

Qualité des eaux des têtes de bassin versant de la frange atlantique du massif central français.

Water quality of the headwaters from the west of the french Massif Central.

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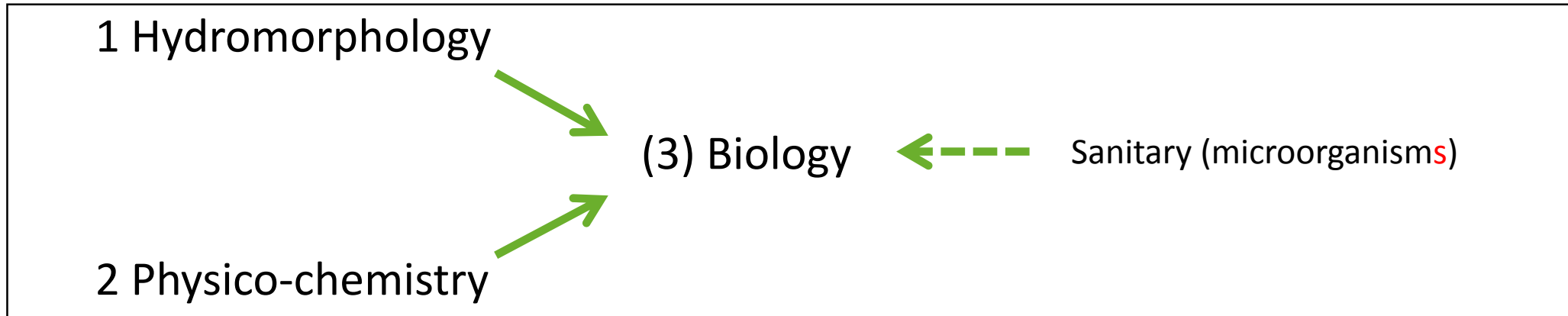


PERIGUEUX, 5-8 NOVEMBER 2019



What is water quality?

➤ 3 criteria, but in fact 2



➤ Water quality = Relative concept

- ✓ **To aquatic life**
- ✓ To human use

➤ Metrics of evaluation

- ✓ Different types (physico-chemical, biological, ...)
- ✓ Spot or time-integrative approach
+ impact of watershed activities

Water quality and aquatic life

➤ Aquatic environment = 3 key functions for species

- ✓ Habitat
- ✓ Source of food
- ✓ Reproduction

➤ Human activities affect (in)directly its

- ✓ Hydromorphology
 - ✓ Pond, dam, change of sediment granulometry distribution,...
 - ✓ Physico-chemistry
 - ✓ Macropollutants (C, N, P) + TSS
 - ✓ Micropollutants (heavy metals, pesticides, pharmaceuticals,)
- + (competition between invasive and endemic species, ...)



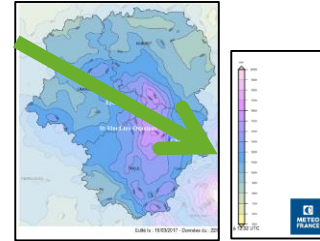
What we know about headwaters from west of french Massif-central

➤ Natural environment

- ✓ Granitic/gneiss bedrock
- ✓ Atlantic climate (rain gradient 800-1600 mm/year)
- ✓ Altitude 250 – 970 m
- ✓ 5-10 % of surface are wetlands

➤ Rural area with low density of population with economic activities

- ✓ Extensive cattle breeding
- ✓ Forestry
- ✓ Abandoned small mining/industrial plant



Weak Human
impact expected
and assumed on
water quality



For more than 10 years
(WFD 2000), numerous
hydromorphological
issues were highlighted



Hydromorphological alterations

- Affect physical properties of aquatic environment
 - ✓ Characteristics of waterbeds
 - ✓ Characteristics of flow
- Cause damages on aquatic species due to the alteration of one or more key-functions of aquatic environment
- Numerous actions to comply WFD2000 objectives, but currently a limited success to achieve the good environmental status of water body in headwaters
 - ✓ A longer time is required to achieve species recolonization?
 - ✓ Only one level of water quality was considered : physico-chemical aspects were too poorly considered (except Temperature (O_2))

