegradable: >15 days.

3. ***Toxicity*** risk of chemicals is dominantly due to their harmful effects, so that a cut-off value for toxicity was included already in the initial phase.
   Cut-off values for organics:
   1 mg/l – for chemicals with log Kow < 4.5 and Mw = 200
   10–20 mg/l – for chemicals with log Kow = 3 and Mw = 200.
   Cut-off values for inorganics: 1 mg/l.

Criteria setting for DSHPL and DSPL chemicals

Selection procedure: different criteria setting was applied to select the chemicals for the “Danube Sediment High Priority List” and the “Danube Sediment Priority List”.

Criteria for ***“High Priority List”***:
Log K_{ow} > 4.5 for organics; K_d > 1700 l/kg, S_w < 1 mg/l, for inorganics
Degradation half-life: >15 days
Acute toxicity for aquatic species: < 1 mg/l.

Criteria for ***“Priority List”:***
3 < log K_{ow} < 4.5 for organics; 100 < K_d < 1700 l/kg, for inorganics
7 days < degradation half-life > 15 days
1 mg/l < acute toxicity for aquatic species: < 100 mg/l.

Results of the first tier: DSHP and DSP chemicals

	First tier	Second tier	Third tier
Danube Sediment High Priority List	44 (-8 +10)	46	26
Danube Sediment Priority List	102	80	20
Non-Sediment Priority Chemicals	421		
Waiting list	134	?	?
Total (CAS)	701	126	46

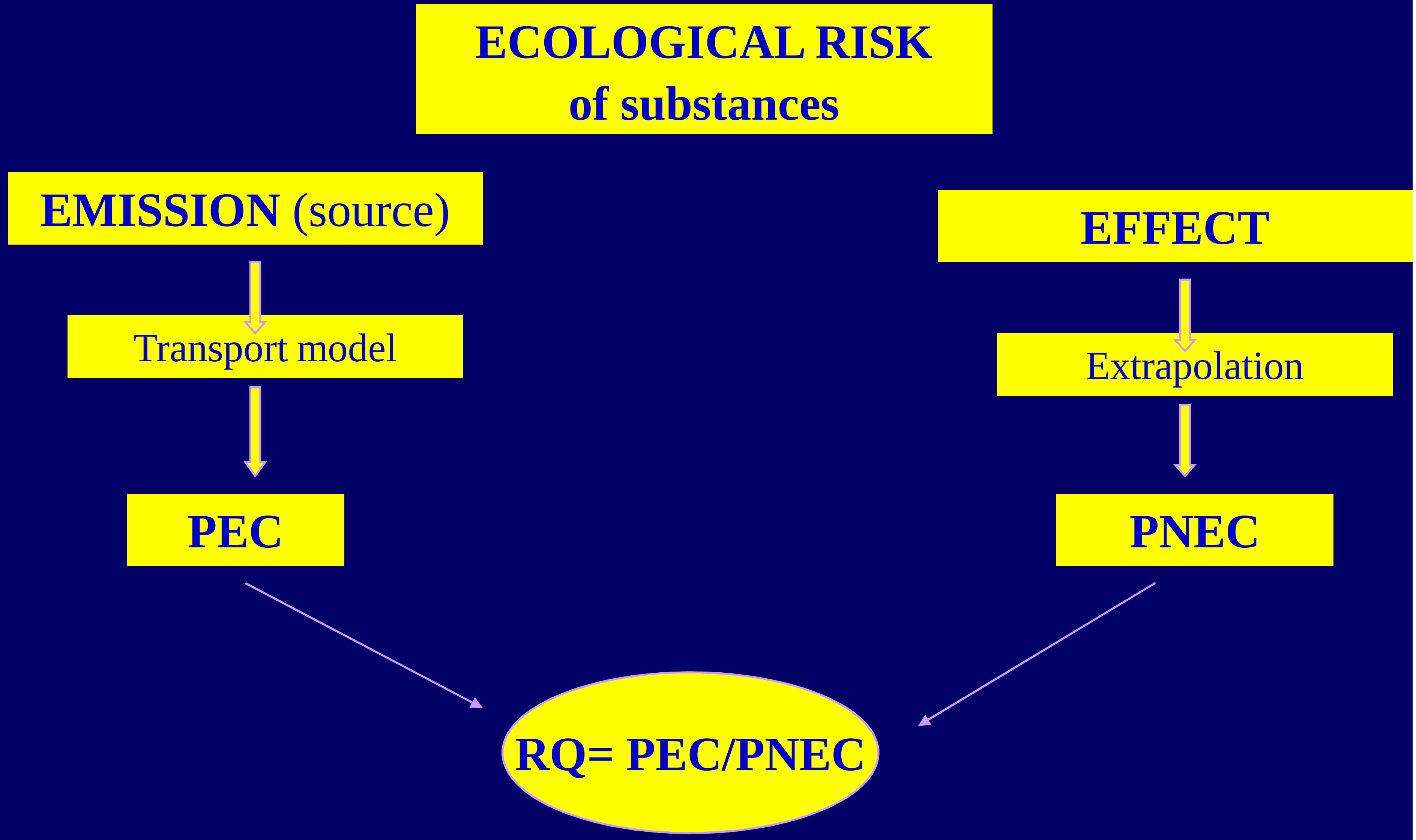
Danube River convention: 40 chemicals.
23 of these did not get in our DSHPL or DSP list.

