

Séminaire
LUN 20 NOV 2017

ACE-ICSEN



Comment une mesure environnementale entraîne une nouvelle pollution : l'exemple de l'antimoine dans les bassins versants urbains

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Louise Bordier*



Séminaire ACE-ICSEN
Changements environnementaux et société
WWW.ICSEN.OVSQ.FR



Objectif : *Réduire la pollution automobile*

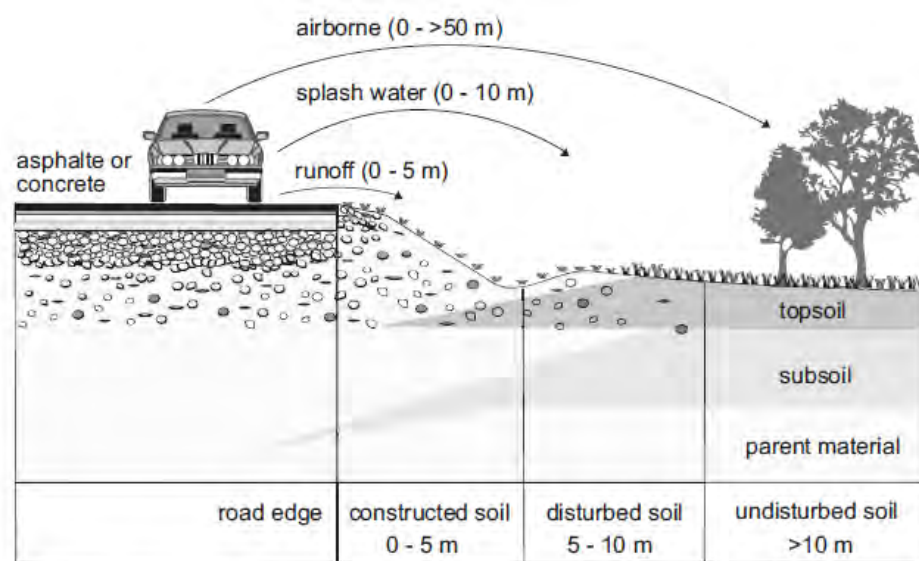
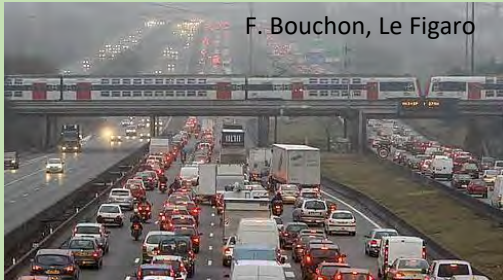


Fig. 1. Schematic sketch of a roadside environment and pathways for pollutant dispersion.

Werkenthin et al., 2014

Mesures et conséquences

Conséquence : *Contamination globale*

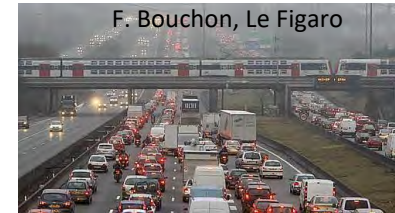


Observée dans les
glaces polaires

Réduire les émissions gazeuses des moteurs mise en place des **pots catalytiques**

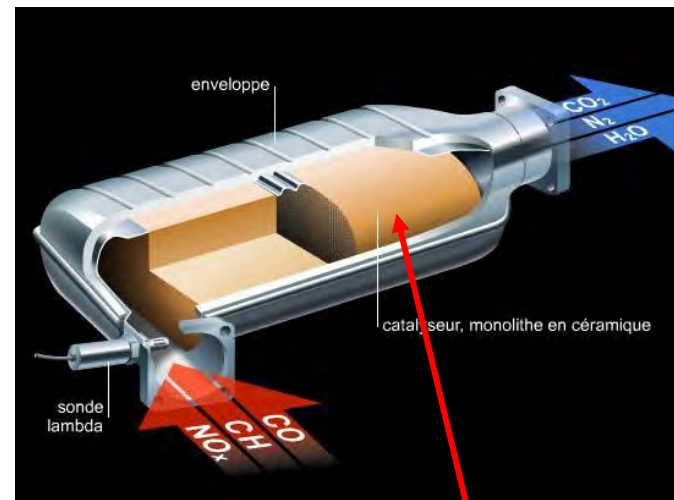
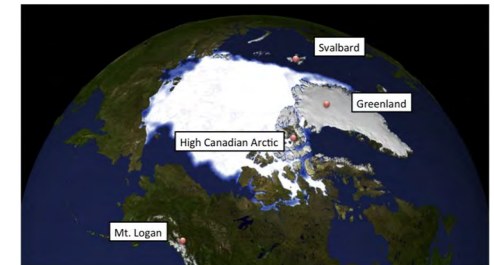
Objectif :