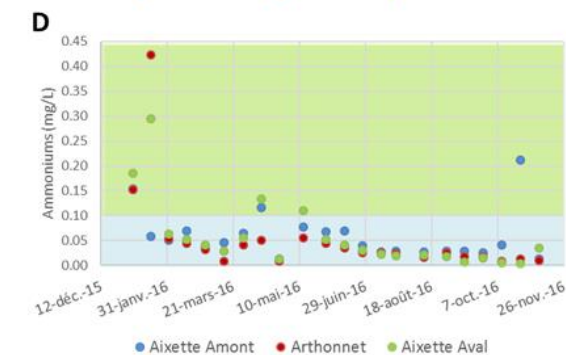
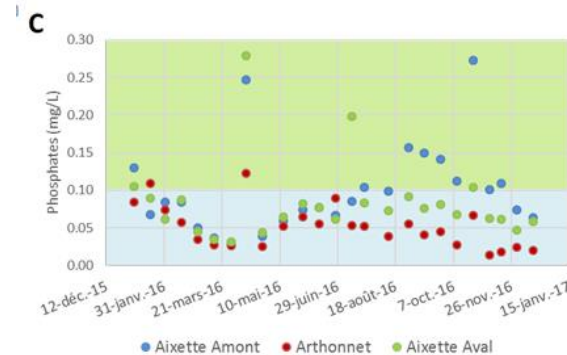
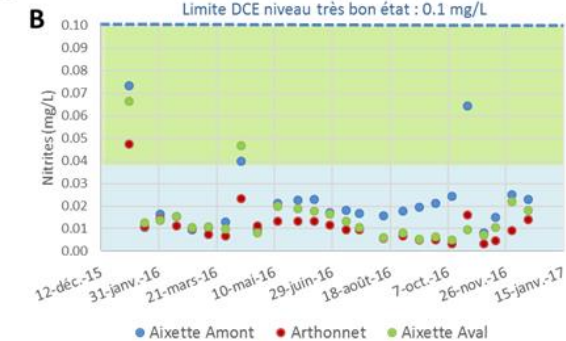
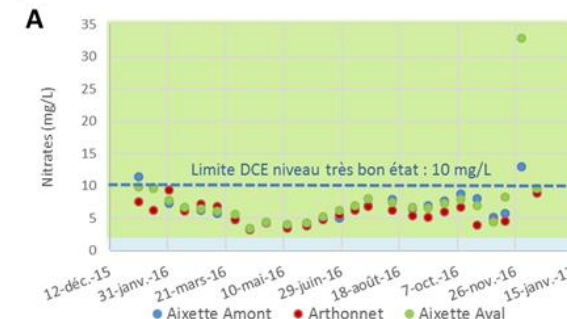
Ex. changes of granulometric size distribution of sediments with alteration of flow



Physico-chemical characteristics of headwaters from west of french Massif-central

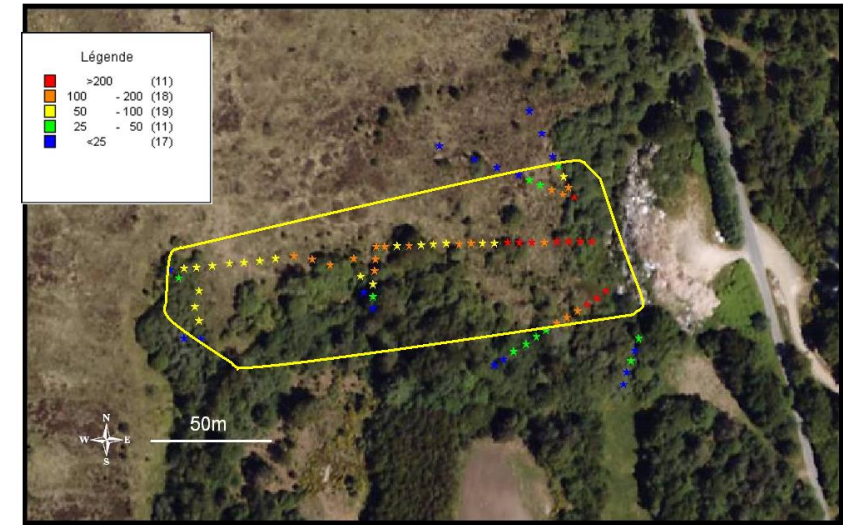
➤ The usual physico-chemical metrics meet the good Environmental state of water body of headwaters, but mainly concern C, N, P pollutants

(1998-2004)	Vézère		Gartempe	
	min	max	min	max
Size of catchment (km ²)	70		6	
Daily flow(m ³ s ⁻¹)	0,3	7,2	0,03	0,24
pH	5,6	6,8	6,2	7
Alcalinity - HCO ₃ ⁻ (mg,L ⁻¹)	< 5	6	10	23
Conductivité (μS,cm ⁻¹)	17	26	52	76
DOC (mg C per L)	2,8	10,2	4,9	16,2
NO ₃ ⁻ (mg,L ⁻¹)	0.5	2	1	4
NH ₄ ⁺ (mg,L ⁻¹)	<0.01	0.05	0.01	0.09
PO ₄ ³⁻ (P mg,L ⁻¹)	<0.01	0.04	0.01	0.12