EU list (Dir. 76/464) of chemicals hazardous for aquatic env: 141 chemicals
Only 20 of these are included in our DSHPL or DSPL.

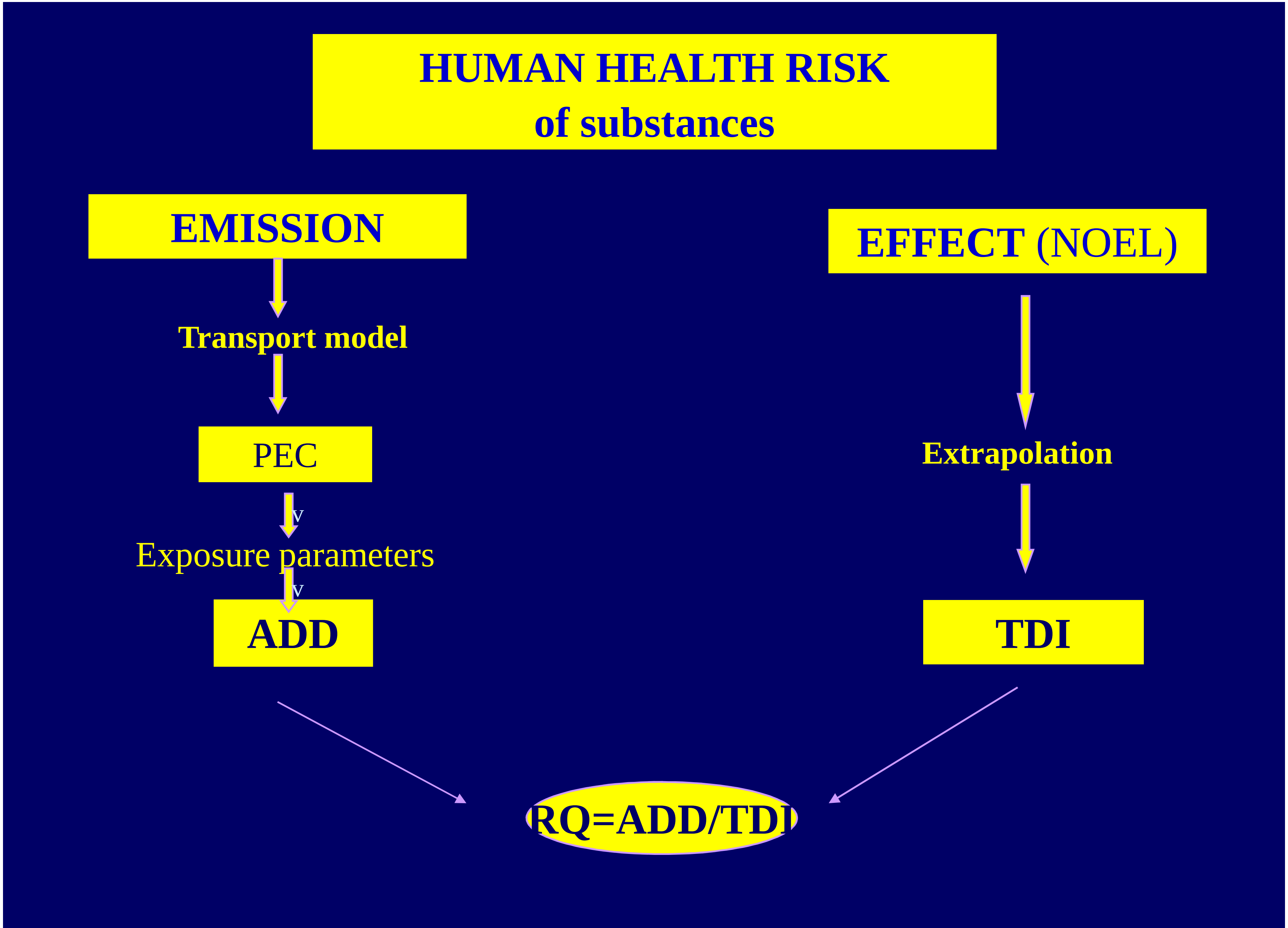
Sediment-specific priority list differs from the water-priority list!

