



# Swimming? Drinking? Fishing?

## Pharmaceuticals cause negligible health risk, except under extreme conditions.

### Human Health Risk Assessment of Pharmaceuticals in the European Vecht River

👤 Daniel J Duarte, Rik Oldenkamp, Ad Ragas

#### INTRO

- Human exposure to pharmaceutical pollution vary over space and time.
- Studies often limited in scope.
- Systematic integration of exposure routes, behaviors, and concentrations needed.

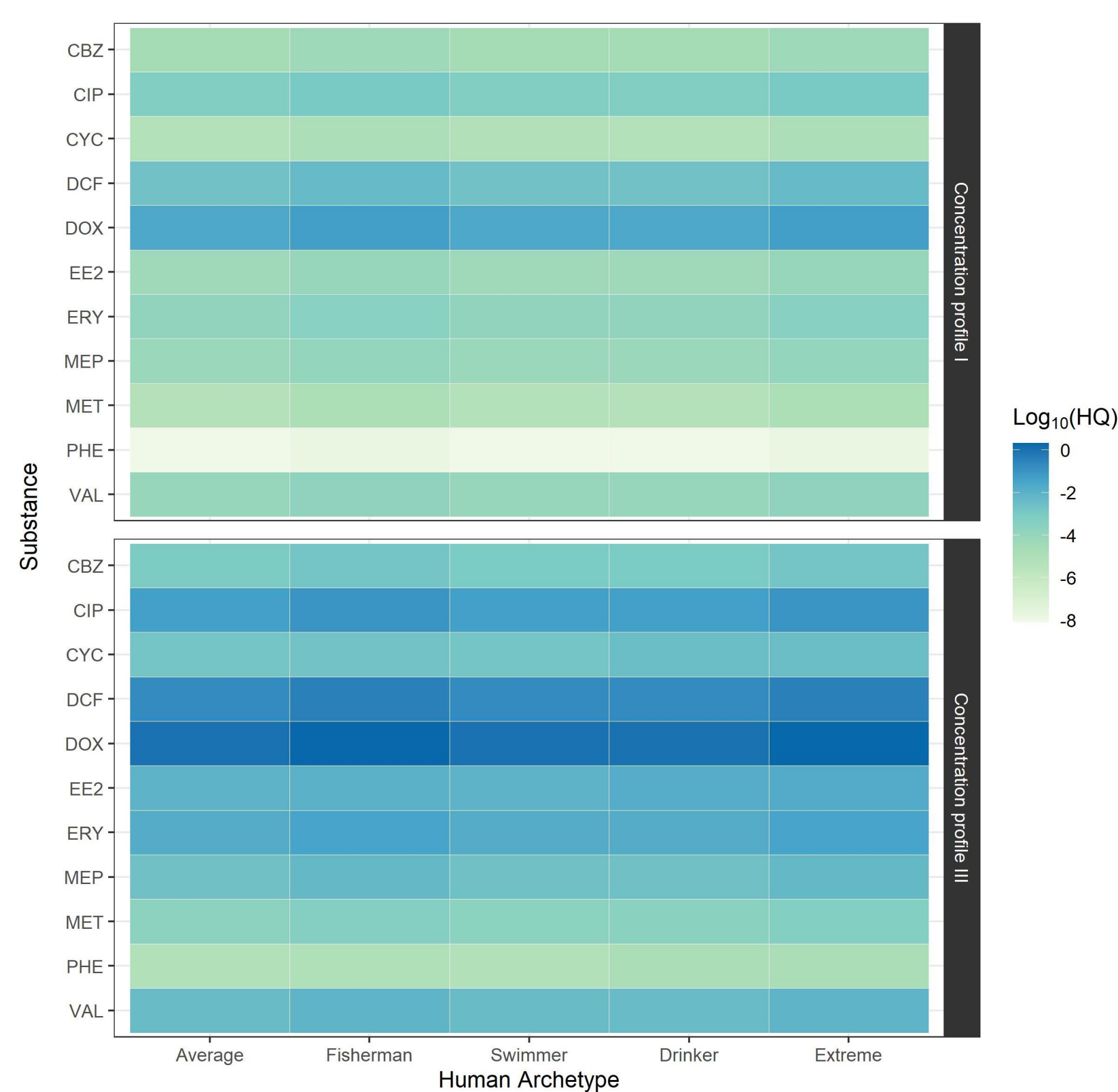
#### METHODS

- Human lifetime exposure model
- 15 pharmaceuticals
- 3 environmental conditions
- 5 human behaviors
- 5 age groups

#### CONCLUSIONS

- Environmental concentrations and human behavior highly dictate risks.
- Repurpose assessment from reactive to proactive.
- Cheap and easy tool for water managers.