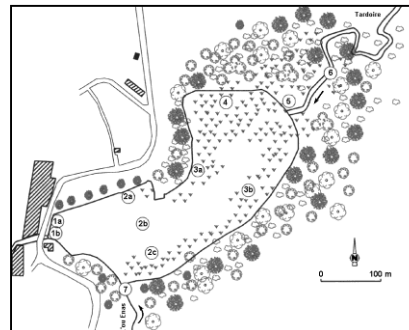
Micropollutants of headwaters from west of french Massif-central: metals/metalloids

- Localized pollution mainly
- Metals/metalloids are mainly present in sediment
 - ✓ Du to their chemical properties
 - ✓ Accumulation in pond, dam, ... where sediments settle
- Origins
 - ✓ Natural : Geochemical background
 - ✓ Human : mining activities; metal processing industry, old little landfill



Ex. Pollution plume of small landfill, only enrichment of soil with Hg

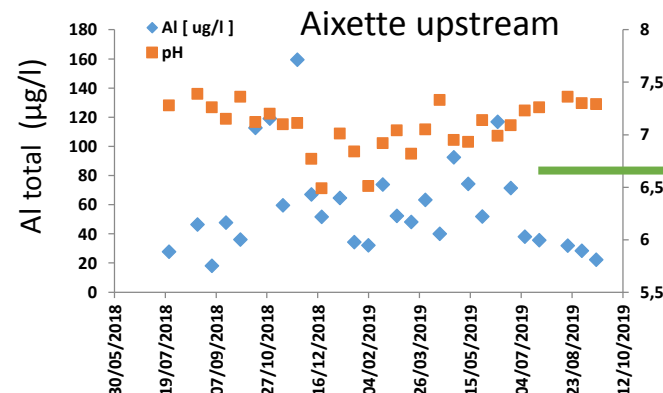
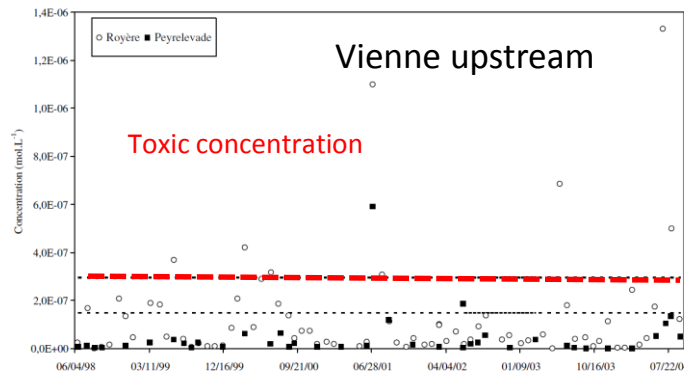
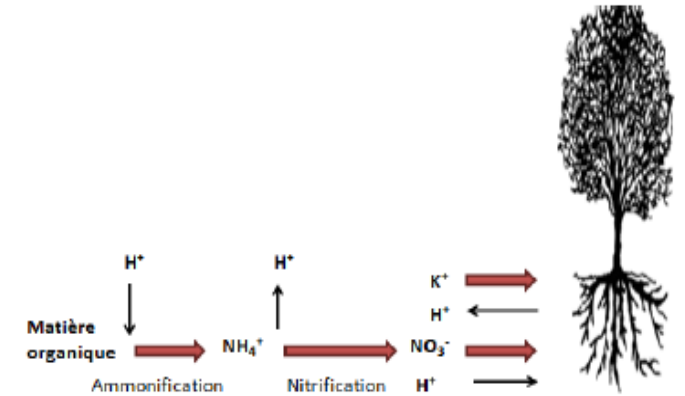
Ex. Pollution of pond sediments at the upstream of closed metal processing industry



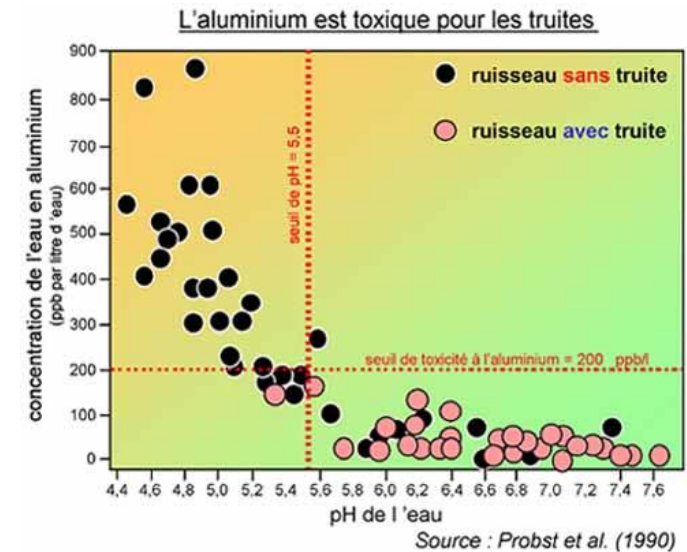
Sample	Zn	Cu	Pb	Cr	Ni	OM
	Sediment (mg/kg)					%
Tardoire	38,7	20,4	18,1	32,0	6,9	1,1
1	278,3	659,6	52,5	62,4	40,4	15,5
2a	380,8	1054,8	50,6	65,2	39,5	16,7
2b	236,2	443,2	43,5	62,5	35,7	17,6
2c	273,3	666,0	49,6	68,6	39,8	16,7
3	217,4	316,4	37,6	110,7	28,9	17,1