Second and third tier: Quantitative Risk Assessment

- **Also called absolute risk assessment**
- **It characterizes the risk with real quantities**
- **Its result can be generic or site specific**
- **Its result is suitable for decision making**
- **The target value of remediation or other RR activity can be determined**
- **It can be used for preliminary or for detailed assessment**
- **It can be used for chemicals, activities or contaminated sites**
- **It works with a gradual iterative methodology: cost effective**
- **It works with worth case estimation: excludes the negative cases/contaminants during the procedure as soon as possible**
- **It is a conservative approach: overestimation of the risk and exclusion only of the safe negatives**



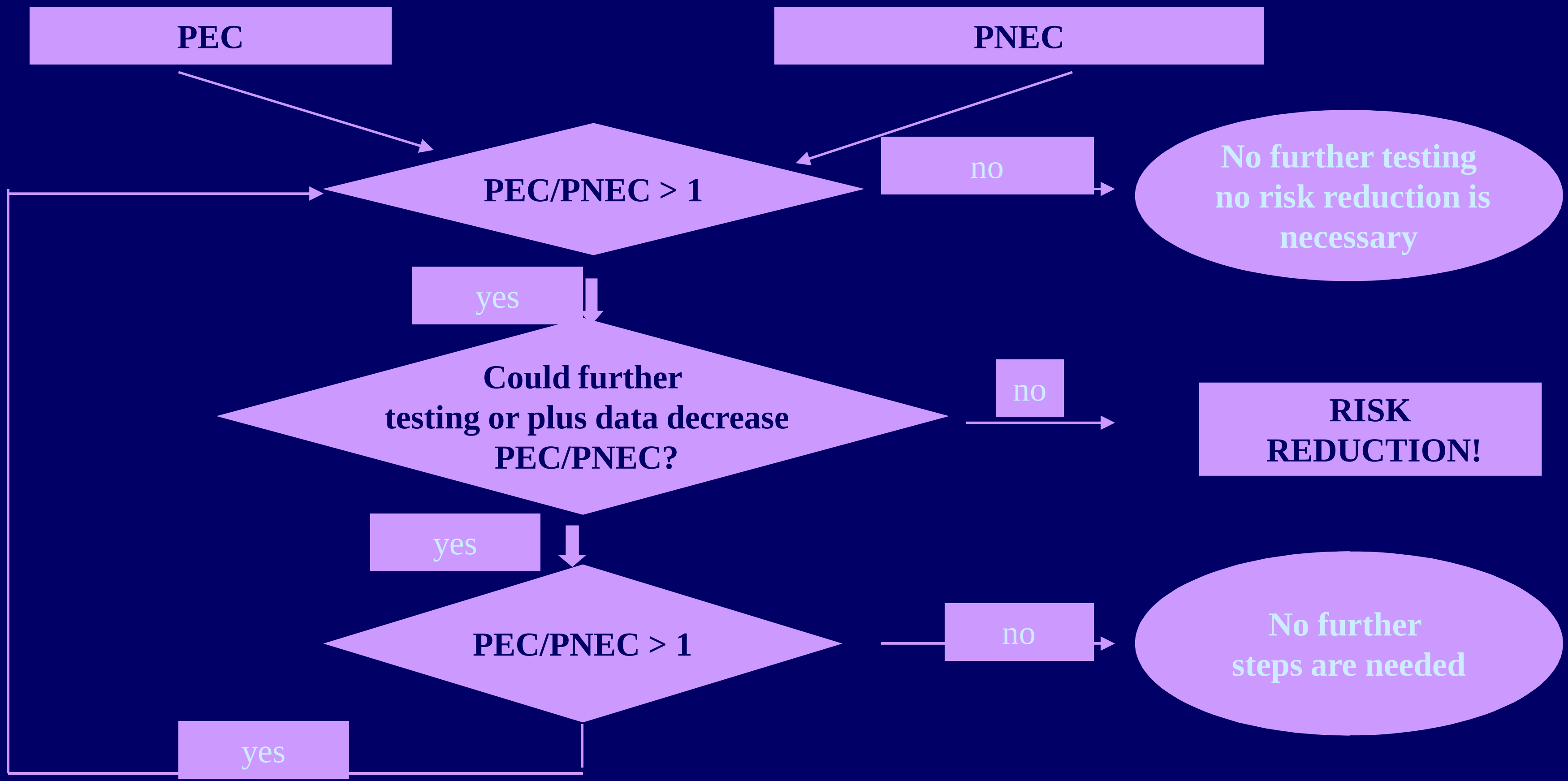
Technical guidance document for environmental risk assessment of new and existing substances, Brussels, 1996: it supports the orders of EC 1488/94 and EEC 793/33


HUMAN HEALTH RISK
of substances
EMISSION
Transport model
PEC
Exposure parameters
ADD
EFFECT (NOEL)
Extrapolation
TDI
RQ=ADD/TDI

Quantitative environmental risk assessment of substances

Characteristics:

- gradual procedure (cost effective),
- iterative
- it uses worth case estimation (pessimistic model)
- it works also in case of lack of data (exclusion)



Second tier: Generic Risk Assessment

The quantity of risk of Danube Sediment Priority chemicals: 126 substances

1. Exposure (PEC) with European default values
2. Effect (PNEC) assessment
3. RQ was calculated as a ratio of PEC and PNEC

Second tier: generic risk assessment

1. Exposure assessment (PEC) requires the following data

T = tonnage: produced and used tonnage in the catchment area;

f_{water} = fraction of tonnage released into river water: the release from production and use has been estimated on the basis of EU-TGD (1996), according to use-patterns:

use in closed system: 0.01 use resulting in inclusion into matrix: 0.1
non-dispersive use: 0.2 dispersive use: 1.0

Dilution was calculated with the Q = average annual flow of Danube: 2044 m^3/sec.