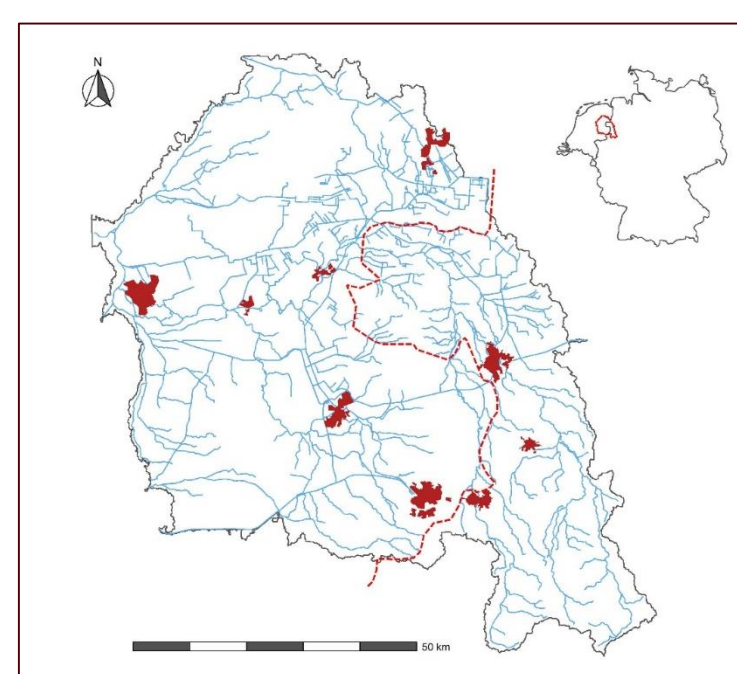
#### RESULTS



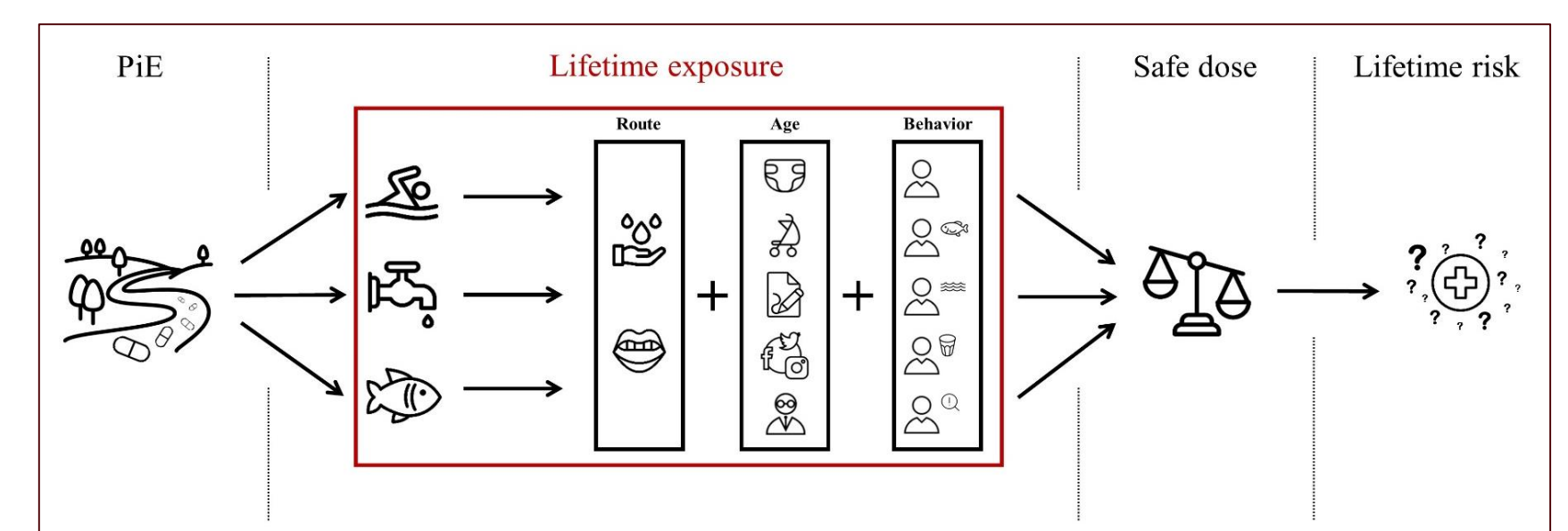
**Figure 1.** Human health lifetime hazard quotients (HQ) of studied pharmaceuticals in the Vecht River catchment. CBZ, carbamazepine; CIP, ciprofloxacin; CYC, cyclophosphamide; DCF, diclofenac; DOX, doxycycline; EE2, 17 $\alpha$ -ethinylestradiol; ERY, erythromycin; MEP, metoprolol; MET, metformin; PHE, phenazone; VAL, valsartan. Concentration profile I and II correspond to average and maximum environmental concentrations, respectively.