Réduire la pollution automobile

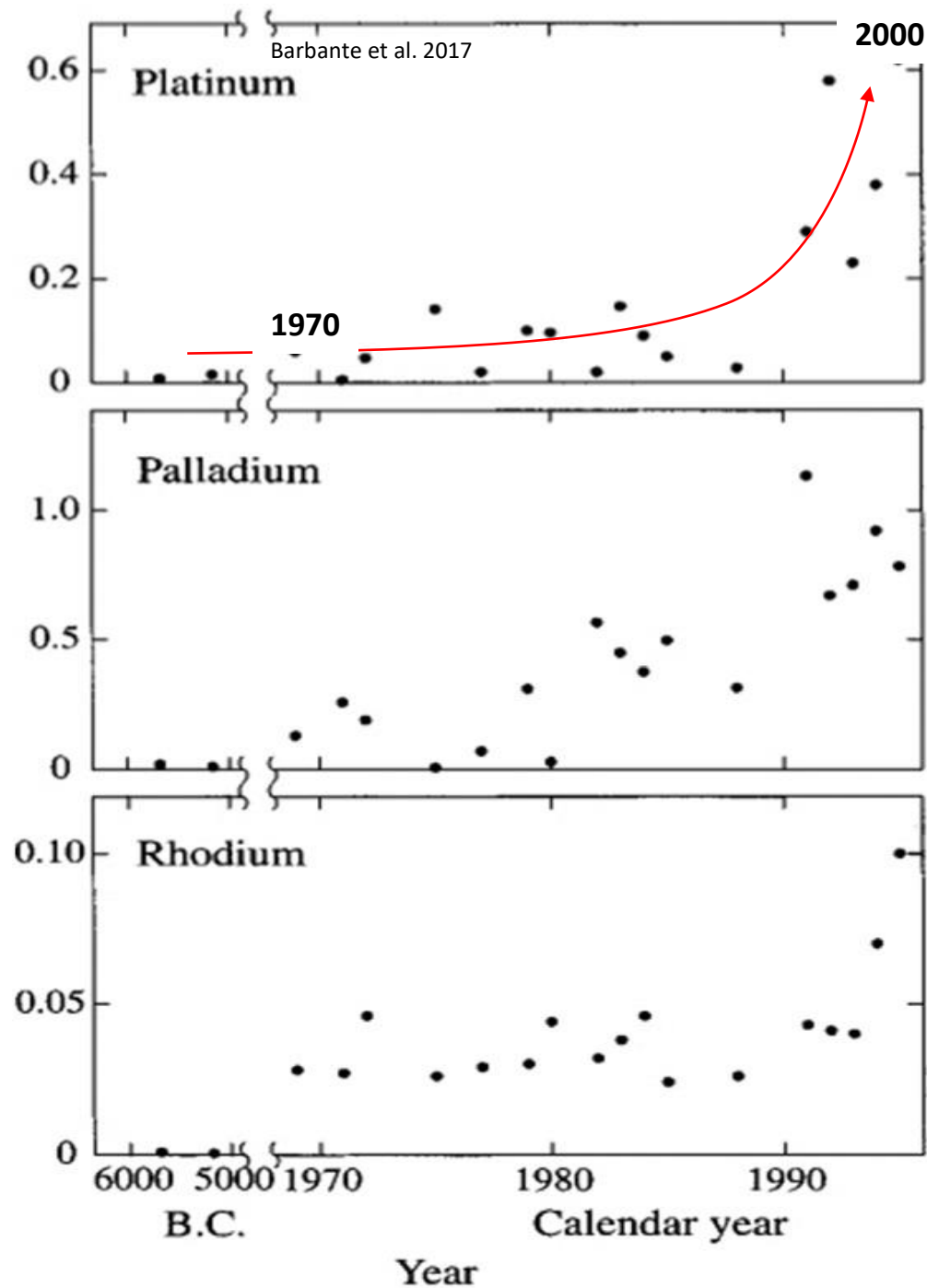


Conséquence :