Micropolluants of headwaters from west of french Massif-central: Case of Aluminum

- Soils are rich in Aluminum (6-8%)
- Intensive forestry activity induces acidification of soil and increases aluminum mobility
- Aluminum is toxic for trout ($\text{pH} < 5.6$ and $[\text{Al}] > 200 \mu\text{g/L}$)
 - ✓ Currently study concern drinking water and shown that sub-water contain 200-600 $\mu\text{g/L}$ of Al and present a $\text{pH} \sim 4.8$
 - ✓ Old studies for river (2003), but new studies begin



Labile Al?
(in progress)



Source : Probst et al. (1990)

Fig. 3. Evolution of the sum of concentrations of Al^{3+} , $\text{Al}(\text{OH})_2^{2+}$, $\text{Al}(\text{OH})_3$ and $\text{Al}(\text{OH})_4^-$ as a function of time at Peyreleval and Royère, (--- area beyond which the sum of the concentrations of aluminium forms is toxic according to Kroglund and Finstad [15]).

Laboratoire —————

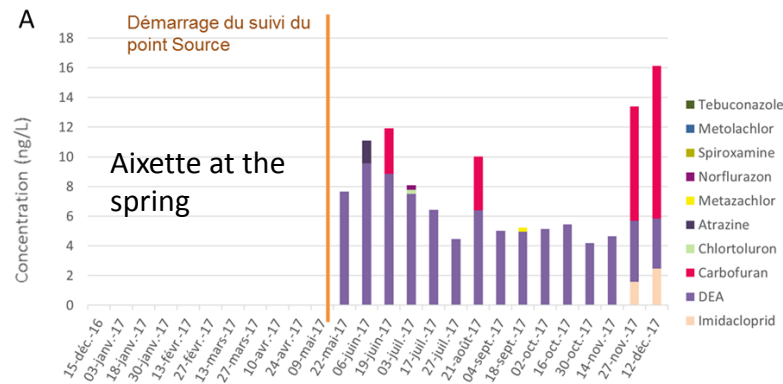
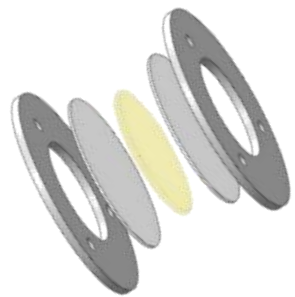
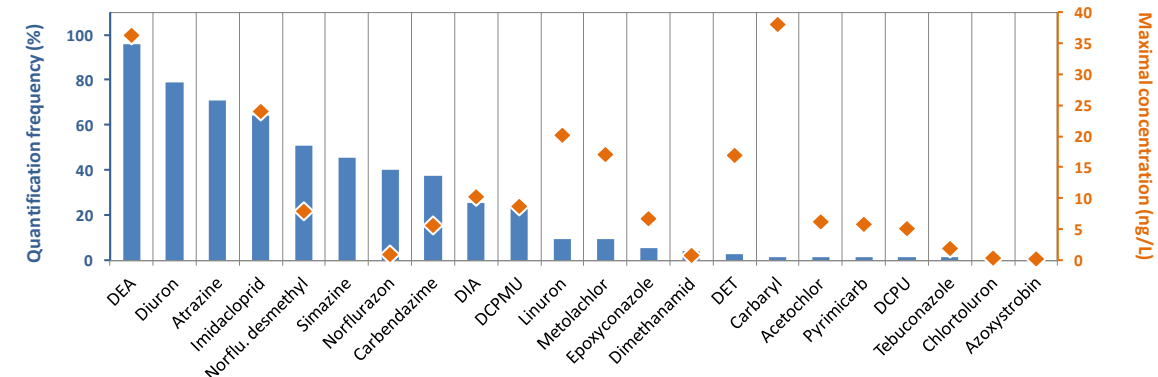
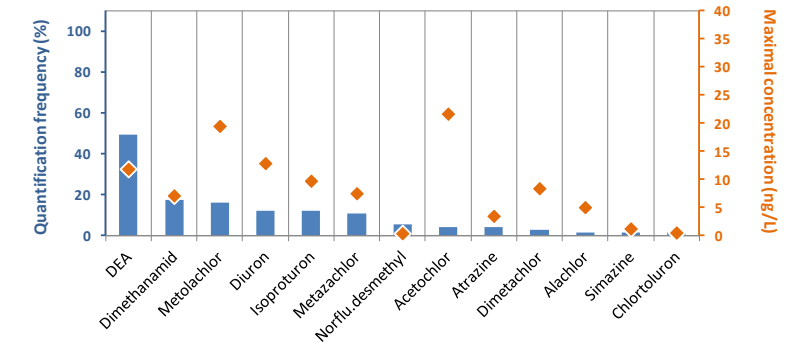
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- A wide-angle photograph of a large, flat, brownish field, likely a dry lake bed or a harvested field. The field is covered in dry, yellowish-brown vegetation and soil. In the background, a dense line of green trees and shrubs stretches across the horizon. The sky is overcast with grey clouds. In the foreground, there is some green, leafy vegetation on the right side.



