



# **PFAS concentraties in waterlopen in Vlaanderen: accumulatie en potentiële effecten op aquatische organismen**

Lieven Bervoets, Lies Teunen, Cara Byns, Claude Belpaire, Thimo Groffen

# PFAS in de media

**De Standaard**  
PFAS zitten overal. Hoe  
ongerust moeten we daarover  
zijn?

Eieren met *forever chemicals* zijn een gezondheidsrisico.  
Maar welk gevaar gaat precies uit van de oude 3M-site in  
Zwijndrecht? En hoe ver reikt het?

Buurtbewoners 3M willen  
individuele PFOS-analyses: "5 maand  
zwanger en alle dagen eieren van  
eigen kippen gegeten"

**MELSELE/ZWIJNDRECHT** Heel wat bewoners uit de omgeving van  
chemiebedrijf 3M vinden de huidige metingen naar PFOS-waarden  
onvoldoende. Ze willen dat er budget wordt vrijgemaakt voor  
individuele analyses. Eén van hen is Rosan Van der Pol (31) uit Melsele,  
vijf maand zwanger en erg ongerust omdat ze tot enkele weken terug  
alle dagen eieren van de eigen kippen heeft gegeten. "Het is onredelijk  
dat mensen worden gerustgesteld met vage gemiddelden", vinden ook  
Groen-parlementsleden Inaade Annouri en Mieke Schauvliege.

## DeMorgen.

Nieuws PFOS-vervuiling

**'Iedereen in Vlaanderen  
neemt via voeding te hoge  
hoeveelheid PFOS in': dit  
zijn de eerste conclusies uit  
het PFOS-rapport**

## Grote zorgen in Nederland over Belgische bron van PFAS-lozingen

Na de ophef over de PFAS-lozingen van de Belgische fabriek van 3M,  
blijkt er amper vijf kilometer van de Nederlandse grens nog een  
belangrijke bron te zijn van PFAS-vervuiling. De Antwerpse  
afvalverwerker Indaver loost al jarenlang PFAS in het water dat uitkomt  
in de Westerschelde, waarvan verschillende PFAS-stoffen "zonder  
vergunning". Daarover maakt de Nederlandse overheid zich achter de  
schermen al zeker een jaar grote zorgen, schrijft het Nederlandse  
onderzoeksprogramma Zembla na inzage in documenten die in  
handen zijn van het tv-programma.

## The New York Times

PFAS: The 'Forever  
Chemicals' You Couldn't  
Escape if You Tried

Virtually indestructible, these artificial compounds are used  
in fast-food packaging and countless household items, but  
they have been found as far away as virgin forests.

## The Guardian

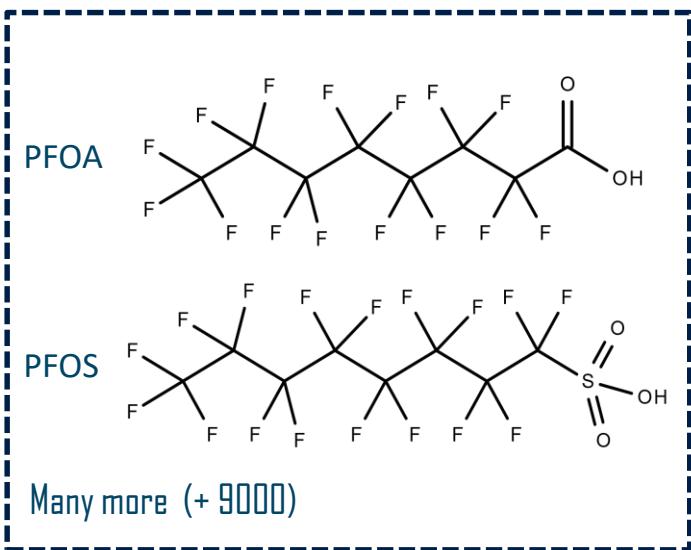
'Forever chemicals': what are PFAS  
and what risk do they pose?

They have useful properties, but some have been banned and  
toxicity of others is unknown

# Wat zijn PFAS?

## Per- and polyFluoroAlkylated Substances

Interessante fysico-chemische eigenschappen



Talrijke toepassingen



Extreem persistent: "forever chemicals"