Degradation rate: $f_{degrwater}$: 0.1 for readily degradable chemicals (hlt: 15 days)
0.5 for inherently degradable (hlt: 50-150 days)
1.0 for persistent chemicals (hlt: infinite)

Sorption is characterised by the K_d for inorganic and the K_p for organic compounds.

Concentration in the sediment: $PEC_{sediment} = K_p \times PEC_{water}$;

$K_p = f_{oc} \times K_{oc}$; $PEC_{water} = Tonnage \times f_{water} \times f_{degr}/Q$

Second tier: generic risk assessment

2. Effect assessment

estimation of the PNEC value from ecotoxicity data or
by using effect based sediment quality criteria, SQC

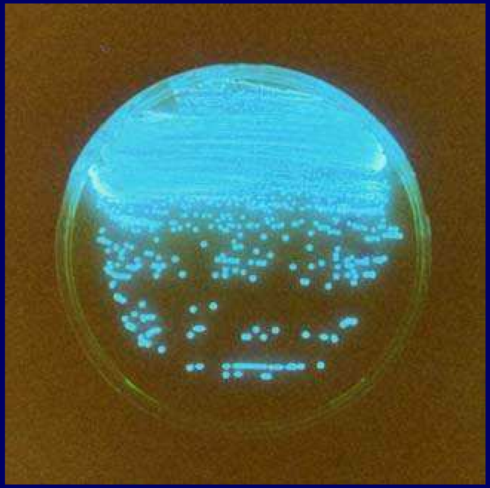
Two different models/approaches were applied:

1. Estimation from water toxicity data using the partition coefficient:

   $SQC = K_d \times WQC.$

2. Extrapolation from the results of acute and chronic laboratory bioassay

   from the results of minimum of three toxicity tests of testorganisms from 3 different trophic levels by the method of factorial extrapolation.



DSHP chemical's name	RQ	DSHP chemical's name	RQ
Methoxichlor	**343–724**	Fluoranthene	0,36
DHTDMAC (cationic detergent)	**55**	Bromopropylate	0,1–0,3
Bis (2-ethylhexil) phthalate	**33**	Dicofol	0,1–0,2
Cypermetrin	**28**	Zinc	0,16
Dibutylphthalate	**25**	Bis (2-ethyhexil) adipate	0,1
Pendimethalin	**1,6–3,2**	Lead	0,05
Trifluralin	**1,4–3,2**	Pencycuron	0,05
Propargite	**0,5-2,5**	DDT (dichlorodiphenyltrichloroethane)	<0,05
Cyhalotrin	**2,3**	Dieldrin	<0,05
HCH isomers	**0,5–1,5**	Ethalfluralin	0,01–0,03
N-Phenyl-2-naphtylamin	**1,7**	Aldrin	0,001–0,03
Oxifluorphen	**0,1–1,4**	Pyridate	0,007
Cadmium	**1,3**	Heptachlor	<0,005
Endrin	**1,2**	Heptachlor-epoxid	<0,004
MDI	**1,0**	Pentachlorophenol	<0,001
Copper	**0,9**	Benzo(a)piren	no data yet
Mercury	**0,8**	DDD (dichlorodiphenyldichloroethane)	no data yet
PCB	<0,75	DDE (dichlorodiphenyldichloroethylene)	no data yet
Nickel	0,65	Hexachlorobenzene	no data yet
Benfluralin	0,64		

DSP chemical’s name	RQ	DSP chemical’s name	RQ
NPEO (anionic detergent)	**219**		
Fenarimol	**9,9–78,3**	HCH isomers	**0,5–1,5**
Bifenox	**0,5–30**	Fenvalerate	**1,0**
Kerosene	**0,16–16**	PCB	<0,75
N-izopropyl-N’-phenyl-p-phenylenediamine	**8,8**	Alachlor	0,1
Metolachlor	**5,0**	1-Methylnaphtalen	no data yet
Ethylbenzene	**4,9**	2,3,4,6-Tetrachlorophenol	no data yet
N-cyclohexyl-2-benzothyazole-sulfen	**4,8**	2,6-Dibromo-4-nitrophenol	no data yet
Endosulfan	**4,0–4,5**	Acenaphthene	no data yet
Diflubenzuron	**3,3**	PAHs	no data yet
Lindane (gamma HCH)	<**3**		