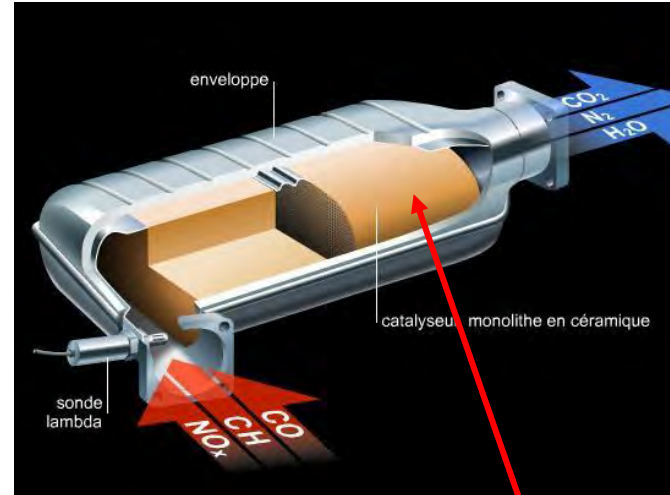
Contamination globale



Catalyseur : contient des
éléments de la mine du **platine**

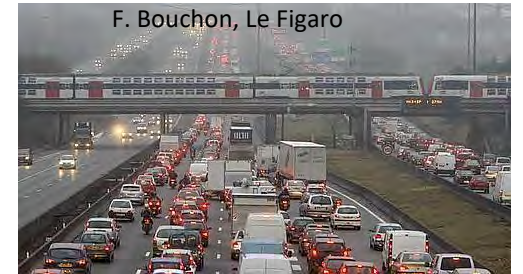


Réduire les émissions gazeuses des moteurs mise en place des pots catalytiques

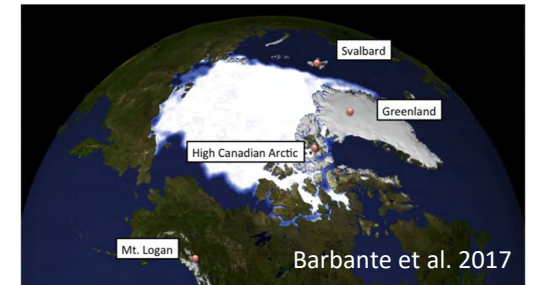


Teneurs en éléments de la mine du **platine** dans les glaces arctiques

Objectif :
Réduire la pollution automobile

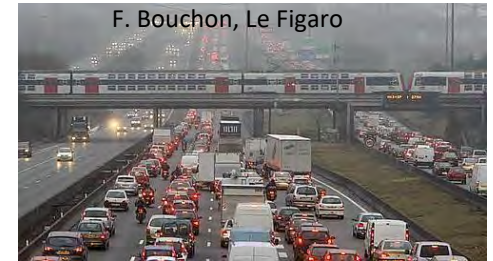


Conséquence :
Contamination globale

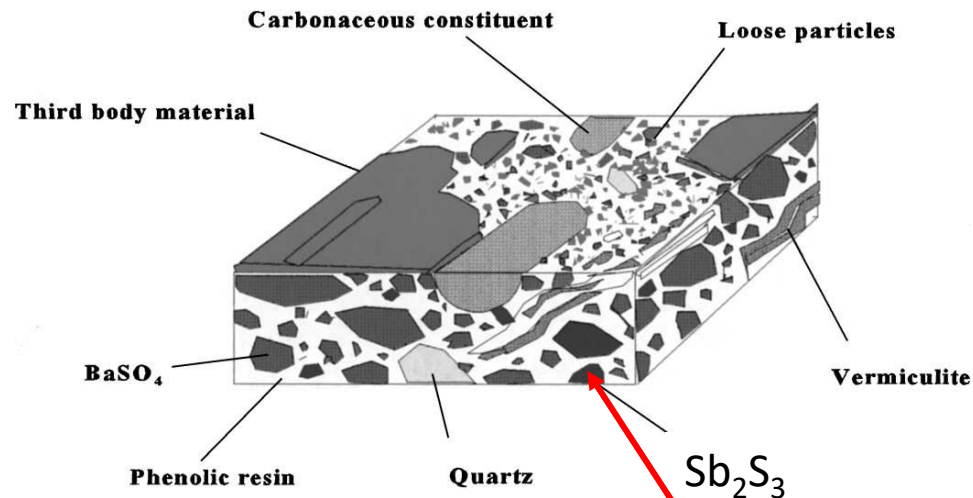
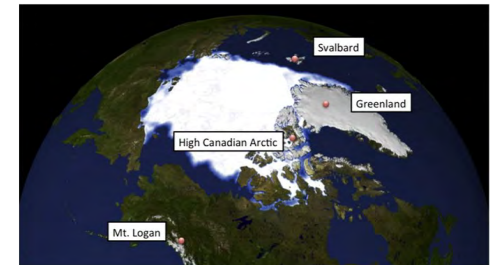


Remplacer l'amiante dans les **freins** de véhicules à moteur

Objectif :
Réduire la pollution automobile



Conséquence :
Contamination globale

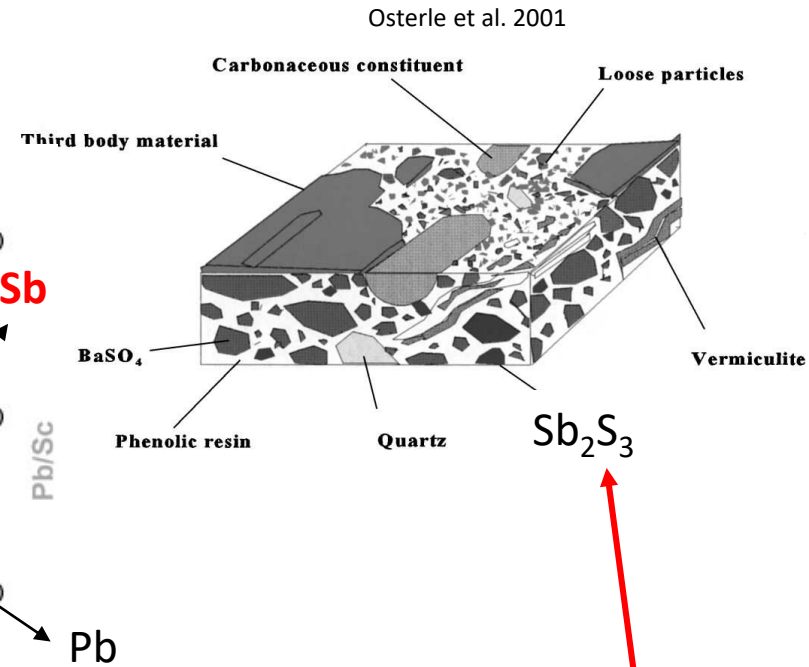
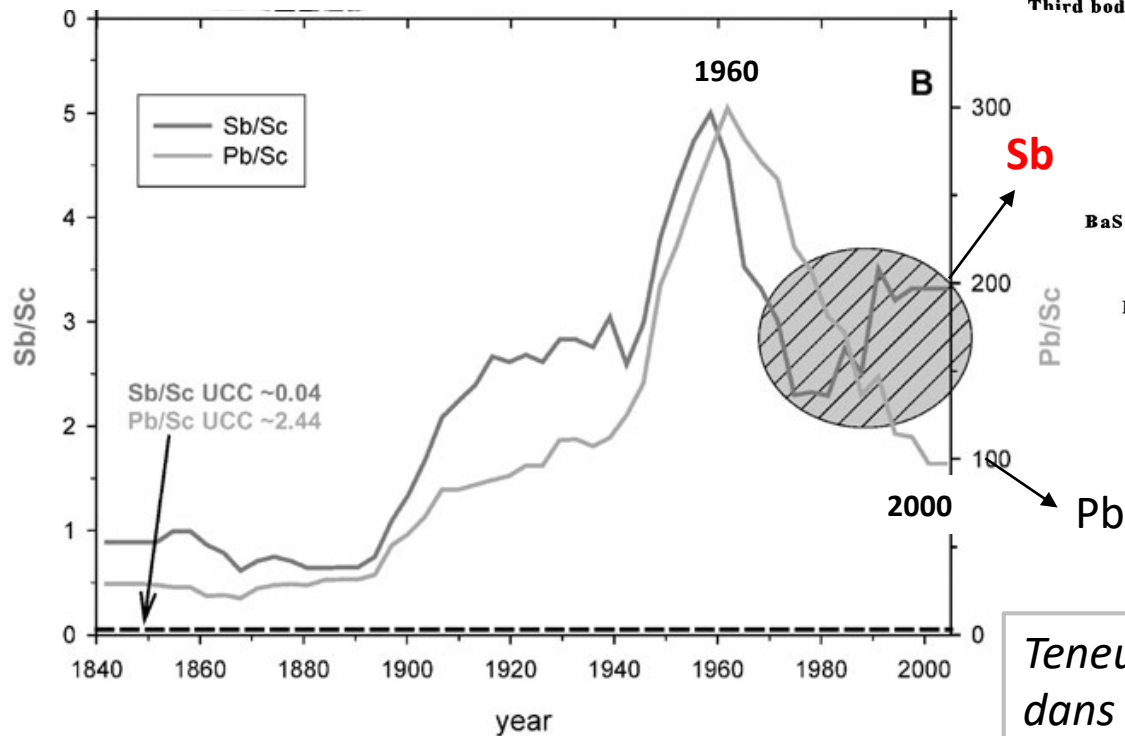


Patin de frein : contient un composé de l'antimoine (Sb)

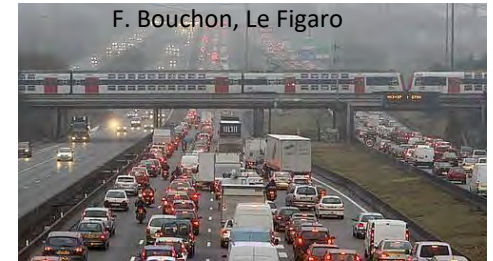
Remplacer l'amiante dans les freins de véhicules à moteur