Bioaccumulatief

Potentieel toxisch



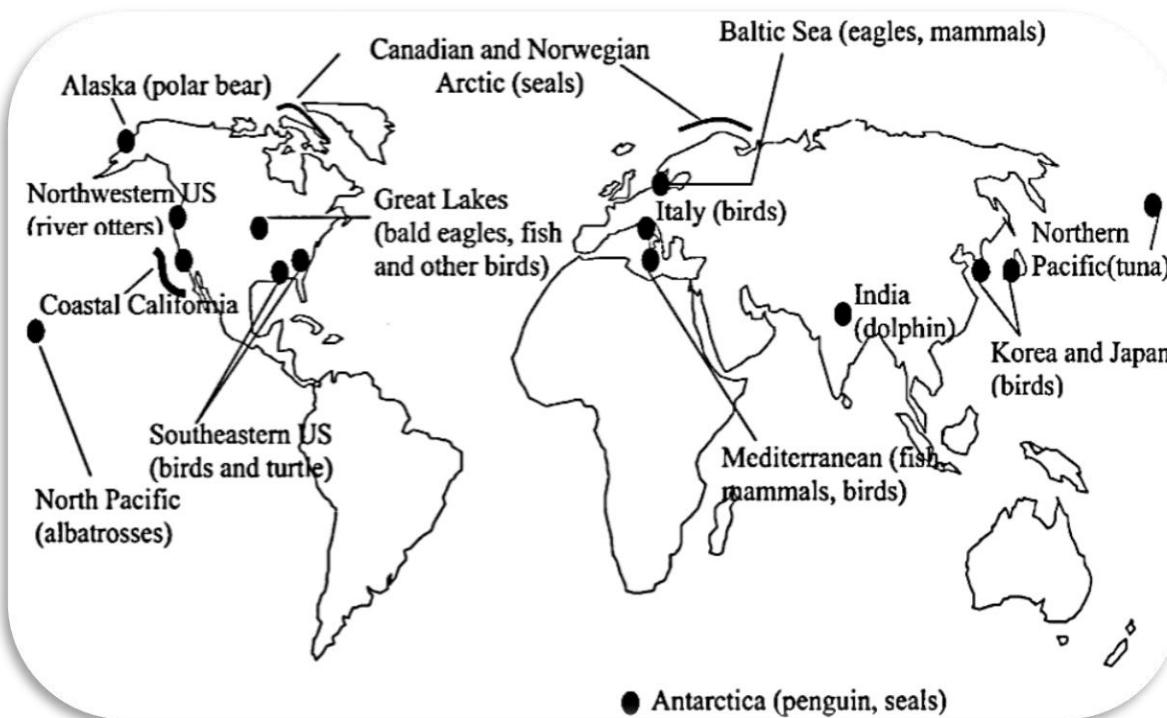
# PFAS toepassingen



**Water- en vet- afstotend, hitte resistant**

# Worldwide distribution & detection

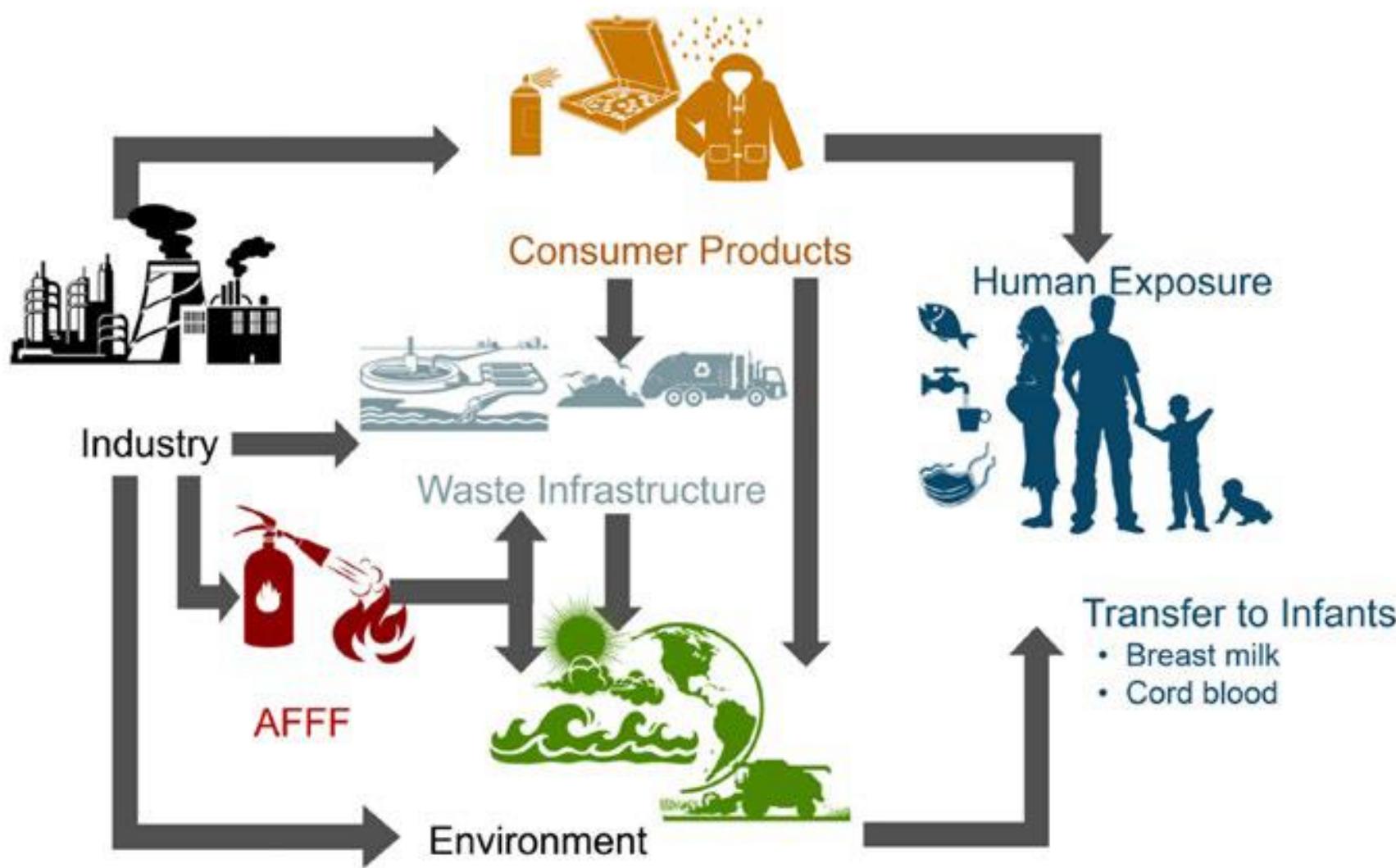
## Environment and wildlife



## Humans



Giesy and Kannan (2001): only PFOS

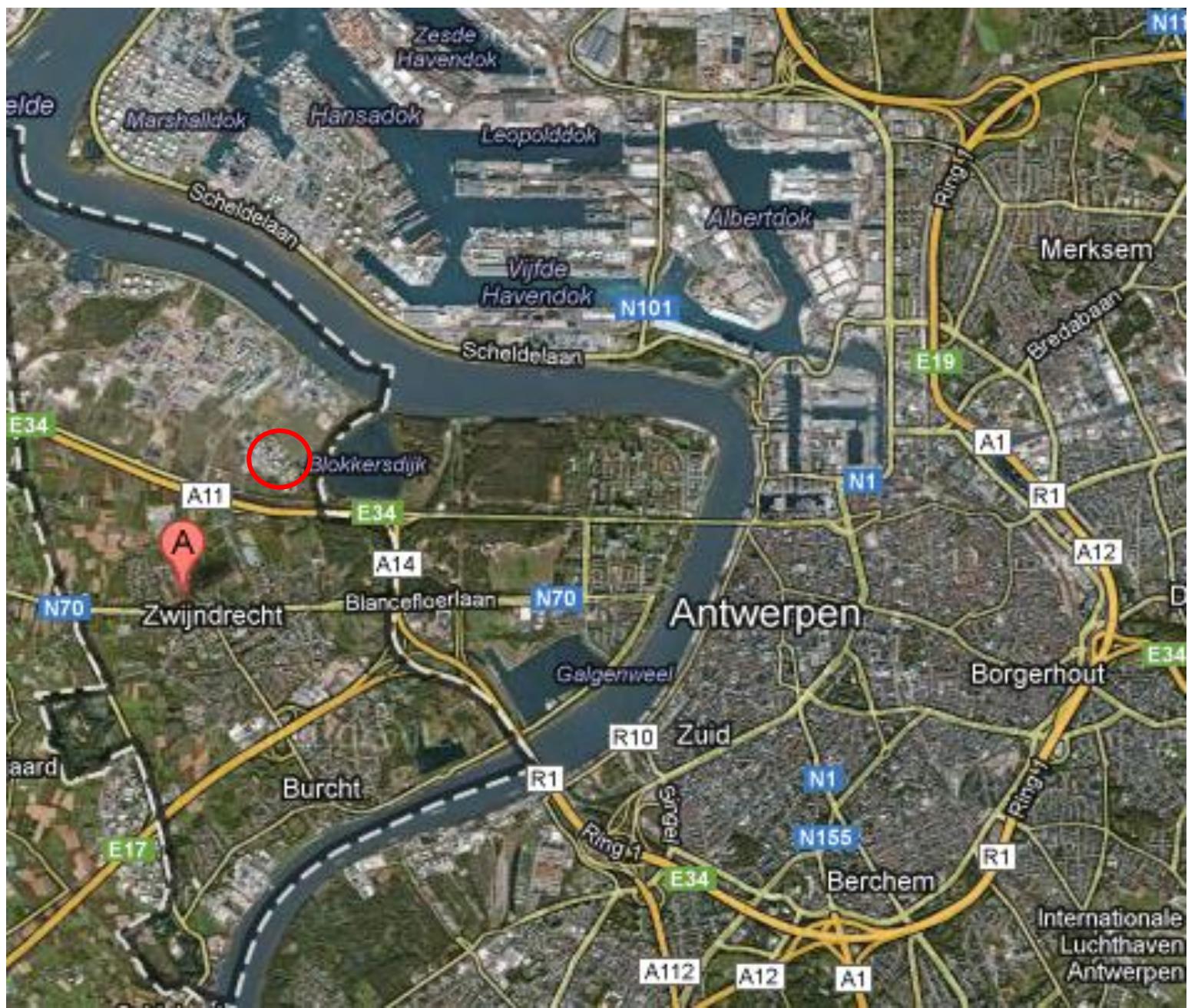


**Figure 1.**

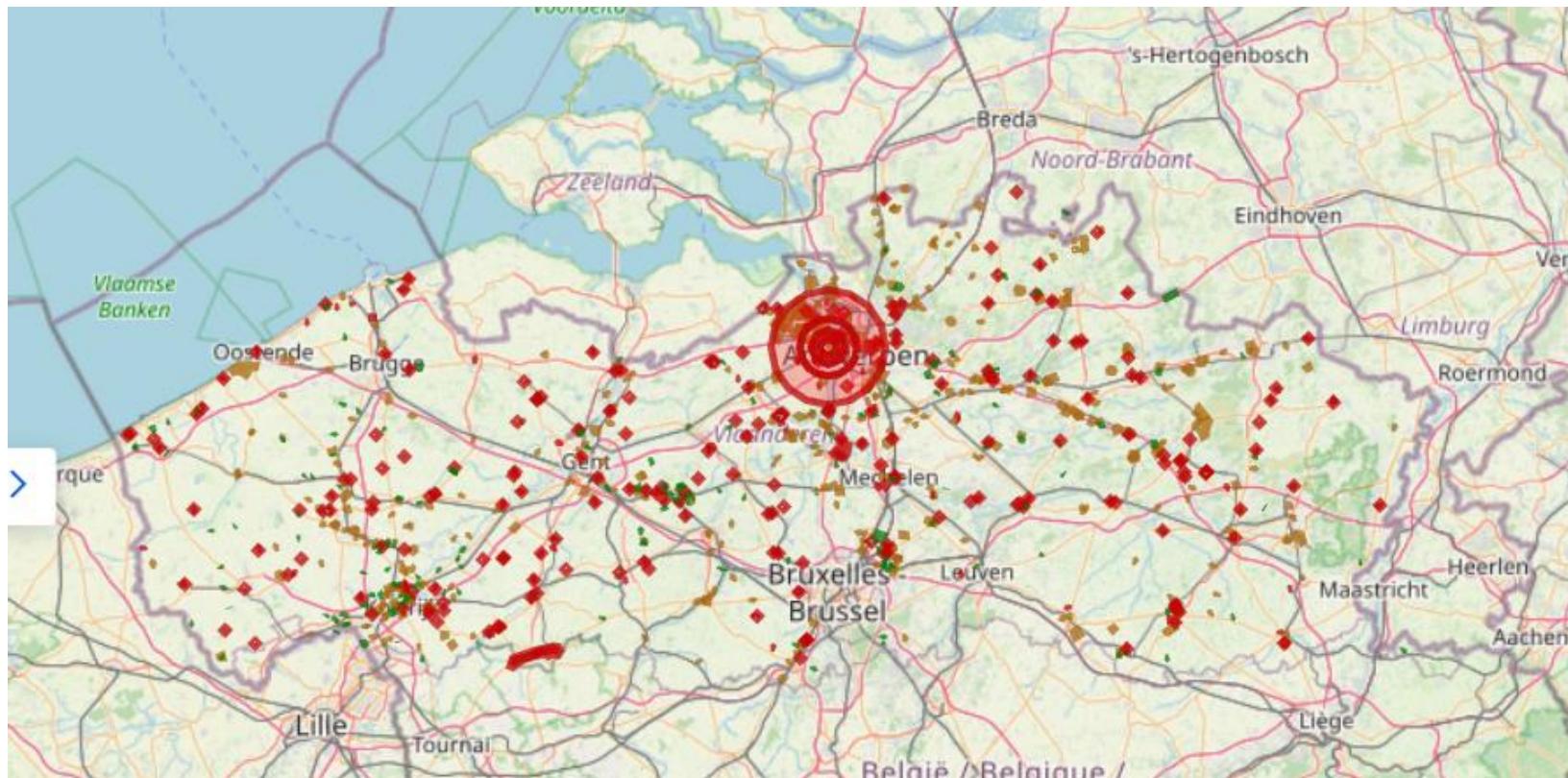
Overview of PFAS exposure pathways for different human populations outside of occupational settings.

# Normen

- Waterkwaliteitsnormen:  
PFOS: gemiddelde van 0,63 ng/l (max 36000 ng/l)  
(nieuwe normen voor 24 PFAS in de maak)
- Biota kwaliteitsnorm:  
PFOS: 9,1 ng/g ww
- Consumptie richtlijn EFSA:  
PFOS+PFOA+PFNA+PFHxS: 4.4 ng/kg bw per week  
(= TDI van 0,63 ng/kg bw/d)







<https://www.vlaanderen.be/pfas-vervuiling>

# Aquatische studies op PFAS

- 2001-2006: studies on PFOS in fish and invertebrates in the Scheldt and North Sea
- 2015-2022: studies on PFAS in fish and mussels from Flemish streams
- 2018-2019: study on PFAS in fish from the North Sea
- 2021: study on the accumulation of PFAS in mussels exposed in the Scheldt River
- 2019-2023: study on PFAS in water, sediment and invertebrates
- 2015 – 2023: several studies on PFAS in aquatic environment in African countries

## PERFLUOROOCTANE SULFONIC ACID IN BIB (*TRISOPTERUS LUSCUS*) AND PLAICE (*PLEURONECTES PLATESSA*) FROM THE WESTERN SCHELDT AND THE BELGIAN NORTH SEA: DISTRIBUTION AND BIOCHEMICAL EFFECTS

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# 2002

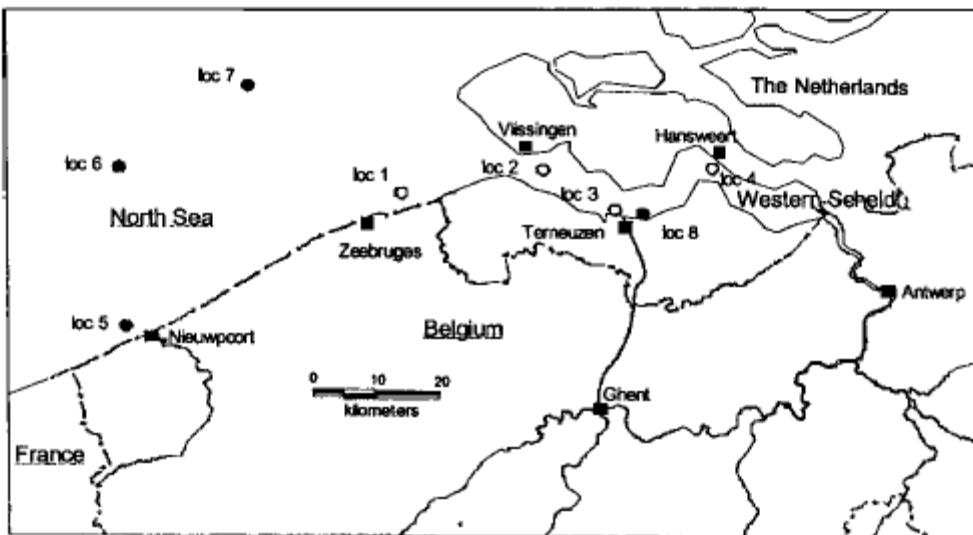


Fig. 1. Area of study and sampling sites. The open circles represent the sampling locations for bib while the black circles show the plaice sampling locations. Cities are indicated with a black square.