Site Specific ERA

PEC estimation and its refined assessment (for all environmental phases)

1. **Maximal measured concentration (in the contamination source)**
2. **Site specific transport model, which considers emission and decrease of the concentration between source and receptor**
3. **Application refined transport model considering partition and biodegradation**
4. **Special needs, eg. food chain effects: bioconcentration, biomagnification**

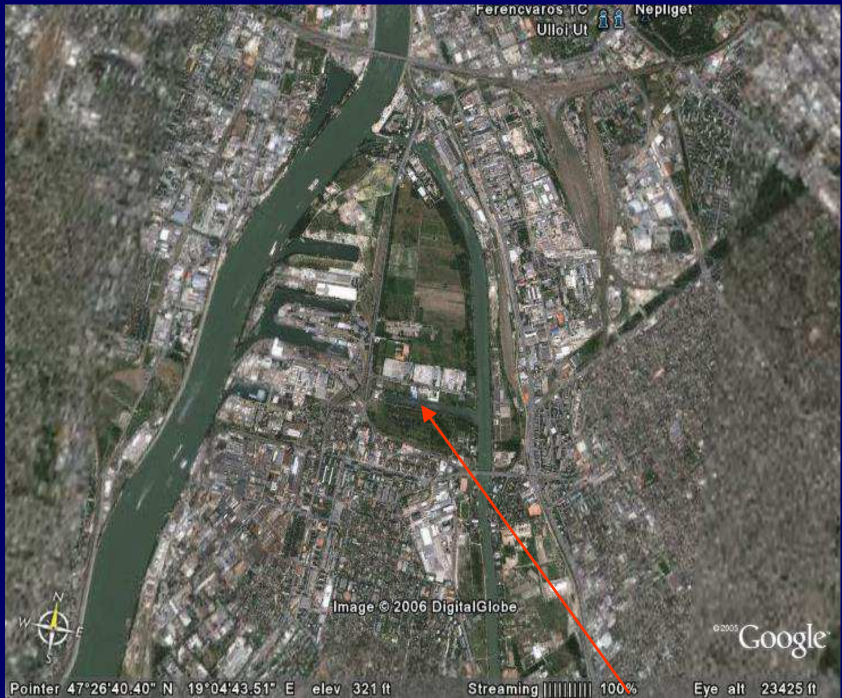
PNEC estimation and it refined assessment

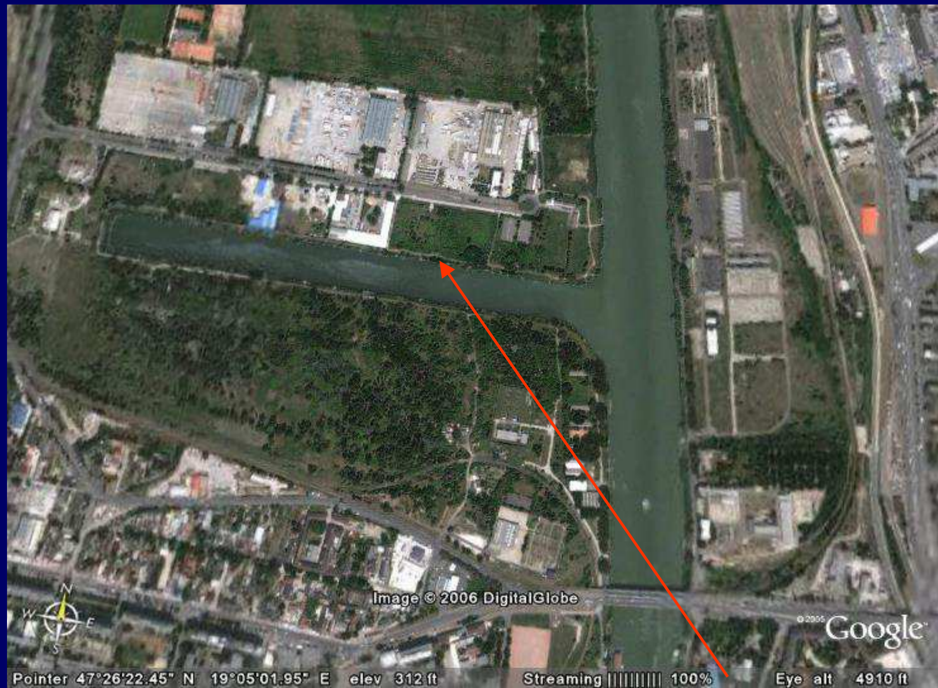
1. **Application of generic PNEC, eg. limit values, or EQC for most sensitive land use**
2. **Considering site specific land uses and habits**
3. **Direct ecotoxicity and toxicity testing: measuring site specific PNEC with indigenous ecosystem-memebers.**

Site Specific Risk Assessment

Selected sites:

1. **HRICOV-reservoir/Slovakia and**
2. **RSD Danube-branch/Hungary**





Name of the pollutant	Hricov/ Sk µg/kg	RSD / Bp µg/kg	PNEC µg/kg	RQ local	RQ reg
Bifenox	30		20	**15**	0,5–30
Br-propylate	11		400	0,027	0,1–0,3
Cyhalotrin		153	30	**5,1**	2,3
Cypermetrin	361		8	**45**	27,6
Bis (2-ethylhexyl) adipate	300		60 000	0,005	0,1
Bis (2-Ethylhexyl) phthalate	1580	1439	30 000	0,05	33
Alfa-HCH	1,34	1,15	2	**0,6**	0,1–1,5
Beta-HCH	115		2	**55**	0,1–1,5
Gamma-HCH	1,38	0,93	2	**0,6**	0,1–1,5
Delta-HCH		0,15	2	0,075	0,1–1,5
2,6-Dibromo-4-nitrophenol		3491	400	**8,7**	no data
Dibutyl-phthalate	879	1108	120	**7,3–9,2**	25
Diphenyl-amin	1180	1122	400	**2,9–2,8**	0,25

Name of the pollutant	Hricov Sk µg/kg	RSD Bp µg/kg	PNEC µg/kg	RQ local	RQ reg
Endosulfan	43	76	2	**21–38**	4,0–4,5
Fenarimol	121		80	**1,5**	9,9–78,3
Fenvalerate	1858	4060	9	**206–451**	1,0
Heptachlor	75	160	500	**0,15–0,3**	<0,005
Heptachlor-epoxid		266	500	**0,53**	<0,004
Hexachlorobenzene	530	257	50	**10,6–5,1**	no data
Methoxychlor	70,6	34,2	1	**71–34**	343–724
Metolachlor		215,6	6	**36**	5
Nonylphenol		48,8	100	**0,49**	no data
NPEO	no data	no data	100		219
N-Phenyl-2-naphthylamine	556	165	480	**1,2–0,3**	1,7
Pendimethalin	199	178	300	**0,7–0,6**	1,6–3,2
Propargite	83		200	**0,4**	0,5–2,5
2,3,4,6-Tetrachlorophenol	102	88	4000	0,02	no data
Total PAH	2990	455	40	**75–11,4**	no data
Total PCB	313	726	20	**15,6–36**	<0,75

Gruiz, K. Risk Assessment of pollutants in Danube sediment

Evaluation and interpretation of the results of RQ regional (generic) and RQ local

Evaluation: if RQ > 1, refined RA and RR is necessary

- RQ generic > 1: regional level action at Danube catchment scale
- RQ local > 1: local restriction or remediation

Comparative evaluation of regional and local RQ:

- RQ regional agrees with RQ local: chemicals with widespread use in the whole Danube catchment.
- RQ regional differs from RQ local: locally different production and use
    - RQ regional < RQ local: local production and/or use
    - RQ regional > RQ local: missing local production and use

If facts do not support/confirm these results repeat the assessment with more precise input data. Additional testing of sediment samples is also recommended!

Inorganic micropollutants in HU-Danube sediment

Copper content of Danube water and sediment

Danube km	$C_{Cu\ water}$ (ppb)	$C_{Cu\ sediment}$ (ppm)	K_{swCu} (l/g)
1848.4	22.5	22.9	1.0
1806.2	23.4	2.5	1.0
1802.0	24.6	39.0	1.6
1761.0	27.9	50.0	1.8
1717.0	24.6	21.9	0.9
1707.0	4.2	43.0	10.2
1659.0	2.9	47.0	16.2
1560.0	2.0	no data	
1479.0	2.1	no data	

Similar trends are shown by other toxic metals!!

River	Site location	River km	$CaCO_3$ %	humus %	Mechanical composition (%)		
	Name	km	%	%	Sand	Silt	Clay
Danube	Szap	1811	**20.5**	2.4	22.8	66.1	**11.0**
Danube	Medve right	1802	14.5	0.2	92.0	5.6	2.5
Moson Arm	Vének left 2 km	1794	6.5	**3.2**	39.0	42.8	**18.2**
Moson Arm	Vének right	1794	11.0	1.3	79.0	14.9	6.1
Conco creek	Ács 2 km	1777	**23.0**	**3.5**	48.6	36.1	**15.3**
Danube	Upstr. Komárom	1770	16.0	0.7	85.5	10.2	4.4
Danube	Dnstr. Komárom	1761	14.0	2.0	74.1	18.2	7.7
Átalér creek	Mouth 1.5 km	1750	16.5	1.5	84.0	10.3	5.7
Kenyérmezei er.	Mouth 1 km	1722	19.0	**4.2**	23.2	55.3	**21.5**
Danube	Esztergom	1716	**23.5**	**4.3**	42.0	45.2	**12.9**
Danube	Basaharc	1707	**21.5**	**3.3**	46.0	44.3	**10.0**
Danube	Visegrád	1694	16.5	2.2	52.5	38.5	**9.1**
Danube	Pünkösdfürdô	1658	19.5	2.2	72.7	22.4	5.0
Danube	M0 Bridge left	1632	17.5	1.5	78.1	15.7	6.2
Danube	M0 Bridge right	1632	21.5	2.2	65.5	27.4	7.1
Soroksár Arm	53.9 km	1586	**22.0**	1.0	96.3	2.8	0.8
Soroksár Arm	VITUKI 57.3	1586	17.7	0.8	42.5	46.0	**11.5**