Objectif :
Réduire la pollution automobile

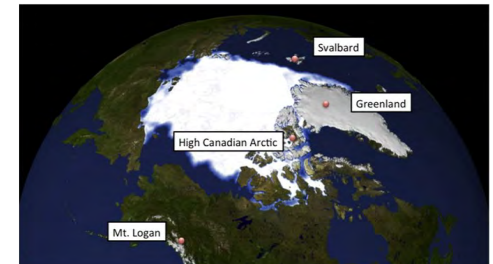
Krachler et al. 2005



*Teneurs en plomb (Pb) et en antimoine (Sb)
dans les glaces arctiques*



Conséquence :
Contamination globale





WP2.3 Impacts des activités humaines sur la pollution des rivières urbaines



Sophie AYRAULT, Cécile QUANTIN,
Claire FROGER (doctorante),
Marion Le Gall (post-doctorante),
Louise BORDIER, Gaël MONVOISIN
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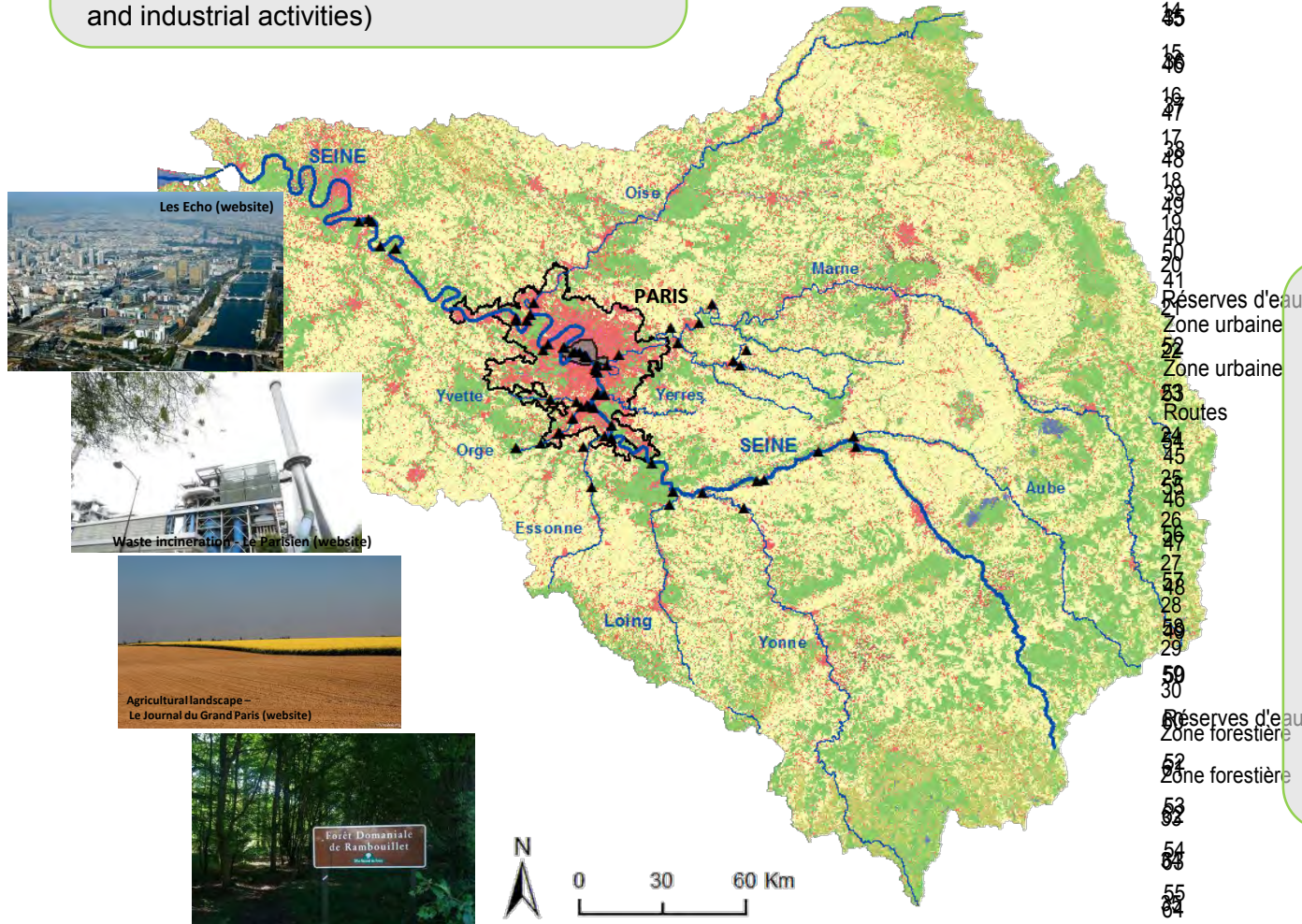
The Seine River catchment, France

- 67 400 km²
- Homogeneous relief, geology and climate
- 12% of the French surface area
- 23% of the French population
- Variable anthropogenic pressures (agricultural and industrial activities)

Legend

- Paris
- Paris metropolitan area
- # Sampling site

- Zone forestière
- Zone urbaine
- Zone forestière
- Zone urbaine



Sampling (1999-2016)

Seine River + tributaries

Suspended sediment

Sediment

Sediment core

Dissolved samples

$n_{\text{samples}} \approx 500$



Measurements

Elemental concentrations

(ICP-MS, INAA)

Lead isotopes ($^{206}\text{Pb}/^{207}\text{Pb}$)

- Atmospheric particles sampled in the Seine River basin (Paris megacity, France), indicated that Sb is (one of) the most enriched element. EF ~10000 in TSP and PM10.