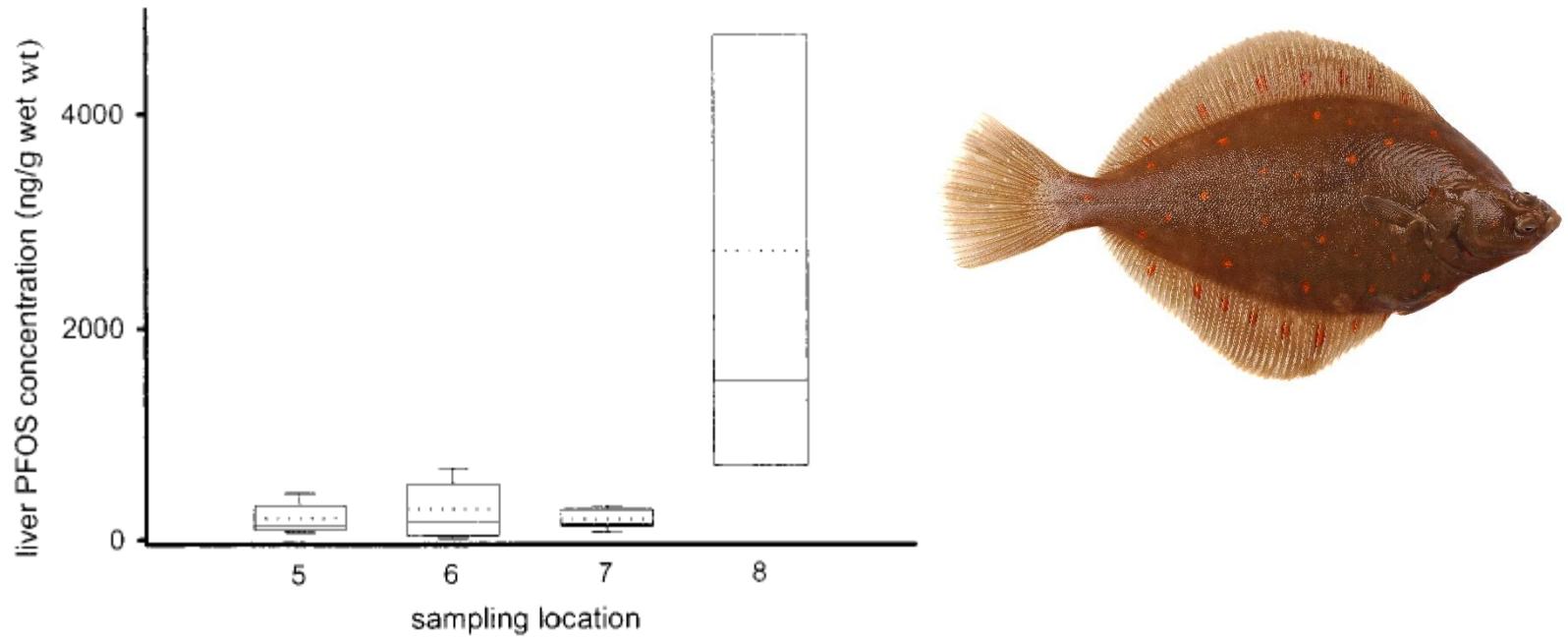


Fig. 4. Liver perfluorooctane sulfonic acid (PFOS) concentrations in plaice at each sampling location. The straight line is the median and the dotted line represents the mean. The 25th and 75th percentiles define the boxes. The whiskers represent the 10th and 90th percentiles. The numbers of plaice for locations 5, 6, 7, and 8 were 7, 6, 5, and 4, respectively.



# Bioaccumulation and trophic transfer of perfluorinated alkyl substances (PFAS) in marine biota from the Belgian North Sea: Distribution and human health risk implications<sup>☆</sup>



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*ECOSPHERE, Department of Biology, University of Antwerp, Groenenborgerlaan 171, 2020, Antwerp, Belgium*

# 2018

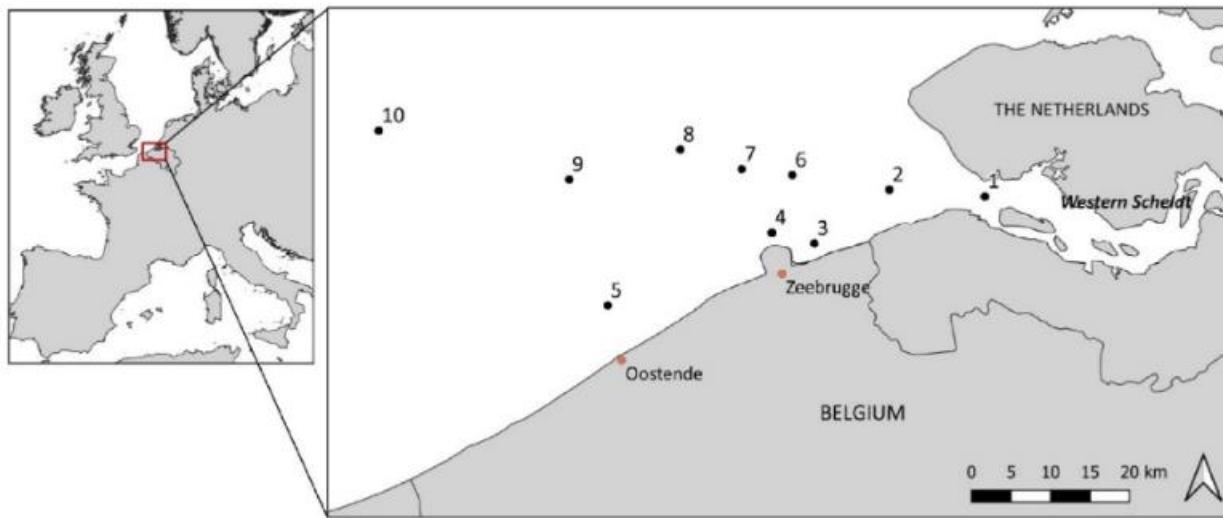
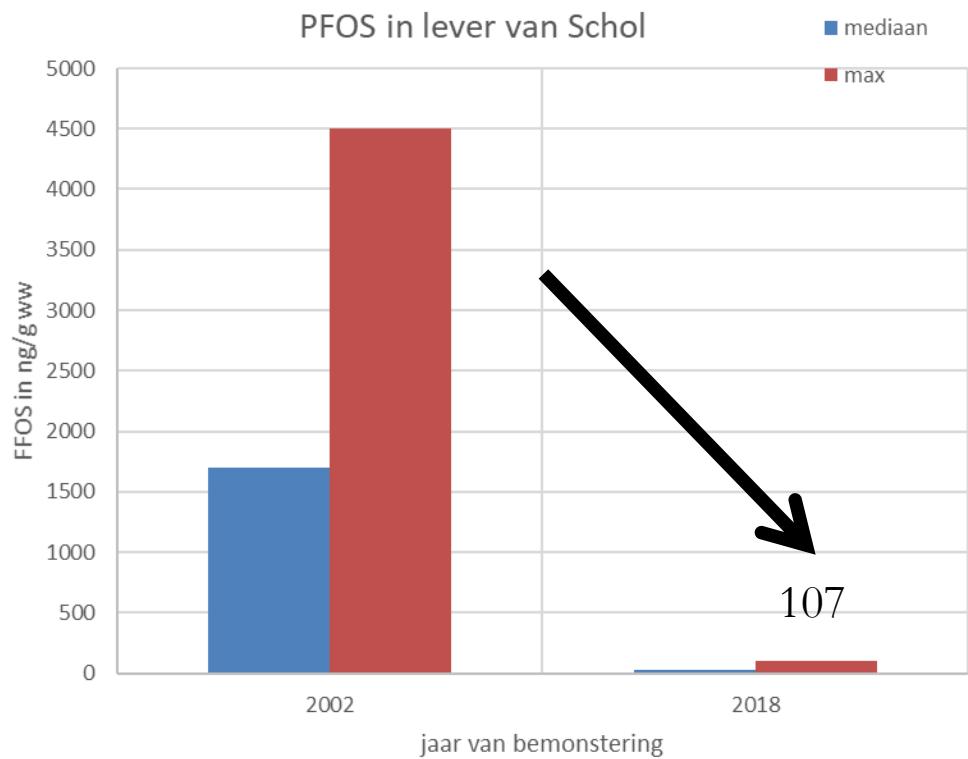


Fig. 1. Overview of the Belgian North Sea and the sampling sites, ranging from the mouth of the Scheldt estuary towards open sea.





Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



Environmental Pollution 137 (2005) 324–333

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ENVIRONMENTAL  
POLLUTION

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[www.elsevier.com/locate/envpol](http://www.elsevier.com/locate/envpol)

## Perfluorooctane sulfonic acid and organohalogen pollutants in liver of three freshwater fish species in Flanders (Belgium): relationships with biochemical and organismal effects

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Adrian Covaci<sup>b</sup>, Lieven Bervoets<sup>a</sup>, Lotte Moens<sup>a</sup>, Geert Huyskens<sup>a</sup>,  
Geert Goemans<sup>c</sup>, Claude Belpaire<sup>c</sup>, Ronny Blust<sup>a</sup>, Wim De Coen<sup>a</sup>

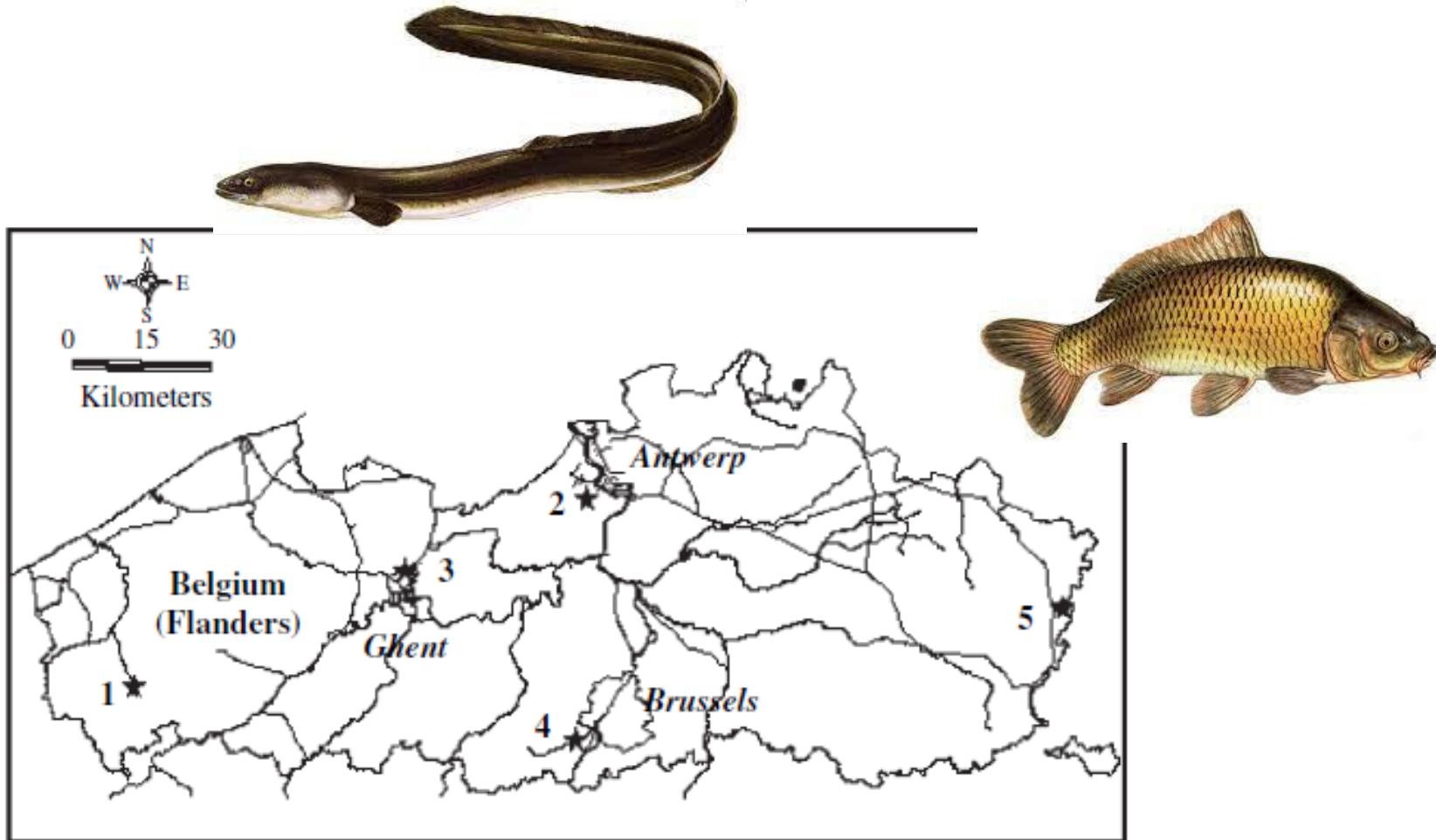
<sup>a</sup>Department of Biology, Research Unit Ecophysiology, Biochemistry and Toxicology, Antwerp University,  
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<sup>b</sup>Toxicological Centre, Antwerp University, Universiteitsplein 1, B-2610 Wilrijk, Belgium

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Received 13 September 2004; accepted 7 January 2005

*Hepatic perfluorooctane sulfonic acid contamination in Flanders (Belgium) might affect  
serological endpoints in feral carp and eel.*