River	Site location	River km	Excess heavy metals in sediment (ppm)							
			Cd	Co	Cr	Cu	Ni	Pb	Zn	TEL
Danube	Szap	1811	-0.19	3.80	-4.33	13.71	17.85	-34.81	21.99	57
Danube	Medve right	1802	-0.27	1.17	-33.92	-15.87	-2.39	3.63	-5.65	5
Moson Arm	Moson Vének left 2 km	*1794	0.09	3.11	-21.85	3.76	5.59	-47.79	31.71	44
Moson Arm	Moson Vének right 2 km	*1794	0.32	2.22	-31.97	-10.50	-2.60	-44.01	-6.58	2
Conco creek	Ács 2 km	*1777	-0.41	-5.03	-53.37	-12.57	-10.03	-57.35	-44.26	-
Danube	Upstream Komárom	1770	-0.29	1.53	-32.93	-13.90	-3.21	-44.75	-12.18	1.5
Danube	Downstr. Komárom	1761	-0.25	-0.50	-35.43	-10.55	-2.61	-37.07	3.91	4
Átalér creek	Átalér Mouth 1.5 km	*1750	-0.25	-0.24	-32.89	-12.34	-8.70	-36.75	3.54	3.5
Kenyérmezei	Km. Creek mouth 1 km	*1722	3.18	-1.49	-30.67	162.74	8.28	-44.53	40.69	215
Danube	Esztergom	1716	-0.29	1.20	-27.78	-3.36	1.45	-21.07	49.67	52
Danube	Basaharc	1707	-0.27	2.68	-25.23	-3.25	3.65	-46.89	37.71	44
Danube	Visegrád	1694	-0.33	2.76	-27.67	-4.80	2.22	-43.95	26.53	31
Danube	Pünkösdfürdô	1658	-0.22	3.70	-29.03	-7.52	2.74	-41.09	29.16	36
Danube	M0 Bridge left	1632	-0.16	2.33	-24.79	2.13	0.72	-33.69	57.37	63
Danube	M0 Bridge right	1632	-0.10	2.21	-27.11	3.70	2.74	-27.87	52.80	62
Soroksár Arm	RSD Gubacsi Br. 53.9km	*1586	0.20	-2.84	12.43	3.20	1.61	175.19	15.25	203
Soroksár Arm	RSD VITUKI 57.3 km	*1586	-0.18	4.24	10.94	36.07	17.52	8.40	201.0	277
	Target values for HM		0.8	20	100	36	35	85	140	

Ecotoxicity testing: the proper tool for ERA

Problems of testing of sediment samples

- mixture of contaminants: sinergism, antagonism
- interactions between contaminants, matrix and biota
- medium: extract, pore water, whole sample
- biotransformation: effect of products
- biodegradation
- availability: physico-chemical and biological availability differs
- analytical programme includes only part of the really occurring chemicals
- biotic and abiotic composition of the environmental sample influence the results

Ecotoxicity testing gives solution for some of the problems

- integrates interactions between toxicants
- integrates interactions between toxicant and matrix
- measures bioavailable ratio of the contamination
- measures chemically not measurable toxicants by their effect
- measures effects of chemicals not included into the analytical programme

River	Site location	River km	Ecotoxicity testing				
			B. subtilis	*A. agile*	*S. alba*	*Vibrio fischeri*	
						EC_{20}	EC_{50}
Danube	Szap	1811	-	+	-	**<1**	50
Danube	Medve right	1802	-	+	-	34	>50
Danube Arm	Vének left 2 km	1794	-	+	-	**5.5**	**28**
Danube Arm	Vének right 2 km	1794	-	+/-	-	28	>50
Conco creek	Ács 2 km	1777	-	+/-	-	50	>50
Danube	Upstr Komárom	1770	-	+/-	-	26	>50
Danube	DwnstrKomárom	1761	-	+/-	-	20	>50
Átalér creek	Mouth 1.5 km	1750	-	+	-	50	>50
Keny. creek	Mouth 1 km	1722	-	+	-	**<1**	**1.9**
Danube	Esztergom	1716	-	+	-	**1.5**	50
Danube	Basaharc	1707	-	+/-	-	**1.8**	50
Danube	Visegrád	1694		+	-	22	35
Danube	Pünkösdfürdô	1658	-	+	-	50	>50
Danube	M0 Bridge left	1632		+	-	16	50
Danube	M0 Bridge right	1632	-	+	-	**7.0**	48
RSD	Gubacsi Bridge	1586	-	+	-	**2.1**	**9.2**
RSD	VITUKI 57.3 km	1586	-	+	-	**2.7**	**12.3**