⇒ Arnac Stream
(Dowstream site)
Auvézère tributary



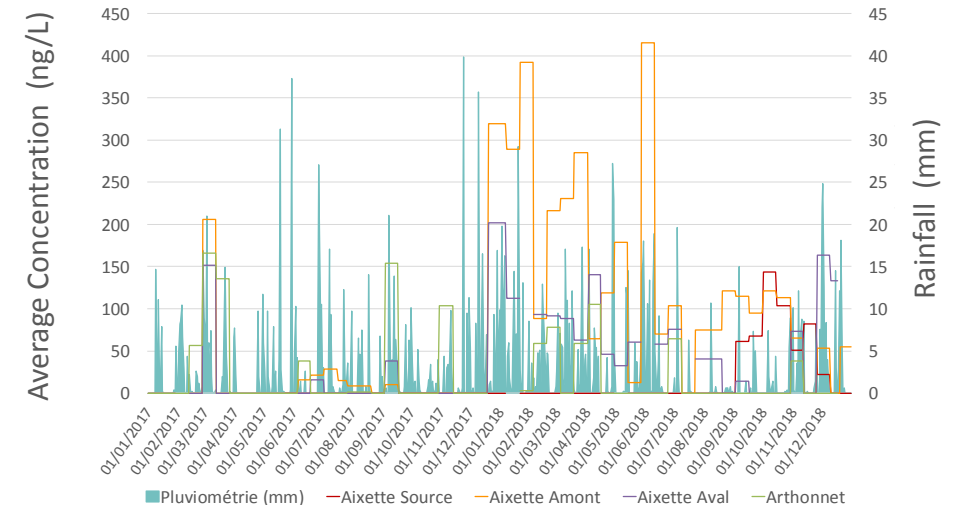
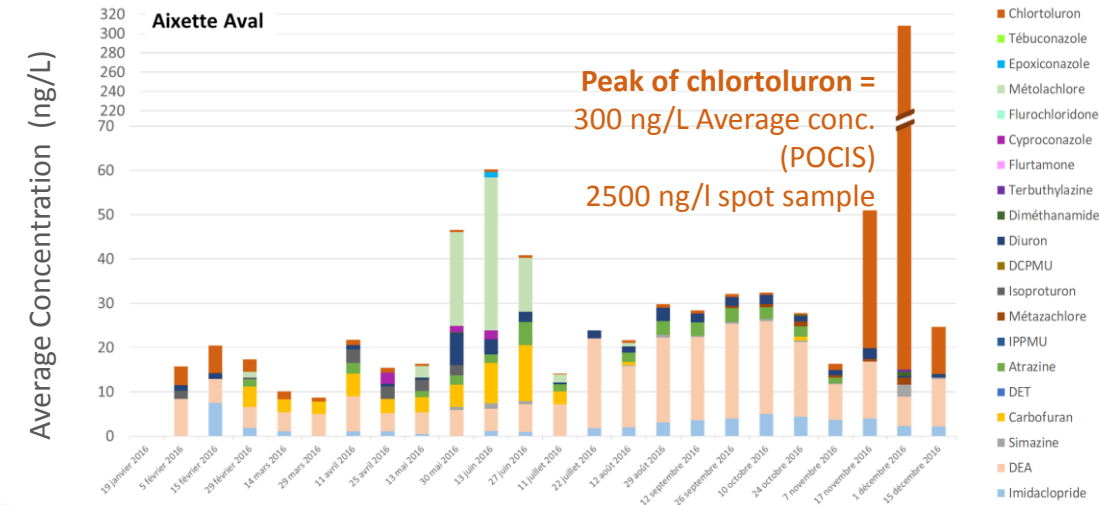
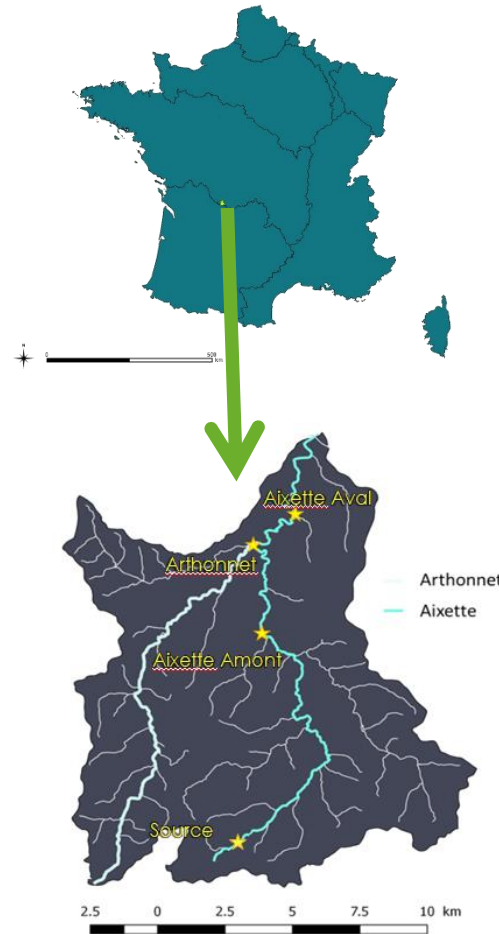
Micropolluants of headwaters from west of french Massif-central: Pesticides and their metabolites