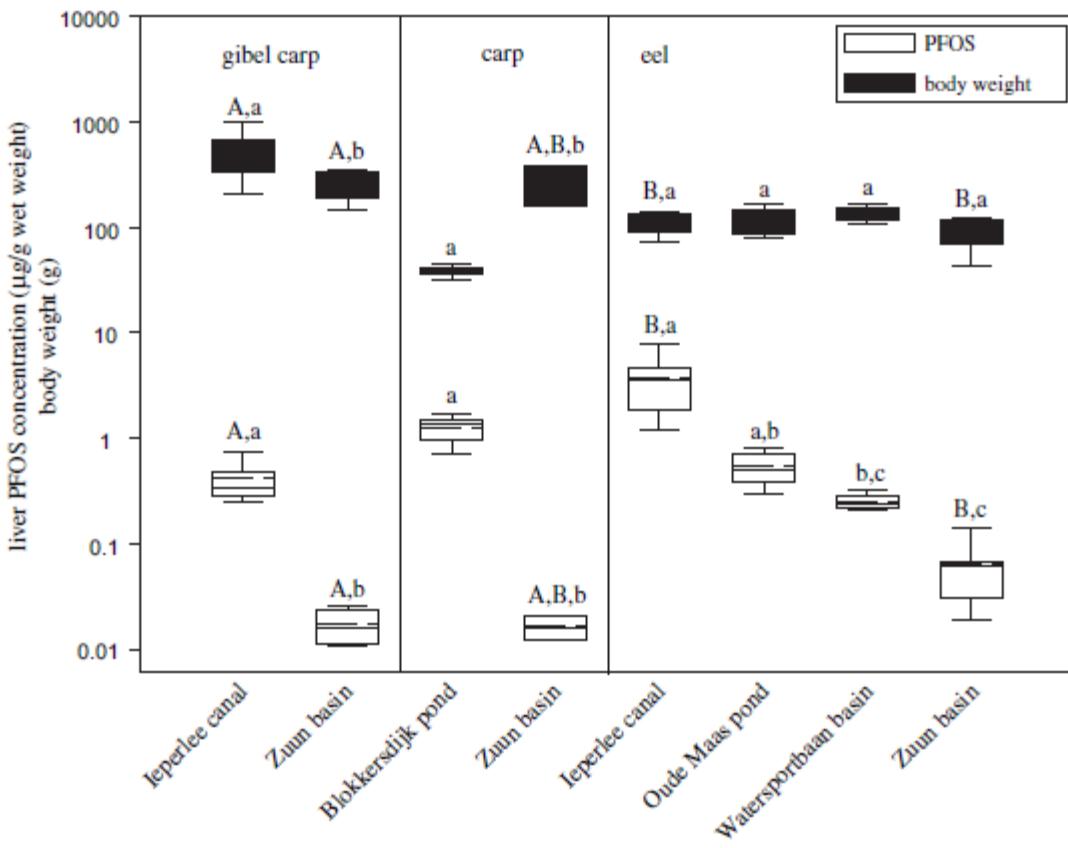


Fig. 2. Liver PFOS concentrations and body weight of gibel carps, carps and eels at each sampling location. The straight line is the median and the dotted line represents the mean. The 25th and 75th percentiles define the boxes. The whiskers represent the 10th and 90th percentiles. The lower case a, b and c indicate significant differences within species. The capitals A and B indicate significant differences between species for identical sampling locations. Boxes having different letters are significantly different ( $p < 0.05$ ). PFOS, perfluorooctane sulfonic acid.

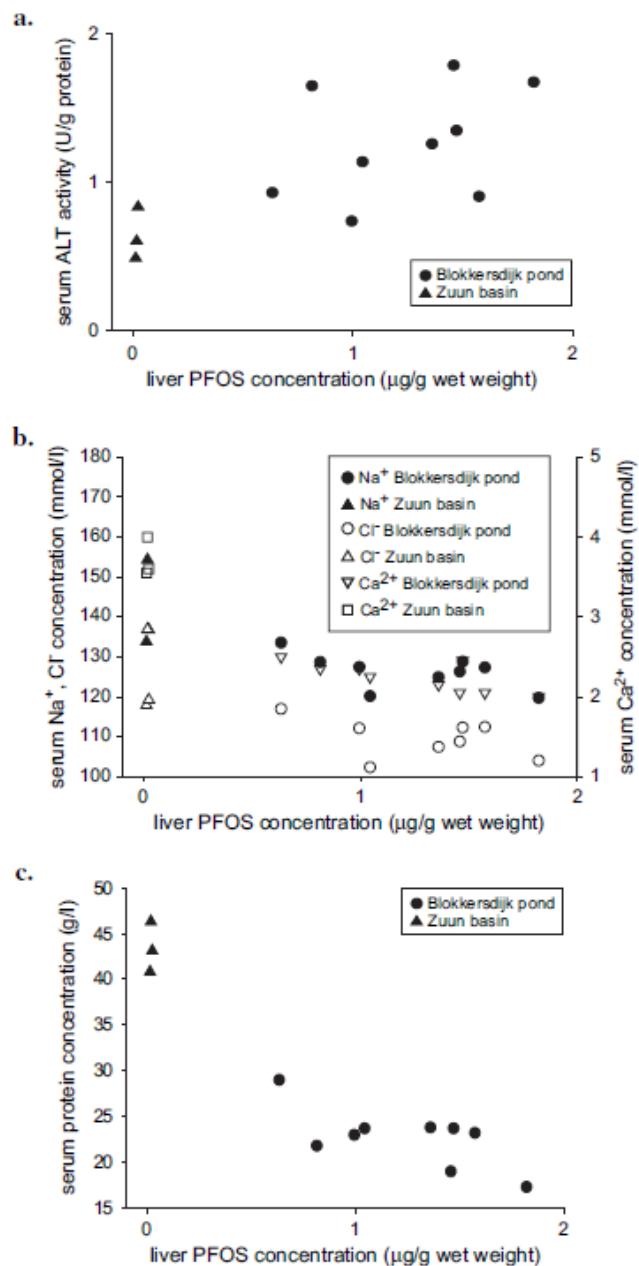


Fig. 3. The relationships between the carp liver PFOS concentration and the serum ALT activity (a), electrolyte concentrations (b) and serum protein concentration (c). PFOS, perfluorooctane sulfonic acid; ALT, alanine aminotransferase.

Veldstudies naar monitoring van biota in  
het kader van de rapportage van de  
chemische toestand voor de  
Kaderrichtlijn Water 2015-2018  
Algemene trends en relaties

Finale versie

Teunen L., Belpaire C., Dardenne F., Blust R., Covaci A. en Bervoets L.

19 maart 2020

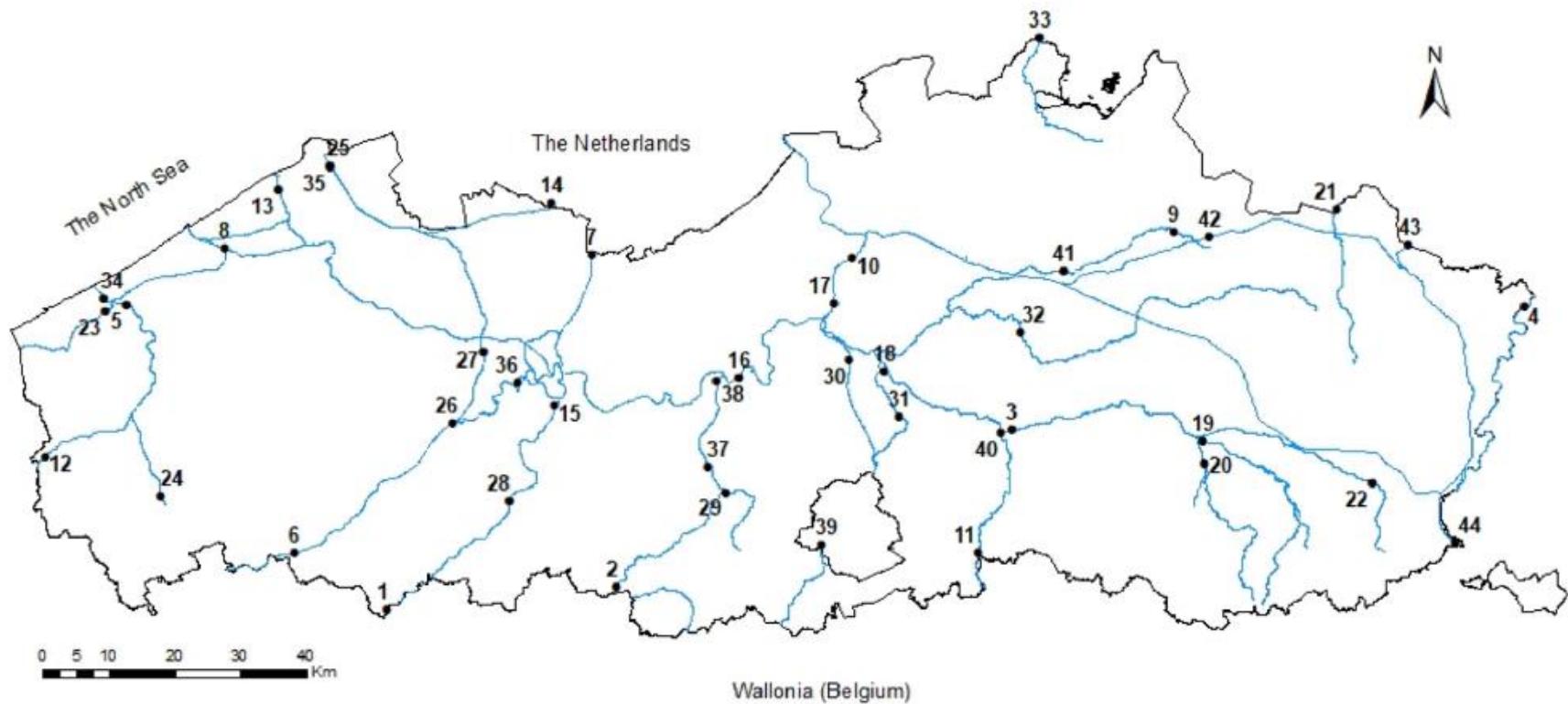


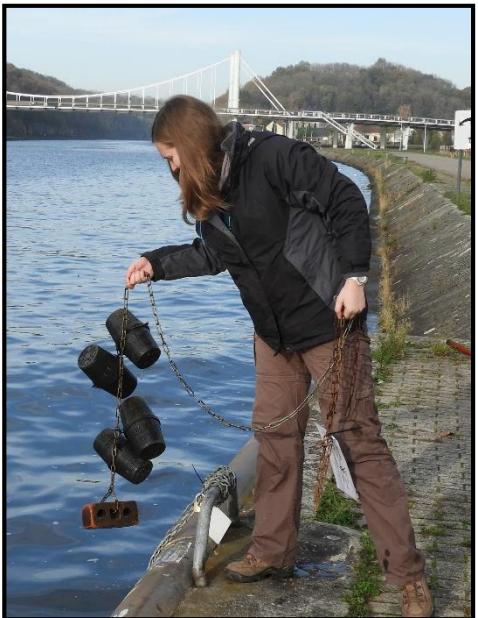
Fig. 1. Map of Flanders (northern part of Belgium) with 44 sampling locations (2015-2018). Detailed information on sample points are indicated in Table SI-1.