**Table 1.** Names and therapeutic classes of pharmaceuticals.

API	Abbreviation	Therapeutic class
Amantadine	AMA	Antiparkinson
Carbamazepine	CBZ	Antiepileptics
Ciprofloxacin	CIP	Antibacterials
Cyclophosphamide	CYC	Antineoplastics
Diclofenac	DCF	NSAID
Doxycycline	DOX	Antibacterials
Erythromycin	ERY	Antibacterials
17 $\alpha$ -Ethinylestradiol	EE2	Sex hormones
Iopamidol	IOP	Contrast media
Metformin	MET	Antidiabetics
Metoprolol	MEP	Beta blockers
Oxazepam	OXA	Anxiolytics
Phenazone	PHE	Analgesics
Sulfamethazine	SUL	Antibacterials
Valsartan	VAL	Angiotensin II receptor blockers



**Figure 2.** Vecht River basin in the Dutch-German border.



**Figure 3.** Human health risk assessment and lifetime exposure model.

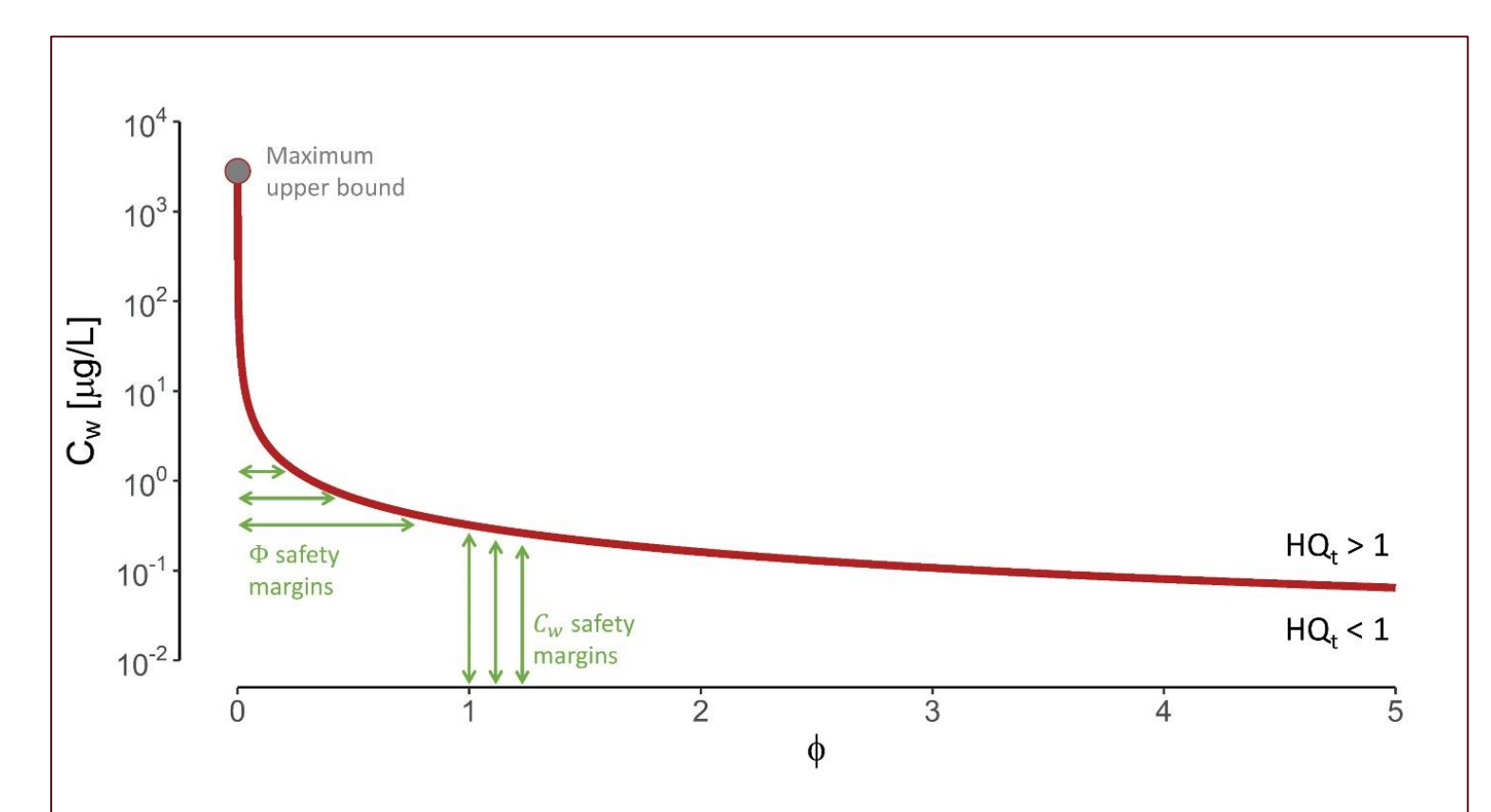
**Table 2.** Geometric mean of pharmaceutical daily uptake per age group and concentration profile for an average behavior archetype. Environmental concentrations: average (I), high (II) and maximum (III).