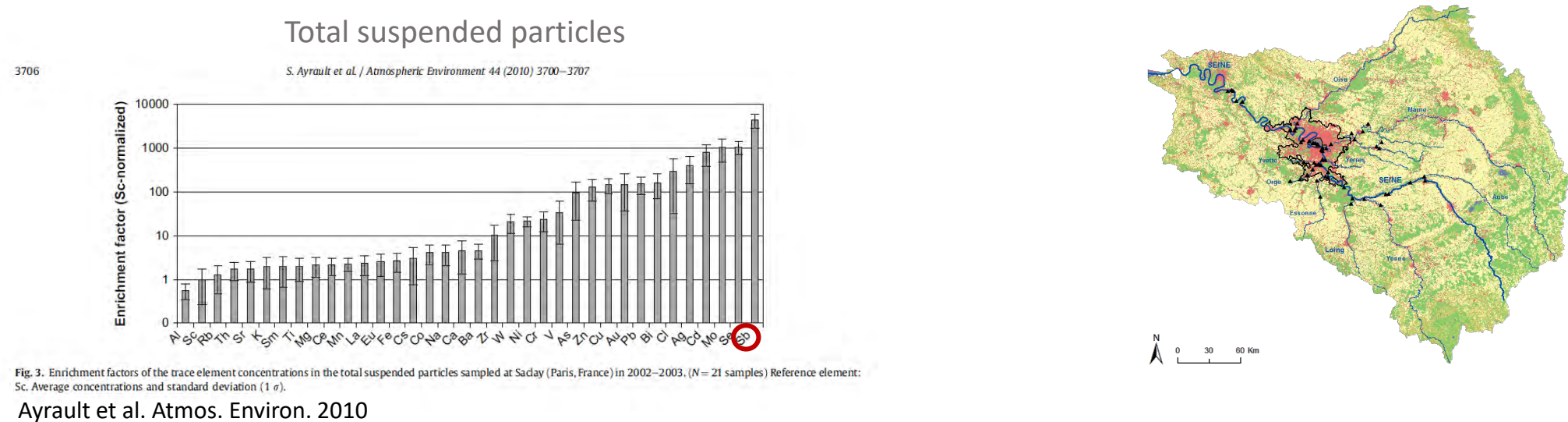
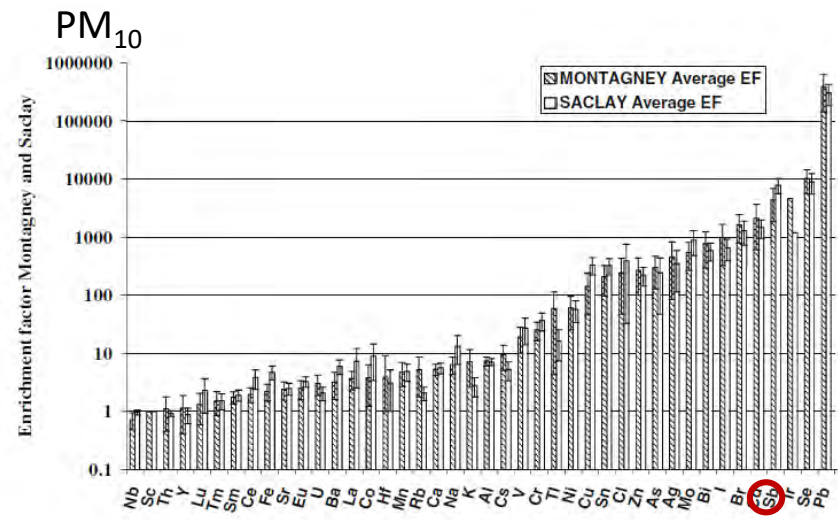


Fig. 1 Average enrichment factors relative to Sc and the upper continental crust (Taylor and McLennan 1985; Wedepohl 1995) at Montagney and Saclay



Comment l'environnement réagit à cette nouvelle pression anthropique ?

1

Quand apparaît-elle ?

2

Où apparaît-elle ?

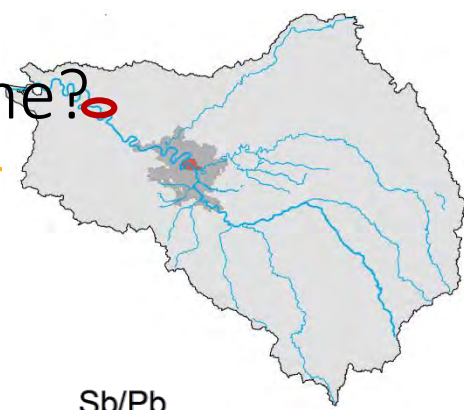
3

Quel est le comportement de ce nouvel antimoine ?

