Relevance and applicability of active biomonitoring in continental waters under the Water Framework Directive

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In order to achieve the objectives of the European Union's Water Framework Directive (WFD) for assessing chemical contamination of water bodies [i.e. checking compliance with Environmental Quality Standards (EQSs) for priority substances (PSs), and monitoring trends of contamination], it is necessary to propose reliable methodologies for monitoring micropollutants. For hydrophobic substances, this involves the use of integrative matrices (e.g., biota or sediment).

We discuss here the implementation and the feasibility of a large-scale chemical biomonitoring approach for continental waters, considering the benefits and the limitations of existing biomonitoring strategies, the factors that can affect data interpretation, and the choice of species with regard to the WFD. Current scientific knowledge shows that, unlike the marine environment, continental waters have only a few established and standardized biomonitoring methodologies.

From the literature reviewed, active approaches to biomonitoring (using transplanted organisms) appear to be more suitable than passive approaches (based on sampling of indigenous species), as they implement reproducible strategies, control biotic confounding factors and provide robust, comparable results.

If fishes are organisms of choice for checking compliance with biota EQSs, they have several characteristics that limit their use for active biomonitoring, while macroinvertebrates represent a good compromise in terms of feasibility and fulfilling the objectives of the WFD.

Keywords: Active biomonitoring; Biota; Chemical status; Contamination; Continental waters; Environmental Quality Standard (EQS); Passive biomonitoring; Priority substance (PS); Trend monitoring; Water Framework Directive (WFD)

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1. Regulatory setting

The Water Framework Directive (WFD) (Directive 2000/60/EC; [1]) requires Member States (MSs) of the European Union (EU) to achieve good chemical status by 2015 in all water bodies for a list of specific pollutants. This list currently stands at 41 pollutants [33 priority substances (PSs) and eight other pollutants] given in Annex I of Directive 2008/105/EC [2]; furthermore, the European Commission (EC) proposed recently to include 15 additional PSs on this existing list (Table 1; [3]).

The application of the WFD for the surveillance of chemical contamination of surface waters involves two main objectives:

(1) to assess the chemical status of the water bodies, by determining whether contamination levels are compliant with the regulatory Environmental Quality Standards (EQSs); and,
(2) to assess the temporal trends of the contamination in the different environmental compartments of aquatic ecosystems.

EQSs are defined as ''the concentration of a particular pollutant or group of pollutants in water, sediment or biota which should not be exceeded in order to protect human health and the environment'' [1]. EQSs are determined according to the 2011 ''Technical guidance for deriving environmental quality standards'' [4]. They cover a series of different protection objectives that integrate effects on aquatic

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Table 1. Relevance of biota as a monitoring matrix for the 33 priority substances (PSs) and the eight other pollutants listed by the Directive 2008/105/EC [2] and for the 15 substances proposed by the European Commission for revision of the list of PSs [3]. Table adapted from CMA guidance [5]

Water framework directive priority substances [2]	BCF	Log K_{OW}	Biota
Alachlor	50	3.0	N
Anthracene	162–1440	4.5	O
Atrazine	7.7–12	2.5	N
Benzene	13	2.1	N
Brominated diphenyl ether	14350–1363000	6.6	P
Cadmium		n.a.	n.a.
C10-13-chloroalkanes	1173–40900	4.4–8.7	P
Chlorfenvinphos	27–460	3.8	O
Chlorpyrifos (-ethyl, -methyl)	1374	4.9	O
1,2-Dichloroethane	2–<10	1.5	N
Dichloromethane	6.4–40	1.3	N
Di(2-ethylhexyl)phthalate (DEHP)	737–2700	7.5	O
Diuron	2	2.7	N
Endosulfan	10–11583	3.8	O
Fluoranthene	1700–10000	5.2	P
Hexachlorobenzene	2040–230000	5.7	P
Hexachlorobutadiene	1.4–29000	4.9	P
Hexachlorocyclohexane	220–1300	3.7–4.1	P
Isoproturon	2.6–3.6	2.5	N
Lead		n.a.	n.a.
Mercury		n.a.	P
Naphthalene	2.3–1158	3.3	O
Nickel		n.a.	n.a.
Nonylphenols	1280–3000	5.5	O
Octylphenol	471–6000	5.3	O
Pentachlorobenzene	1100–260000	5.2	O
Pentachlorophenol	34–3820	5.0	O
Polyaromatic hydrocarbons	9–22000	5.8–6.7	P
Simazine	1	2.2	N
Tributyltin compounds	500–52000	3.1–4.1	P
Trichlorobenzenes	120–3200	4.0–4.5	O
Trichloromethane	1.4–13	2.0	N
Trifluralin	2360–5674	5.3	O
DDT (including DDE, DDD)		6.0–6.9	P
Aldrin		6.0	P
Endrin		5.6	P
Isodrin		6.7	P
Dieldrin		6.2	P
Tetrachloroethylene		3.4	N
Tetrachloromethane		2.8	N
Aclonifen		4.04	P
Bifenox		4.48	P
Cybutryne		2.8	N
Cypermethrin		6.6	P
Dichlorvos		1.47	N
Diclofenac		4.5	P
Dicofol		5.02	P
Dioxins			
7 PCDDs		6.64–8.20	P
10 PCDFs		6.1–8.0	P
12 PCBs dioxin-like		6.0–7.71	P
Heptachlor and its epoxide		6.1	P
Hexabromocyclododecane		7.74	P
Perfluorooctane sulfonic acid and its derivatives		n.d.	n.d.
Quinoxyfen		7	P
Terbutryn		3.74	P

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