Age group [years]	Pharmaceutical daily uptake [mg/kg/day]		
	I	II	III
0-1	0 (0%)	0 (0%)	8.86 x 10 <sup>-7</sup> (25%)
1-5	9.03 x 10 <sup>-10</sup> (16%)	4.71 x 10 <sup>-8</sup> (16%)	8.78 x 10 <sup>-8</sup> (10%)
5-10	6.37 x 10 <sup>-10</sup> (14%)	3.32 x 10 <sup>-8</sup> (14%)	6.28 x 10 <sup>-8</sup> (9%)
10-18	3.19 x 10 <sup>-10</sup> (12%)	1.66 x 10 <sup>-8</sup> (12%)	3.56 x 10 <sup>-8</sup> (8%)
18-80	2.05 x 10 <sup>-10</sup> (58%)	1.07 x 10 <sup>-8</sup> (58%)	2.66 x 10 <sup>-8</sup> (47%)

**Table 3.** Pharmaceutical mixture hazard indices.  $d_{HQ}$ , relative change in hazard index;  $H_{I,add}$ , addition-based hazard index;  $H_{I,mt}$ , interaction-based hazard index;  $HQ_{max}$ , highest HQ in mixture (i.e., doxycycline).

Concentration profile	Hazard	Average	Fisherman	Swimmer	Drinker	Extreme
I	$HQ_{max}$	2.59 x 10 <sup>-2</sup>	5.34 x 10 <sup>-2</sup>	2.59 x 10 <sup>-2</sup>	2.59 x 10 <sup>-2</sup>	5.34 x 10 <sup>-2</sup>
	$H_{I,add}$	2.92 x 10 <sup>-2</sup>	2.92 x 10 <sup>-2</sup>	2.92 x 10 <sup>-2</sup>	2.92 x 10 <sup>-2</sup>	6.01 x 10 <sup>-2</sup>
	$H_{I,mt}$	2.98 x 10 <sup>-2</sup>	6.14 x 10 <sup>-2</sup>	2.98 x 10 <sup>-2</sup>	2.98 x 10 <sup>-2</sup>	6.14 x 10 <sup>-2</sup>
	$d_{HQ}$	2%	2%	2%	2%	2%
	$HQ_{max}$	0.97	2.00	0.97	0.97	2.00
II	$HQ_{max}$	1.23	2.54	1.23	1.23	2.54
	$H_{I,add}$	1.28	2.62	1.28	1.28	2.62
	$H_{I,mt}$	1.28	2.62	1.28	1.28	2.62
	$d_{HQ}$	4%	4%	4%	4%	4%
	$HQ_{max}$	1.01	2.03	1.01	1.05	2.07
III	$HQ_{max}$	1.28	2.58	1.28	1.33	2.64
	$H_{I,add}$	1.32	2.67	1.33	1.38	2.72
	$H_{I,mt}$	1.32	2.67	1.33	1.38	2.72
	$d_{HQ}$	3%	3%	3%	3%	3%
	$HQ_{max}$	1.01	2.03	1.01	1.05	2.07

$HQ_{max}$  = highest HQ in mixture (i.e., doxycycline).  $H_{I,add}$  = addition-based hazard index.  $H_{I,mt}$  = interaction-based hazard index.  $d_{HQ}$  = relative change in hazard index.



**Figure 4.** Water concentrations for doxycycline ( $C_w$ ) in relation to the fish consumption of the target population ( $\Phi$ ).

Radboud University

Nijmegen, the Netherlands



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