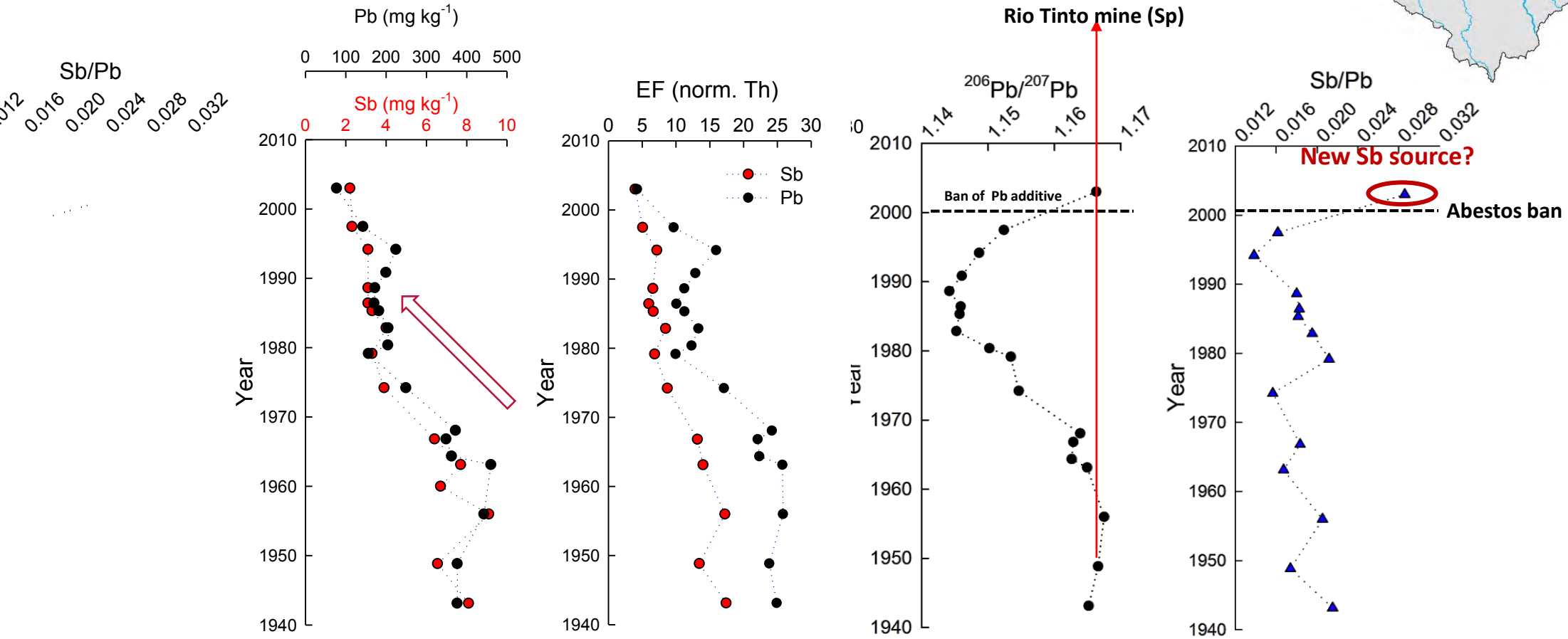
4

Peut-on prouver la relation entre contamination et urbanisation ?

What about Sb concentration in river sediment over time?

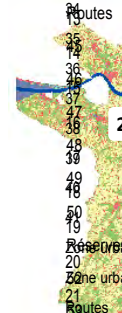


- Temporal information
- → Sediment core in the downstream Seine River section



Spatial information – Sb concentrations in river sediment

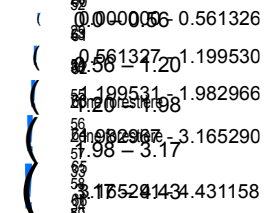
- Mean Sb concentrations for each location
→ Sediment samples, trap (1month)



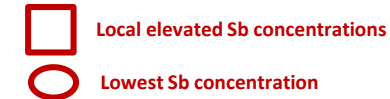
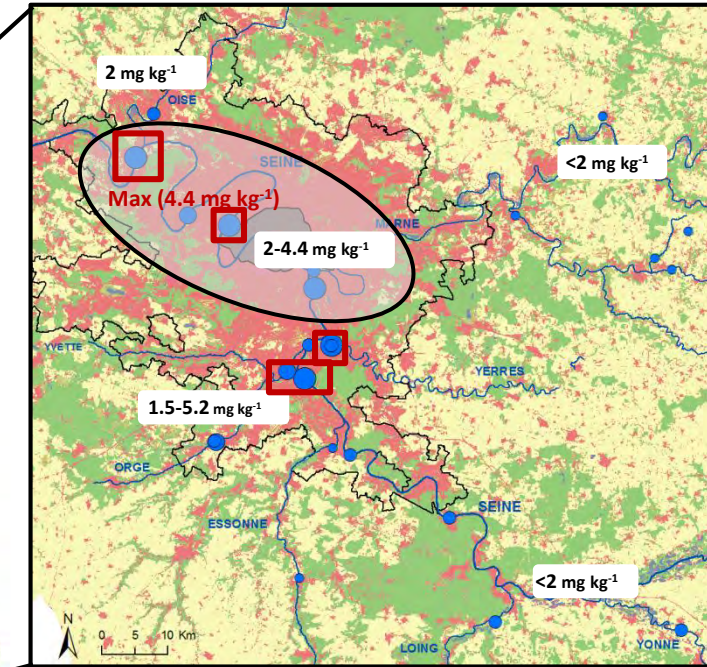
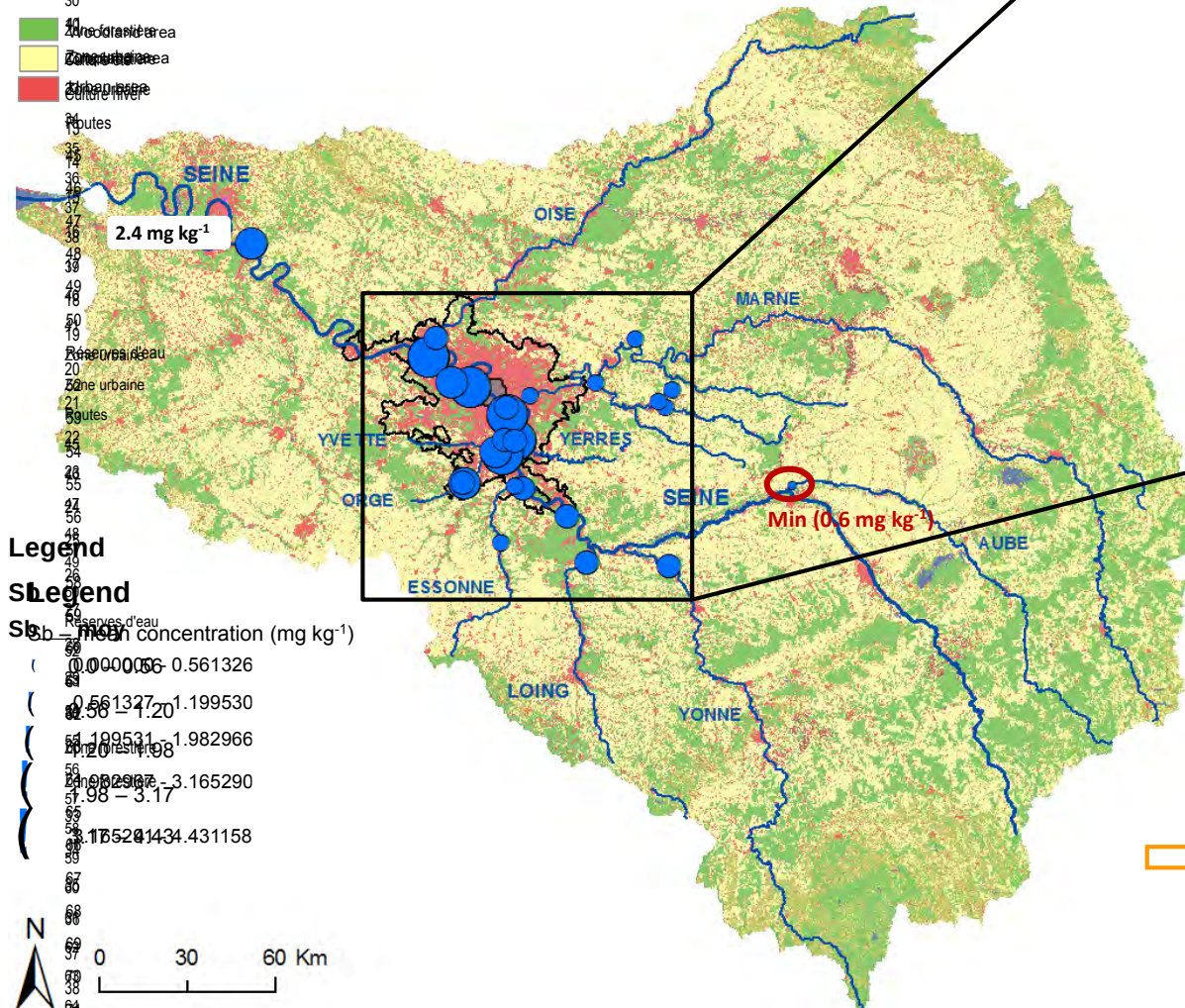
Legend