➤ Neutral pesticides

- ✓ Background noise 20-30ng/L with a lot of compounds
- ✓ Peak concentration ($>2\mu\text{g/L}$) once or twice a year, but never the same compounds

➤ Ionic pesticides

- ✓ Monitoring of 16 herbicides and metabolites
- ✓ Metabolites are mainly found
- ✓ Contamination vary along the year, sometimes in link with rainfall



Micropolluants of headwaters from west of french Massif-central: Pharmaceuticals

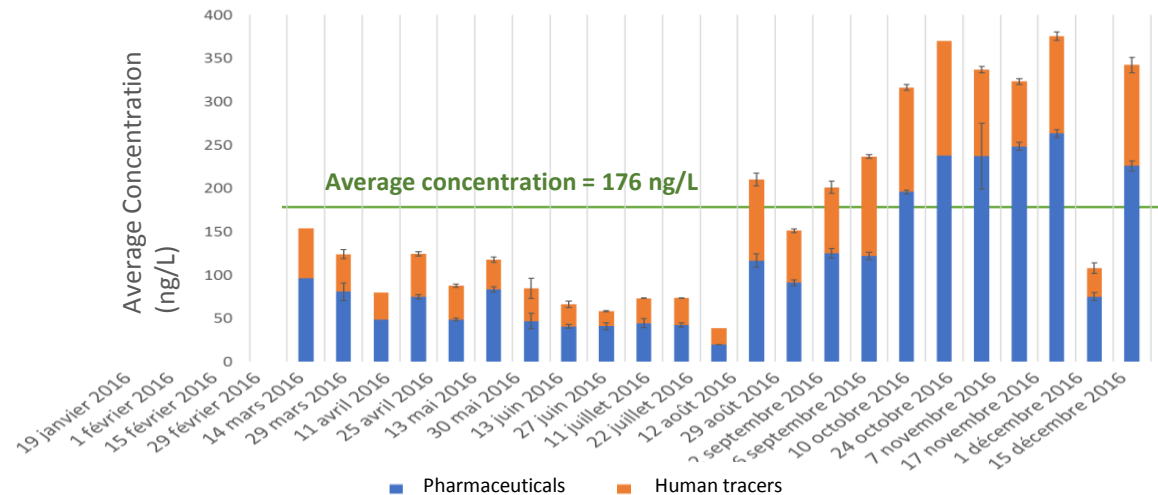
➤ Origins

- ✓ WWTP, none-collective sanitization, agricultural use

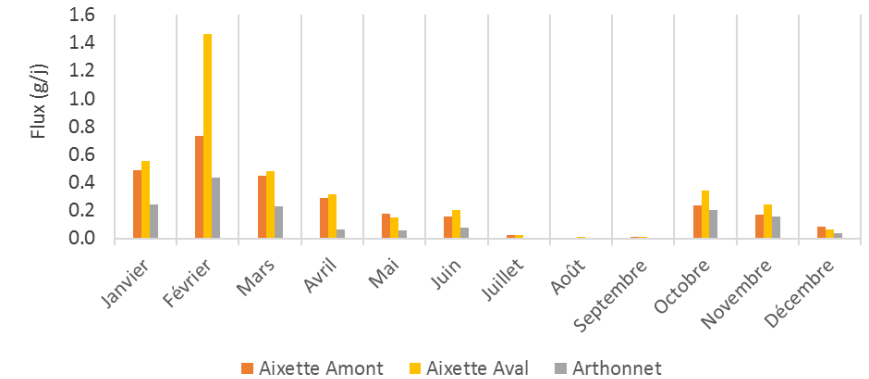
➤ Concentrations & compounds depend on

- ✓ Population age (β -bloquant)
- ✓ Development of disease (antibiotic)
- ✓ Watershed activities (antibiotic for cattle)
- ✓ River dilution ability