*Perca fluviatilis* - Baars



*Anguilla anguilla* – Paling



*Dreissena polymorpha* –driehoeksmossel

RESEARCH

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# PFAS accumulation in indigenous and translocated aquatic organisms from Belgium, with translation to human and ecological health risk

Lies Teunen<sup>1\*</sup> , Lieven Bervoets<sup>1</sup>, Claude Belpaire<sup>2</sup>, Maarten De Jonge<sup>3</sup> and Thimo Groffen<sup>1</sup>

Ecotoxicology and Environmental Safety 231 (2022) 113222



Contents lists available at ScienceDirect

## Ecotoxicology and Environmental Safety

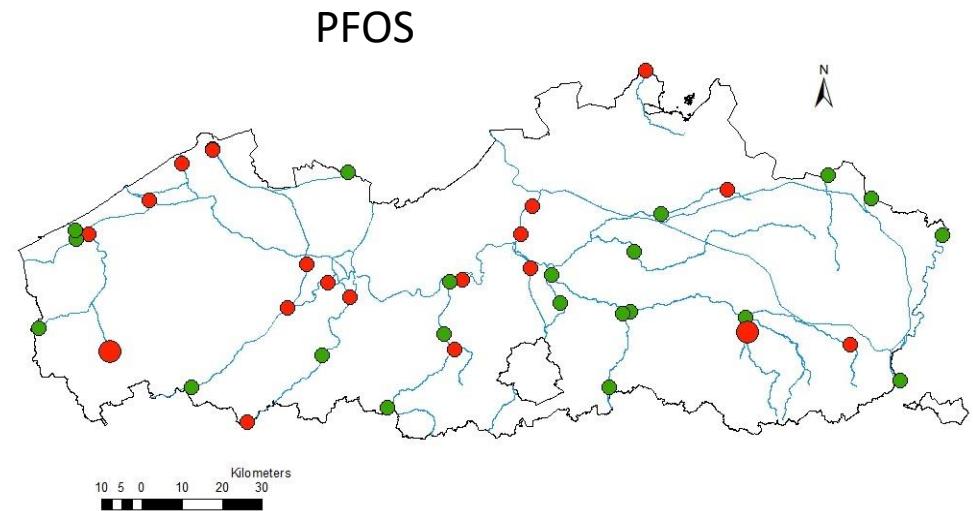
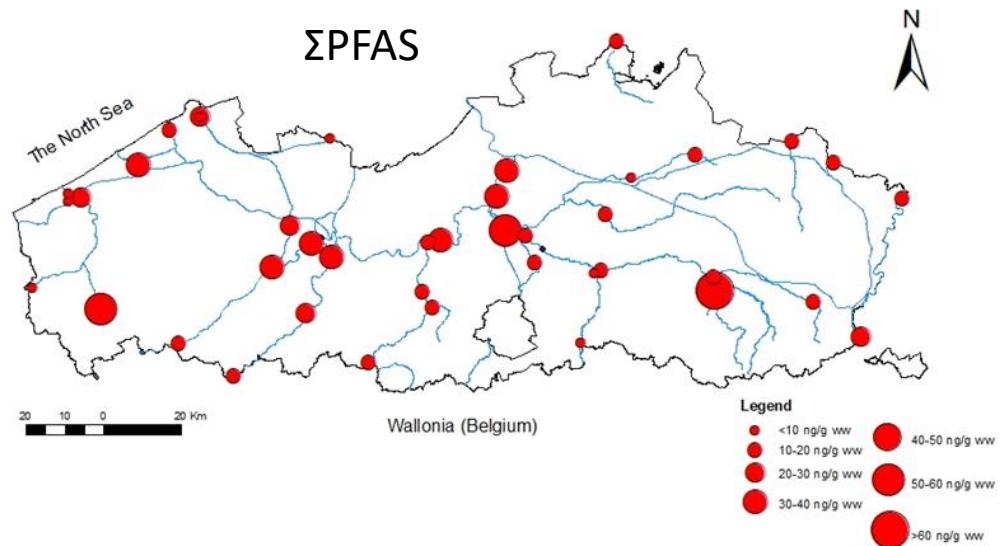
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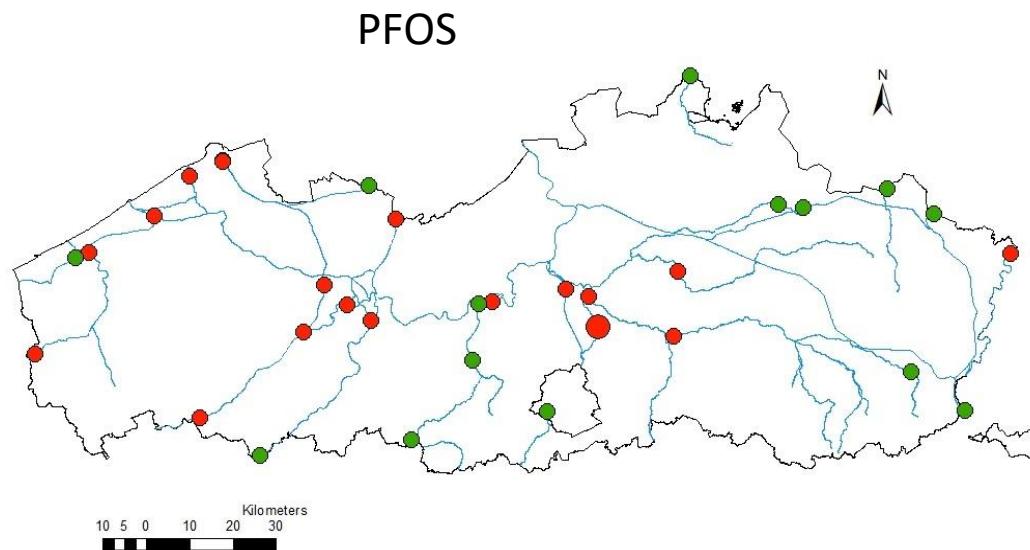
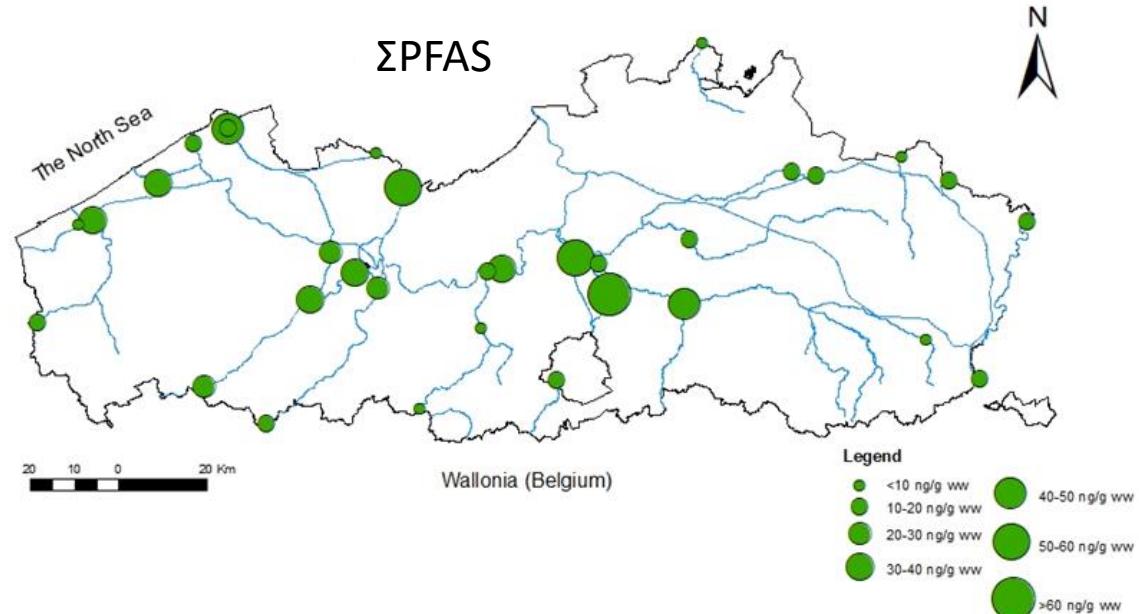


The relevance of European Biota Quality Standards on the ecological water quality as determined by the multimetric macro-invertebrate index: A Flemish case study

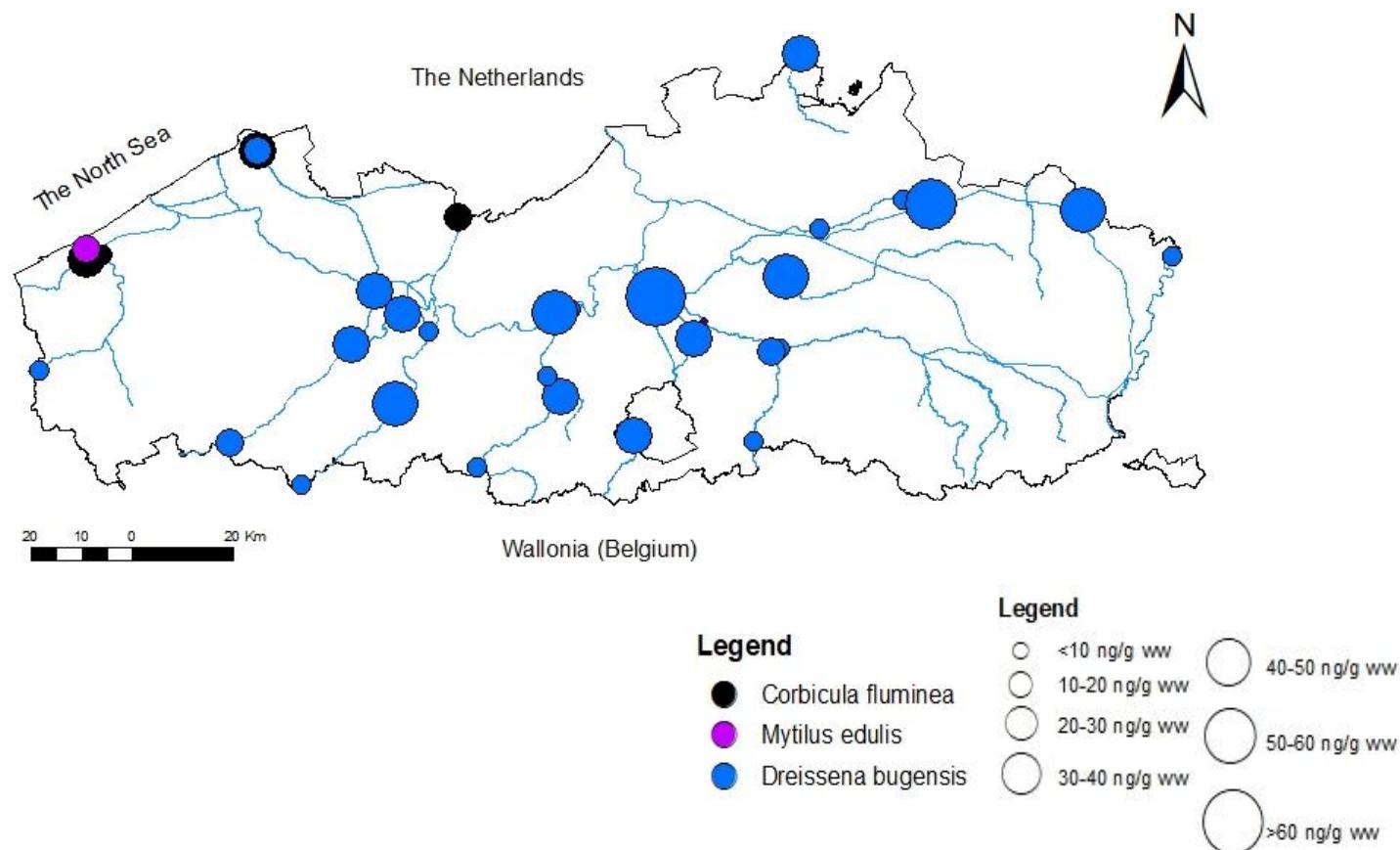
Lies Teunen<sup>a,\*</sup>, Maarten De Jonge<sup>b</sup>, Govindan Malarvannan<sup>c</sup>, Adrian Covaci<sup>c</sup>, Claude Belpaire<sup>d</sup>, Jean-François Focant<sup>e</sup>, Ronny Blust<sup>a</sup>, Lieven Bervoets<sup>a</sup>