Sb legend

Sb – mean concentration (mg kg⁻¹)



0 30 60 Km



Hotspot of Sb contamination

- In the vicinity of Paris city
- Some highly urbanized tributaries

Samples from Laure Tessier, PhD

Spatial information – Sb enrichment factors in river sediment

- Mean EF(\$b/Th\$) for each location

FE < 2: no or minimal enrichment/pollution

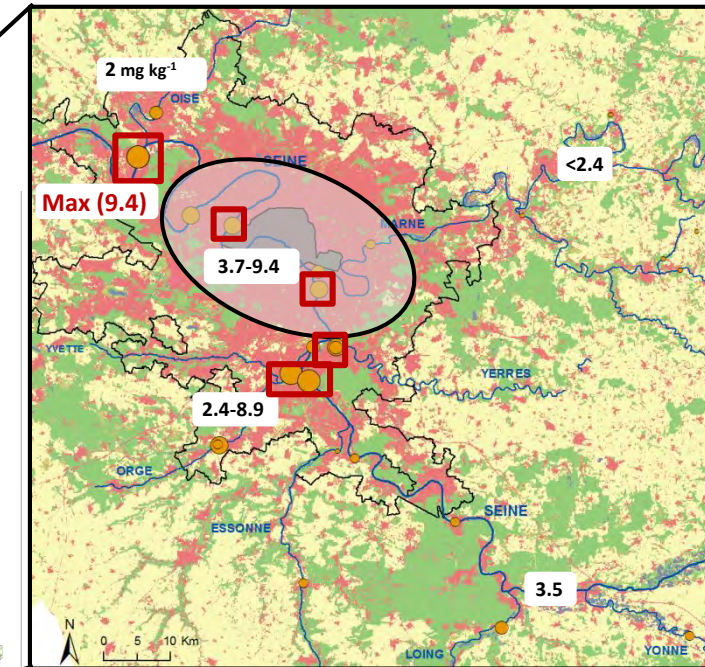
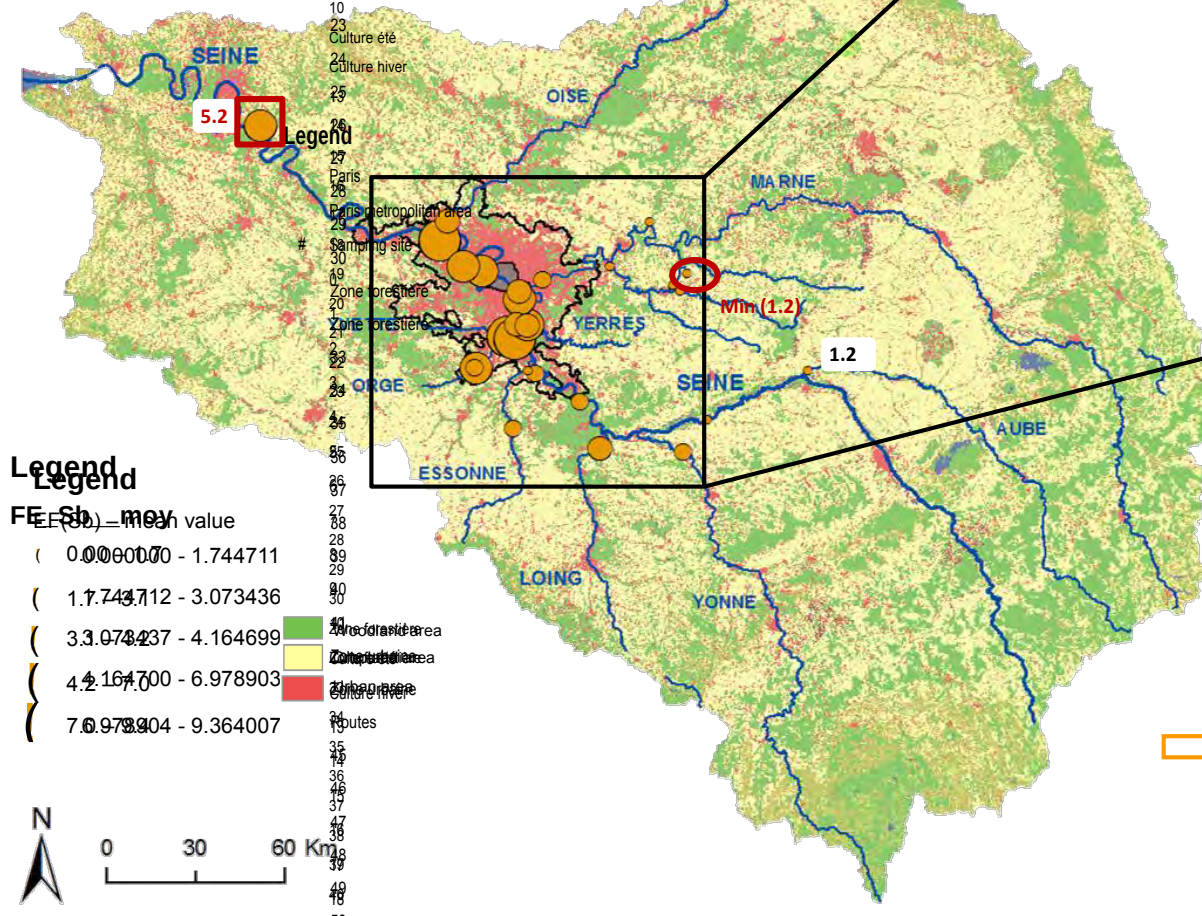
2 < FE < 5: moderate enrichment/pollution