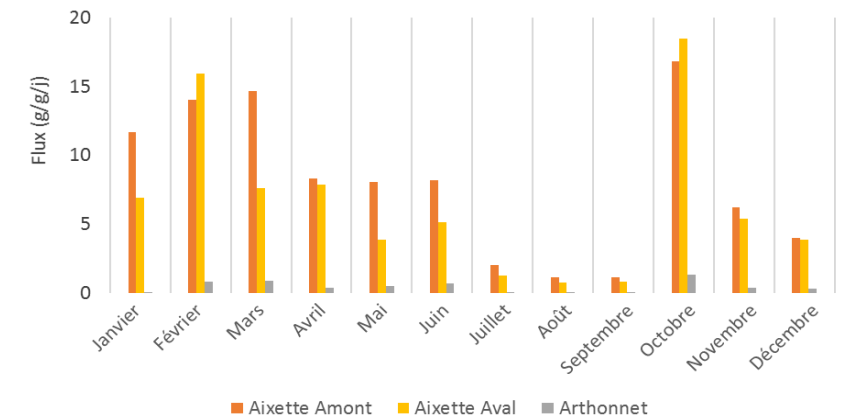
Aixette downstream



Antibiotic for veterinary use
Sulfamérazine et Triméthoprim

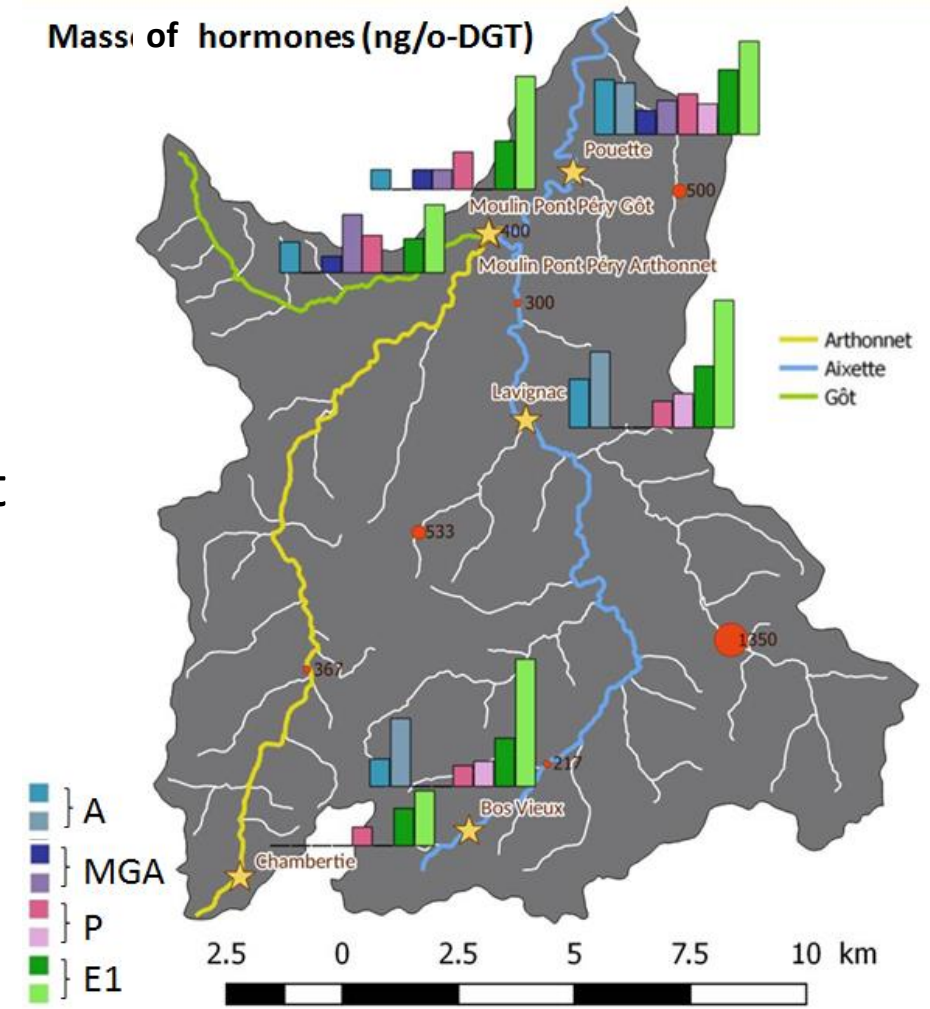
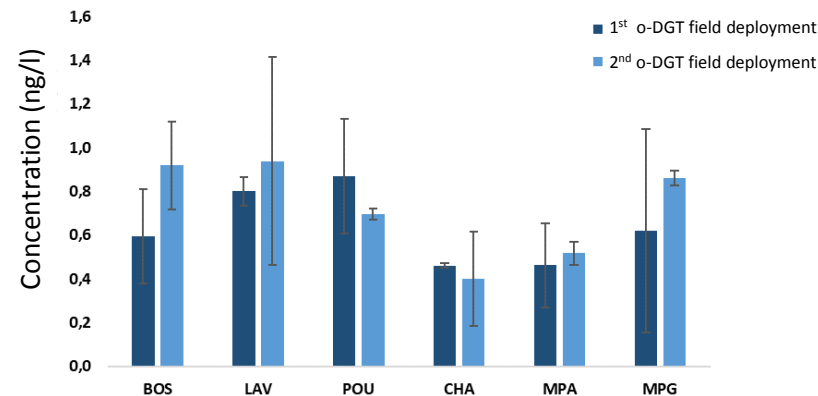
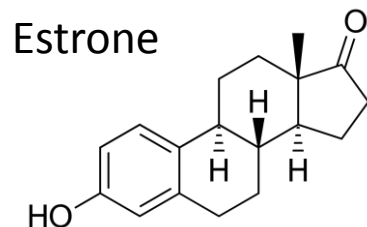