# $\Sigma$ PFAS in mosselen



# Evaluatie:

- EQS<sub>biota</sub> PFOS: 9,1 ng/g ww:
- Paling 46% overschrijding (tot 8.8 x BQS)
- Baars 58 % overschrijding (tot 6 x BQS)

# Evaluatie:

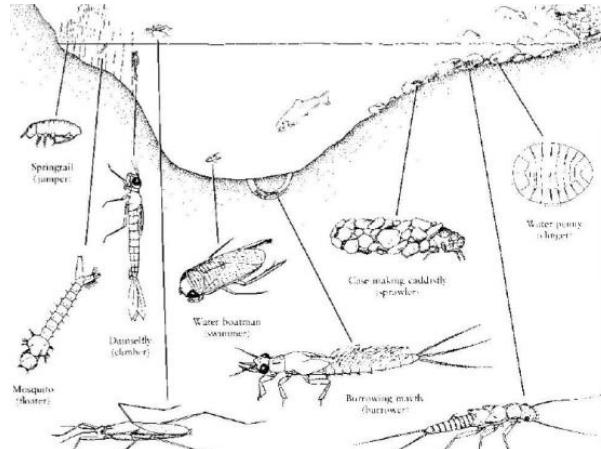
- Richtlijnen EFSA, TWI: 4.4 ng/kg bw per week.
- Met:
  - 70 kg lichaamsgewicht
  - Maximaal 6.4 (0.55) gram eel of 5.0 (1.1) gram baars per dag

# Ecologische evaluatie

## Structuur aquatische levensgemeenschap:

### ➤ Macro invertebraten index, e.g. Multimetric Index Flanders (**MMIF**)

- 5 metrics (#taxa, # EPT taxa, tolerance scores,...)
- Gabriels et al. 2010
- ranging from 0 to 1
- goed quality  $\geq 0.7$

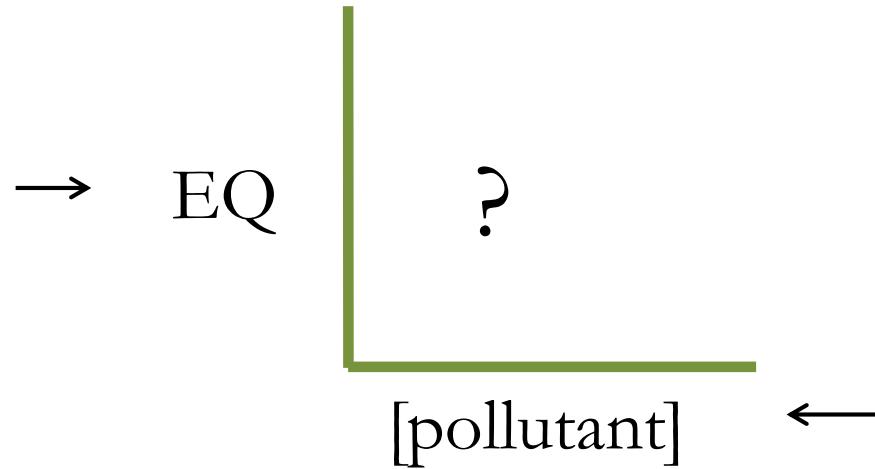


**Table 4**  
Overview of metrics taken into account in the Multimetric Macroinvertebrate Index Flanders.

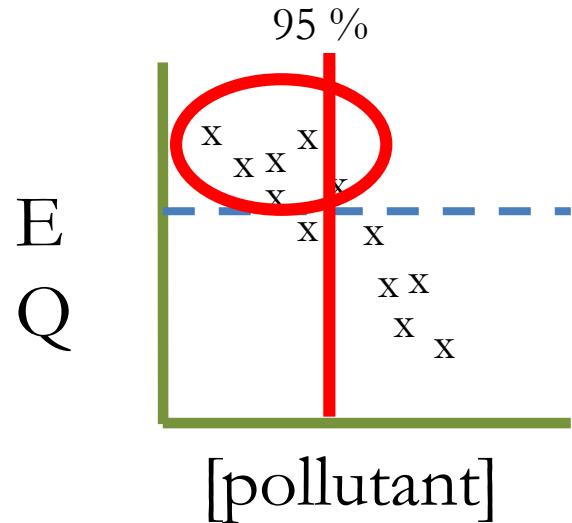
#	Abbreviation	Name	Calculation
1.	TAX	Taxa richness	Total number of present taxa
2.	EPT	Number of EPT taxa	Number of present Ephemeroptera, Plecoptera and/or Trichoptera taxa
3.	NST	Number of sensitive taxa	Number of present taxa with tolerance score $> 5$ , not including Ephemeroptera, Plecoptera and Trichoptera
4.	SWD	Shannon-Wiener diversity	$-\sum_{i=1}^S p_i \ln p_i$ (Shannon and Weaver 1949) with S=taxa richness, $p_i$ =relative abundance of taxon i
5.	MTS	Mean tolerance score	Mean of the tolerance scores of all present taxa

## Kunnen we veilige PFAS waarden afleiden?

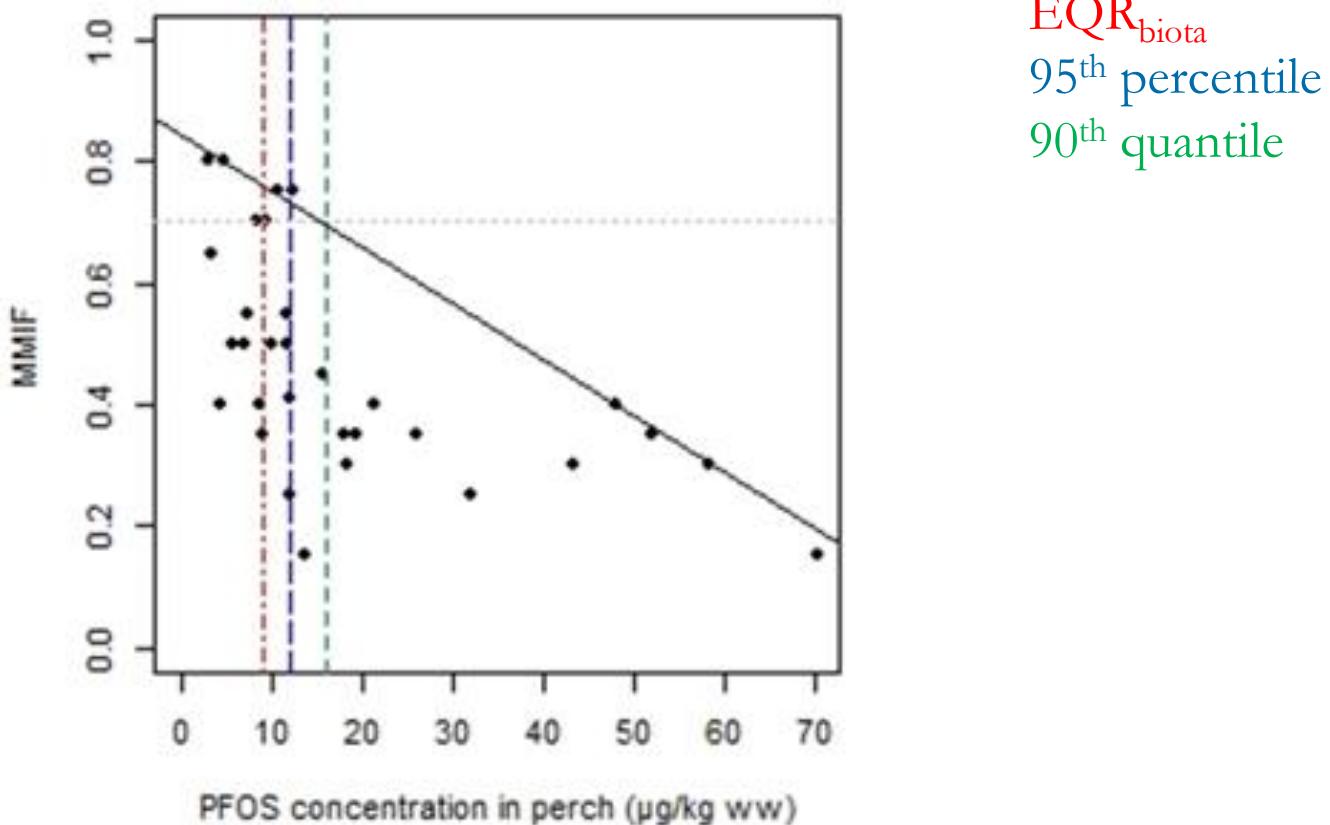
- relateren van geaccumuleerde PFAS met MMIF ?



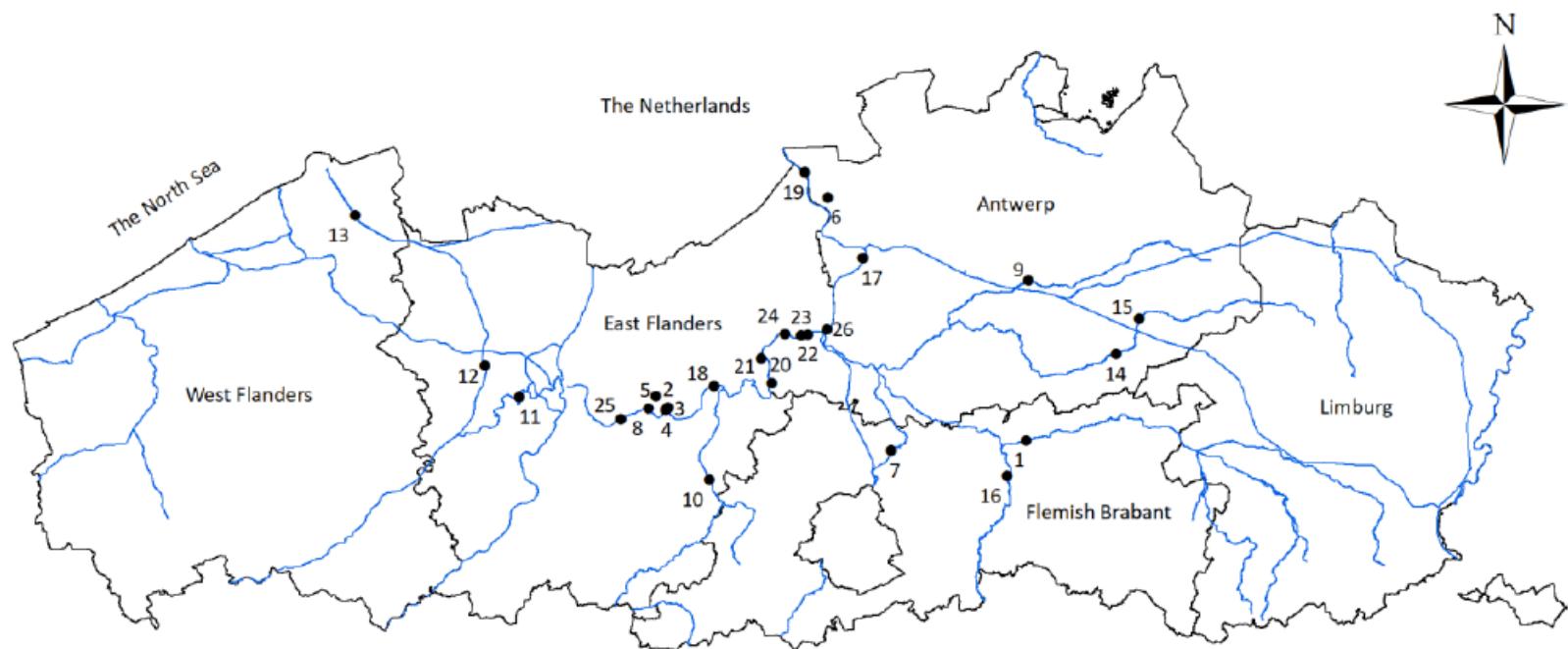
-scatterplots: bepalen van grenswaarden waarboven nooit een goede ecologische status ( $MMIF \geq 0.7$ ) wordt bereikt