River	Site location	River km	Comparison of chemical and ecotoxicity data		
			Sum of Δ TEL	Clay in sediment	Toxicity
			ppm HM	%	g sediment
Danube	Szap	1811	57	**11**	25
Danube	Medve right	1802	5	2.5	>42
Moson Danube Arm	Vének left 2 km	1794	44	**18**	**15**
Moson Danube Arm	Vének right 2 km	1794	2	6	>39
Conco creek	Ács 2 km	1777	0	**15**	>50
Danube	Upstream Komárom	1770	1.5	4	>38
Danube	Downstream Komárom	1761	4	8	35
Átalér creek	Mouth 1.5 km	1750	3.5	6	>50
Kenyérmezei creek	Mouth 1km	1722	**215**	**21**	**1.5**
Danube	Esztergom	1716	52	**13**	26
Danube	Basaharc	1707	44	10	26
Danube	Visegrád	1694	31	9	28
Danube	Pünkösdfürdô	1658	36	5	>50
Danube	M0 Bridge left	1632	63	6	33
Danube	M0 Bridge right	1632	62	7	27
RSD	Gubacsi Bridge 53.9 km	1586	**203**	1	**5.5**
RSD	VITUKI 57.3 km	1586	**277**	**12**	**7.5**

Average heavy metal content of the recollected mussels (mg/kg)

Sample	**Cd**	**Co**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**
Vének Danube, October	1.3	1.3	1.4	11.0	13.8	4.7	495
Vének Danube, November	1.2	1.0	0.8	13.1	11.2	4.7	382
Vének Mosoni, October	**1.6**	1.3	0.8	**20.0**	10.9	7.4	**706**
Vének Mosoni, November	0.3	2.3	0.4	13.0	10.0	1.5	484
Ráckeve, October	0.4	0.5	0.3	9.0	8.6	2.2	291
Ráckeve, November	**1.7**	0.7	1.2	15.2	1.0	7.2	405
Soroksár Arm, October	**1.3**	0.7	0.4	11.8	8.8	3.1	231
Dunaföldvár, October	**1.9**	1.0	0.3	9.3	11.3	4.4	**707**
Control	0.6	0.7	0.14	8.4	10.2	3.9	476

Metal content of sediments (ppm), mussels (deviation from the control) and the calculated BCF

Sediment samples (mg/kg)	**Cd**	**Co**	**Cr**	**Cu**	**Ni**	**Pb**	**Zn**
Vének, Danube	0.16	7.1	21.0	0.7	10.1	56.3	51.9
Vének, Mosoni Arm	0.52	18.9	64.6	31.6	33.8	23.6	141.1
Soroksári Arm,VITUKI	0.32	15.8	83.9	**58.4**	**39.0**	70.6	**286.2**
Mussels $\mathbf{C_{sample}–C_{control}}$ (mg/kg)							
Vének Danube, October	**0.7**	0.6	**1.3**	**2.6**	**3.6**	0.8	19
Vének Danube, November	**0.6**	0.3	0.7	**4.7**	1.0	0.8	less
Vének Mosoni, October	**1.0**	0.6	0.7	**11.6**	0.7	**3.5**	**230**
Vének Mosoni, November	less	1.6	0.3	**4.6**	0.2	less	8.0
Soroksár Arm, VITUKI, October	**0.7**	0.0	0.3	**3.4**	less	less	less
$\mathbf{C_{sample} – C_{control} / C_{sediment}}$ **(-)**							
Vének Danube, October	**4.4**	0.08	0.06	**3.7**	0.36	0.01	0.3
Vének Danube, November	**3.8**	0.05	0.03	**6.7**	0.1	0.01	(–)
Vének Mosoni, October	**1.9**	0.03	0.01	0.4	0.02	0.15	**1.6**
Vének Mosoni, November	(–)	0.08	0.004	0.1	0.006	(–)	0.05
Soroksár Arm, VITUKI, October	**2.2**	0.00	0.003	0.06	(–)	(–)	(–)

Conclusions

1. Tiered Risk Assessment of pollutants in Danube sediment is the proper tool for RANKING & PRIORITY SETTING of chemicals
2. For regional scale risk management: GENERIC ERA
3. For local risk management: SITE SPECIFIC ERA
4. Risk of chemicals on sediments differs from their risk on water!!
5. For decision making a Quantitative ERA is needed
   RISK BASED monitoring and RISK REDUCTION
6. Harmonised analytical tools and toxicity testing is necessary
7. Databases with environmental parameters and
   data on the effect, fate and nature of chemicals' polluting sediment