β -bloquants
Atenolol, Bisoprolol, Metoprolol,
Nadolol, Propranolol et Sotalol



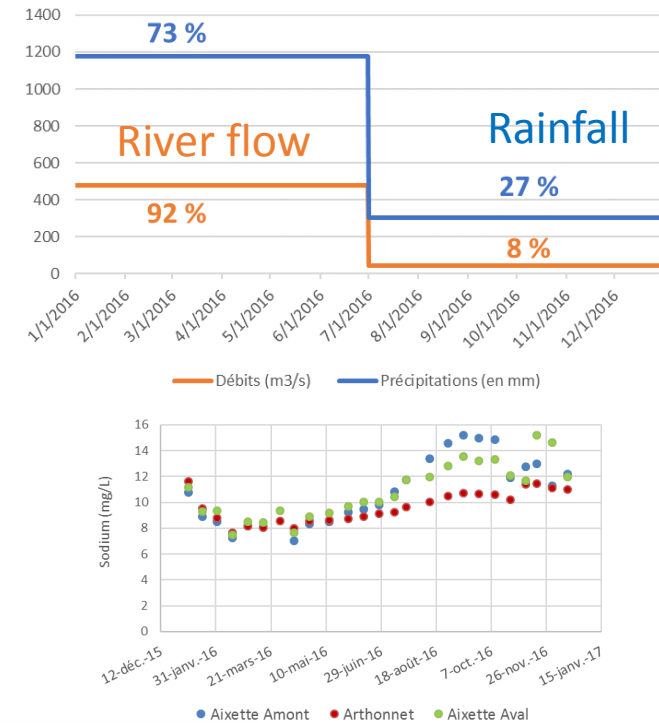
Micropolluants of headwaters from west of french Massif-central: hormones

- Origins of natural and synthetic hormones
 - ✓ WWTP, none-collective sanitization, cattle breeding
- First data on headwaters
 - ✓ 13 hormones monitored with o-DGT
 - ✓ Low content in water at watershed scale: ~ ng/L
 - ✓ Natural hormones (Estrone, progesterone) are present along the watershed
 - ✓ Synthetic hormones are present in the downstream in link with WWTP



To conclude

- The perception of headwaters needs to change : human activities impact water quality, mainly highlighted with organic micropollutants
- Better characterization of water quality is required, specially in the context of climate change
 - ✓ Weak increase of annual average temperature but appearance of short heat-waves ($T^{\circ}\text{C}$ air about 44°C , 2019)
 - ✓ Change of rain distribution over the years
- The first effects of climate change on headwaters are already visible
 - ✓ Decrease of the lower flow rate (-40,-60%)
 - ✓ Increase of duration of low water flow (3-4 Months)
 - ✓ Little tributary starting to dry out
 - ✓ Increase of pollutant concentration due to loss of dilution ability



Future ?

Thanks for your attention!

Works of PEIRENE-Eau are funding by



L'Europe sur le bassin de la Loire, une chance pour tous.



The characterization of headwaters quality was performed with the technical assistance of K Cleries, P Fondanèche, E Ducloux, T Hak, J Leblanc.



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