# Ecologische evaluatie



# PFAS in wolhandkrabben



# PFAS in Hepatopancreas

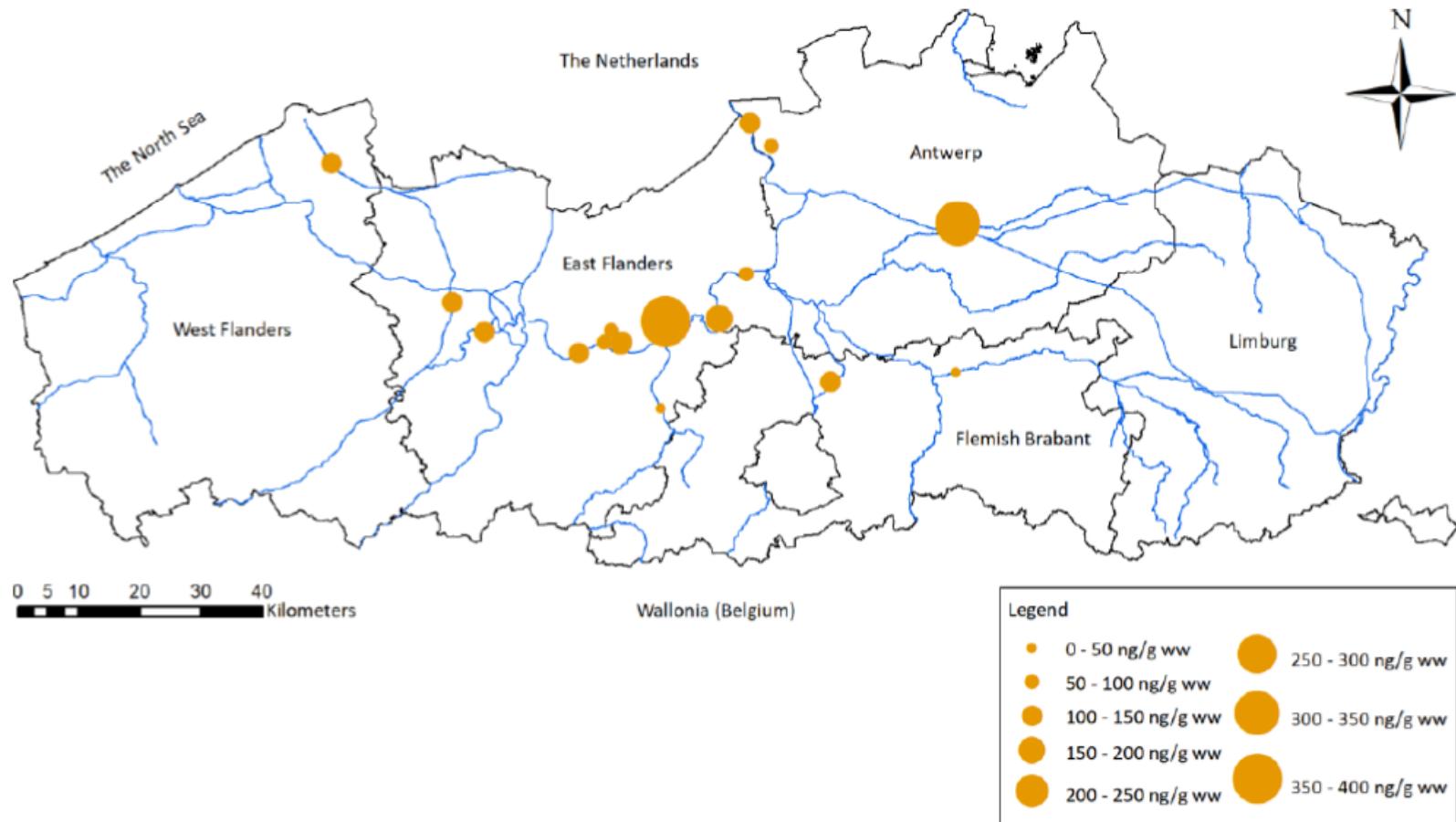


Figure 10. Mean  $\Sigma$ PFAS in hepatopancreas. Made with ArcMap 10.7.1. Only sampling locations with three or more crabs are displayed. Some points overlap; an overview of the mean  $\Sigma$ PFAS in the hepatopancreas per location is shown in Appendix 5.

# PFAS in spierweefsel

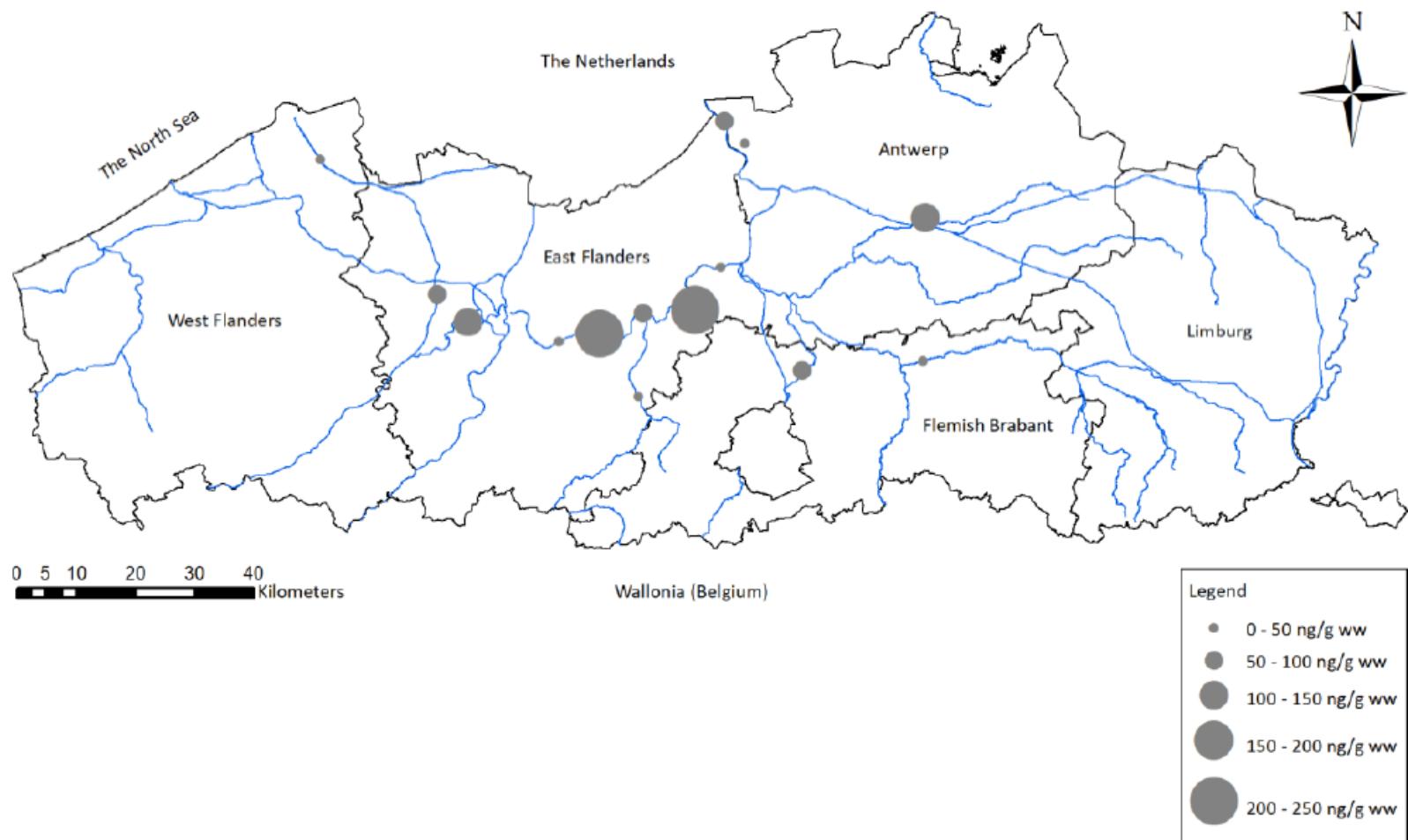


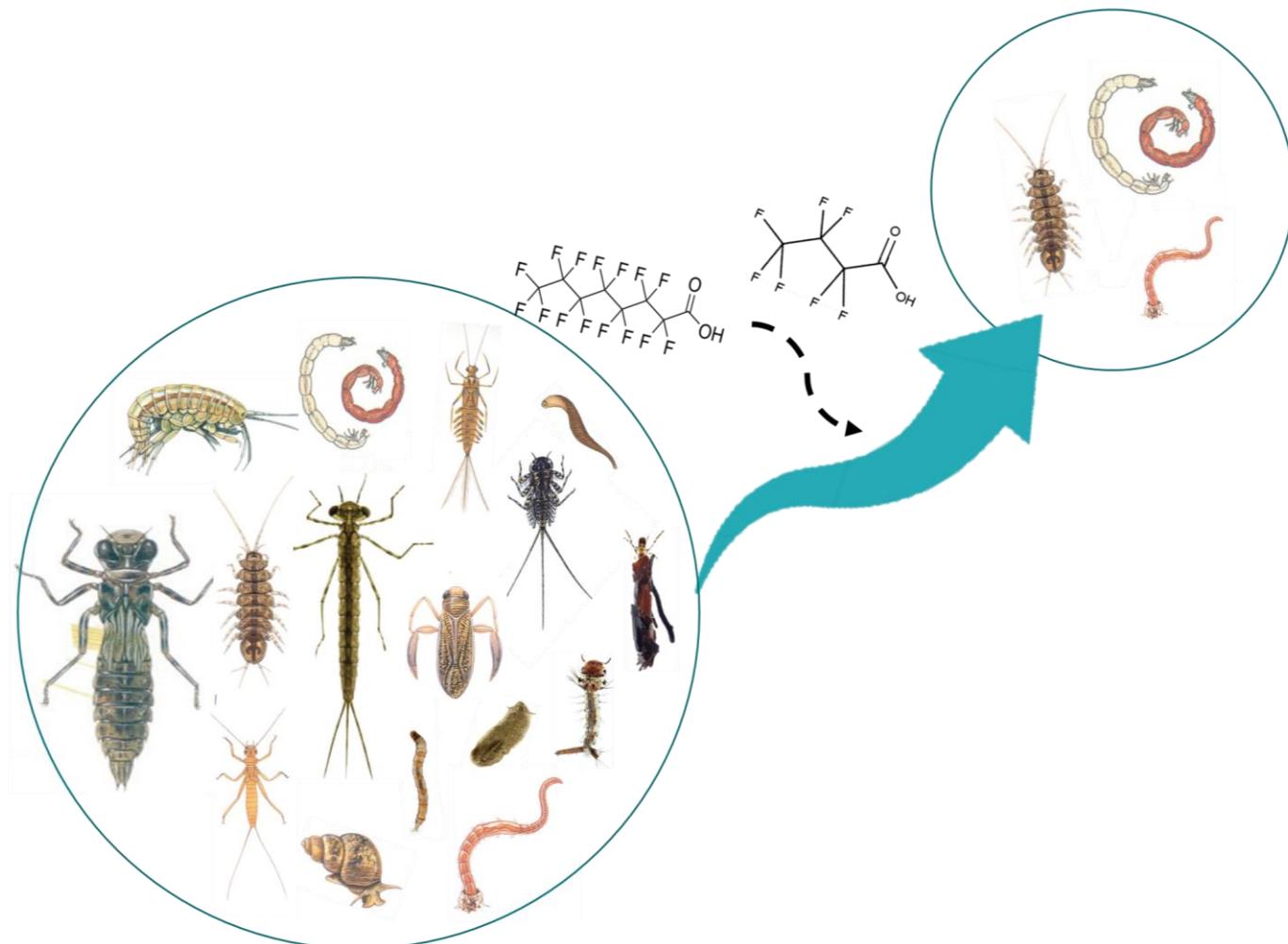
Figure 11. Mean  $\Sigma$ PFAS in muscle tissue. Made with ArcMap 10.7.1. Only sampling locations with three or more crabs are displayed. Some points overlap; an overview of the mean  $\Sigma$ PFAS in muscle tissue per location is shown in Appendix 5.

# Studie van PFAS in water, sediment, en invertebraten

PhD Cara Byns

- 29 locaties (bekken en rivieren)
- Gespreid over Vlaanderen
- 29 PFAS componenten
- Inclusief hotspots:
  - Palingbeek Zwijndrecht
  - Fabrieksloop Willebroek

# Bioaccumulation of PFAS in aquatic invertebrates



- 30 Locations
- PFAS analysis of 29 target analytes in 2 crustacean species:



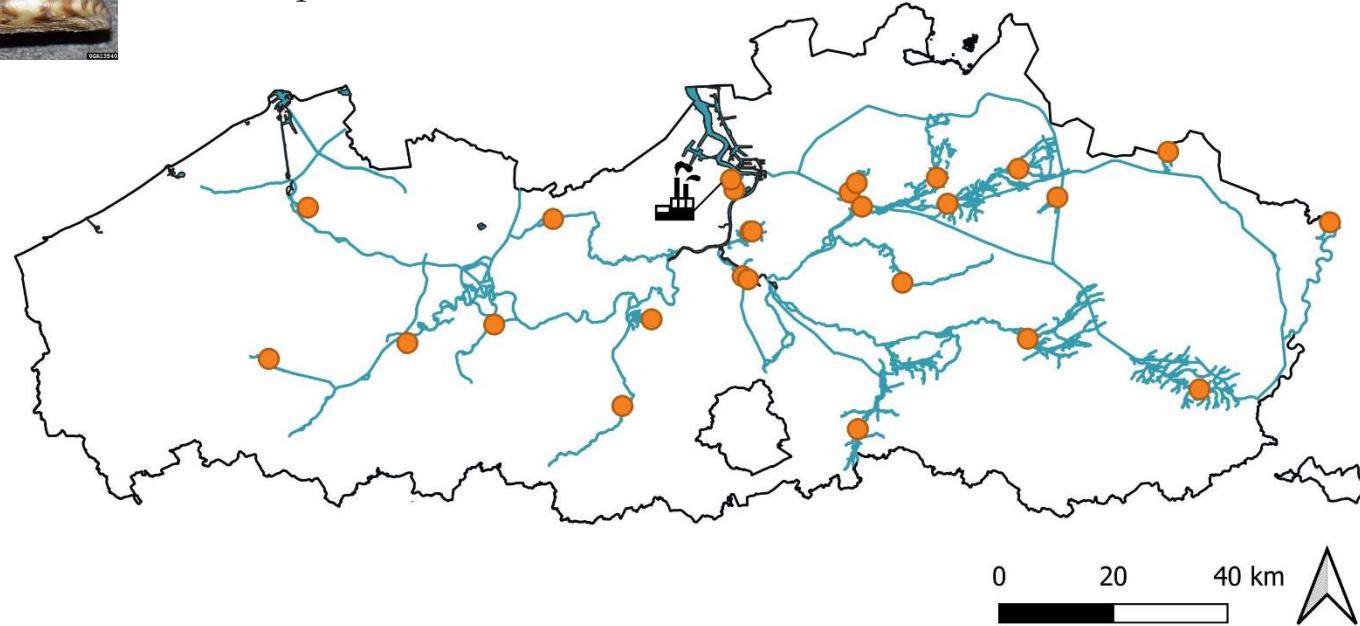
*Gammarus sp.*



*Asselus sp.*



*Dreissena sp.*



Waterloop	PFOA			PFOS		
	sediment ng/g dw	water ng/L	biota ng/g ww	sediment ng/g dw	water ng/L	biota ng/g ww
Vlietbosbeek	<LOQ	<b>0.13</b>		<LOQ	<b>0.04</b>	
Bruchtse Scheibeek	<b>1.27</b>	<b>0.02</b>	<b>0.59</b>	<b>7.94</b>	<LOQ	<LOQ
Laakbeek	<b>0.42</b>	<b>0.01</b>	<b>1.56</b>	<b>0.51</b>	<LOQ	<LOQ
Bankloop	<b>0.80</b>	<b>0.09</b>		<LOQ	<LOQ	
Bergebeek	<b>0.46</b>	<b>0.04</b>	<b>0.37</b>	<LOQ	<b>0.01</b>	<LOQ
Hoeikensloop		<b>0.01</b>	<LOQ		<LOQ	<b>0.79</b>
Leibeeck	<LOQ	<b>0.01</b>	<LOQ	<LOQ	<LOQ	<b>0.21</b>
Demer	<b>0.50</b>	<b>0.01</b>	<b>0.97</b>	<LOQ	<LOQ	<b>2.31</b>
Echelwater	<b>0.76</b>	<b>0.01</b>	<b>0.18</b>	<LOQ	<LOQ	<LOQ
witbeek	<b>0.79</b>	<b>0.01</b>	<b>0.18</b>	<LOQ	<LOQ	<LOQ
Dommelloop	<b>0.40</b>	<b>0.02</b>	<b>3.80</b>	<LOQ	<LOQ	<b>5.38</b>
Scheppelijke nete	<b>1.42</b>	<b>0.02</b>	<b>0.82</b>	<b>0.14</b>	<LOQ	<b>0.65</b>
Vondelbeek	<b>0.51</b>	<b>10.6</b>	<b>0.18</b>	<LOQ	<b>3.81</b>	<LOQ
Molenbeek	<b>2.87</b>	<b>7.30</b>	<b>0.60</b>	<LOQ	<LOQ	<LOQ
Melsenbeek	<b>3.62</b>	<LOQ	<b>0.50</b>	<b>1.68</b>	<LOQ	<LOQ
Zwarde beek	<b>0.65</b>	<b>0.01</b>	<LOQ	<b>5.45</b>	<LOQ	<LOQ
Grote motte	<b>1.22</b>	<LOQ		<LOQ	<LOQ	
Kattebeek	<LOQ	<b>0.01</b>	<b>0.56</b>	<LOQ	<LOQ	<LOQ
Hoofdsloot	<LOQ	<b>0.02</b>	<b>0.77</b>	<LOQ	<LOQ	<b>0.46</b>
Roobeeck	<LOQ	<b>0.01</b>	<LOQ	<LOQ	<LOQ	<LOQ
Tappelbeek stroom af	<LOQ	<b>0.01</b>	<b>4.16</b>	<b>0.63</b>	<LOQ	<b>0.50</b>
Tappelbeek stroom op	<b>0.43</b>	<LOQ	<b>2.11</b>	<LOQ	<LOQ	<LOQ
Molenbeek	<b>1.43</b>	<b>0.02</b>	<b>0.59</b>	<b>0.44</b>	<LOQ	<LOQ
Struisbeek stroom af	<LOQ	<b>0.02</b>	<LOQ	<LOQ	<LOQ	<LOQ
Struisbeek stroom op	<b>0.65</b>	<b>0.01</b>	<b>0.40</b>	<LOQ	<LOQ	<LOQ
Fabrieksloop	<b>6.29</b>	<b>228</b>	<b>20.2</b>	<b>130</b>	<b>485</b>	<b>71.5</b>
Palingbeek	<b>294</b>	<b>39681</b>	<b>520</b>	<b>249</b>	<b>97494</b>	<b>5114</b>
Kleine nete	<b>0.70</b>	<LOQ	<b>2.33</b>	<LOQ	<LOQ	<b>2.04</b>
Kleine nete	<LOQ	<b>0.01</b>		<LOQ	<LOQ	

Component	Fabrieksloop			Palingbeek		
	sediment ng/g dw	water ng/L	biota ng/g ww	sediment ng/g dw	water ng/L	ng/g ww
PFBA	<LOQ	<b>45.6</b>	<LOQ	<b>241</b>	<b>8060</b>	<b>94.4</b>
PFPeA	<LOQ	<b>19.3</b>	<LOQ	<b>133</b>	<b>3254</b>	<b>36.2</b>
PFHxA	<LOQ	<b>53.2</b>	<b>5.35</b>	<b>671</b>	<b>15482</b>	<b>137</b>
PFHpA	<LOQ	<b>52.7</b>	<LOQ	<b>122</b>	<b>7463</b>	<b>30.0</b>
PFOA	<b>6.29</b>	<b>228</b>	<b>20.2</b>	<b>294</b>	<b>39681</b>	<b>520</b>
PFNA	<b>0.37</b>	<b>14.4</b>	<LOQ	<b>0.54</b>	<b>293</b>	<b>5.93</b>
PFDA	<b>3.70</b>	<b>14.7</b>	<b>3.40</b>	<b>0.75</b>	<b>254</b>	<b>17.6</b>
PFUnDA	<b>1.77</b>	<b>14.9</b>	<b>2.70</b>	<LOQ	<LOQ	<b>1.02</b>
PFDoDA	<b>17.0</b>	<LOQ	<b>6.84</b>	0.47	<LOQ	<b>11.6</b>
PFTrDA	<b>4.12</b>	<LOQ	1.33	<LOQ	<LOQ	<b>5.72</b>
PFTeDA	<b>6.04</b>	<LOQ	<LOQ	<LOQ	<LOQ	<b>4.49</b>
PFBS	<LOQ	<LOQ	<LOQ	<b>720</b>	<b>12040</b>	<b>63.3</b>
PFPeS	<LOQ	<LOQ	<LOQ	<b>22.2</b>	<b>1087</b>	<b>14.4</b>
PFHxS	<LOQ	<LOQ	<LOQ	<b>1066</b>	<b>29298</b>	<b>312</b>
PFHpS	<LOQ	<b>18.3</b>	<LOQ	<b>18.0</b>	<b>3535</b>	<b>96.6</b>
PFOS	<b>130</b>	<b>485</b>	<b>71.5</b>	<b>249</b>	<b>97494</b>	<b>5114</b>
PFDS	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<b>5.65</b>
FBSA	<LOQ	<LOQ	<LOQ	<b>51.1</b>	<b>3486</b>	<b>17.5</b>
11Cl-PF3Ouds	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
9Cl-PF3ONS	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
4:2 FTS	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
6:2 FTS	<b>17.8</b>	<LOQ	<b>0.97</b>	<b>2.89</b>	<LOQ	<LOQ
8:2 FTS	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
ADONA	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
HFPO-DA	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PFEESA	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PF4OPeA	<LOQ	<LOQ	<LOQ	<LOQ	<b>19.7</b>	<LOQ
PF5OHxA	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
3.6-OPFHpA	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<b>14.2</b>

# resultaten

- 8/29 componenten nooit boven de LOQ
- Meest gedetecteerde componenten:
  - In sediment:
    - PFOA in 20/30 locaties: max 294 ng/g dw
    - PFOS in 9/30 locaties: max 249 ng/g dw
  - In water:
    - PFOA in 27/30 locaties, max 39700 ng/L!!!
    - PFOS in 5/30 locaties, max 97494 ng/L!!!
  - In invertebraten: afhankelijk van de soort

# Conclusie

- Veel studies over de accumulatie van PFAS
- Weinig effectstudies op aquatische organismen
- Geen normen voor meeste PFAS