5 < FE < 20: significant enrichment/pollution⁴⁸

20 < FE < 40: very high enrichment/pollution

FE > 40: extreme enrichment/pollution

Sutherland (2000), Szuszkiewicz et al. (2016)



Local elevated EF(Sb)

 Lowest EF(Sb)

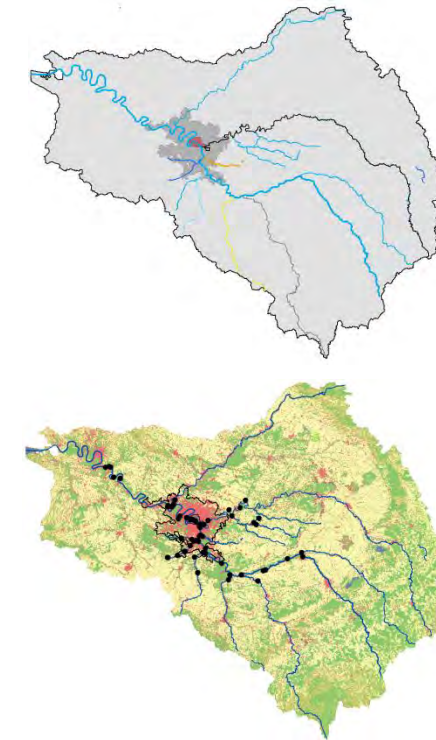
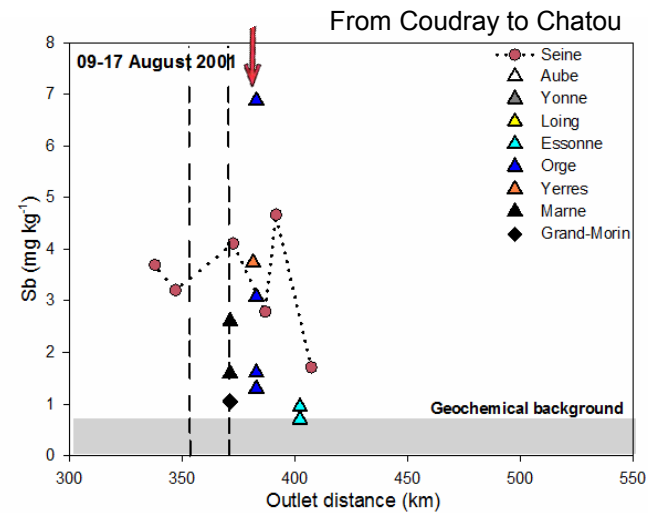
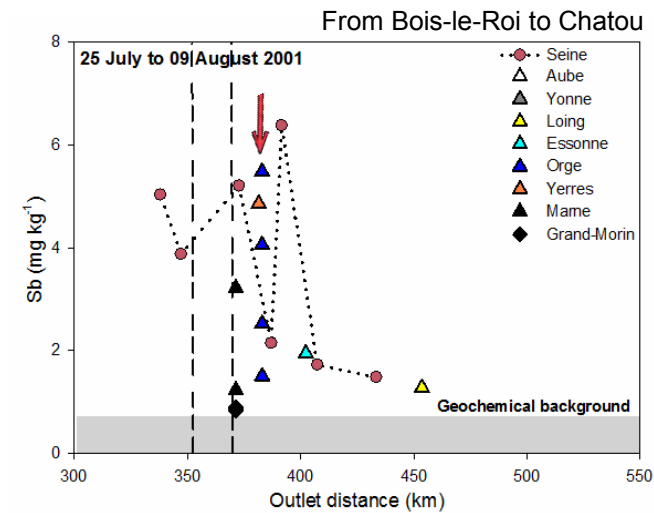
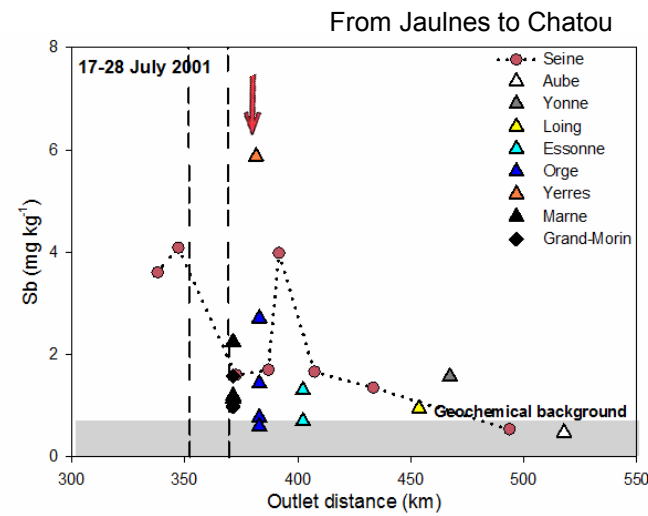
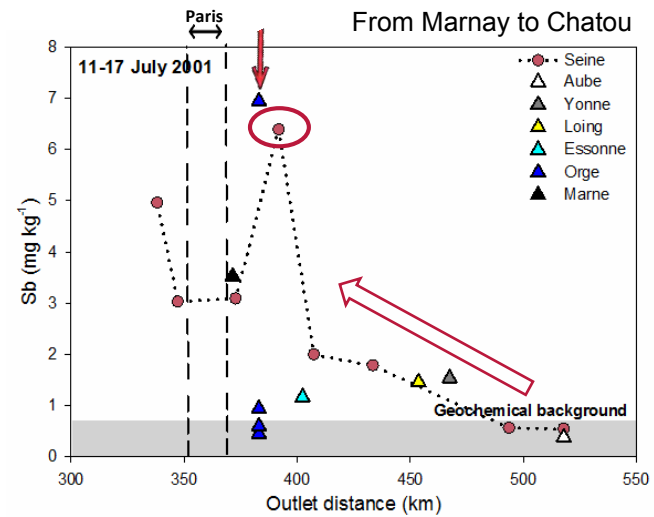
Sb geochemical background : 0.8 mg kg⁻¹

Hotspot of Sb contamination

- In the vicinity of Paris city
- Some highly urbanized tributaries

Data from Laure Tessier, PhD

Spatial information – Sb concentrations along the river network



Sb contamination

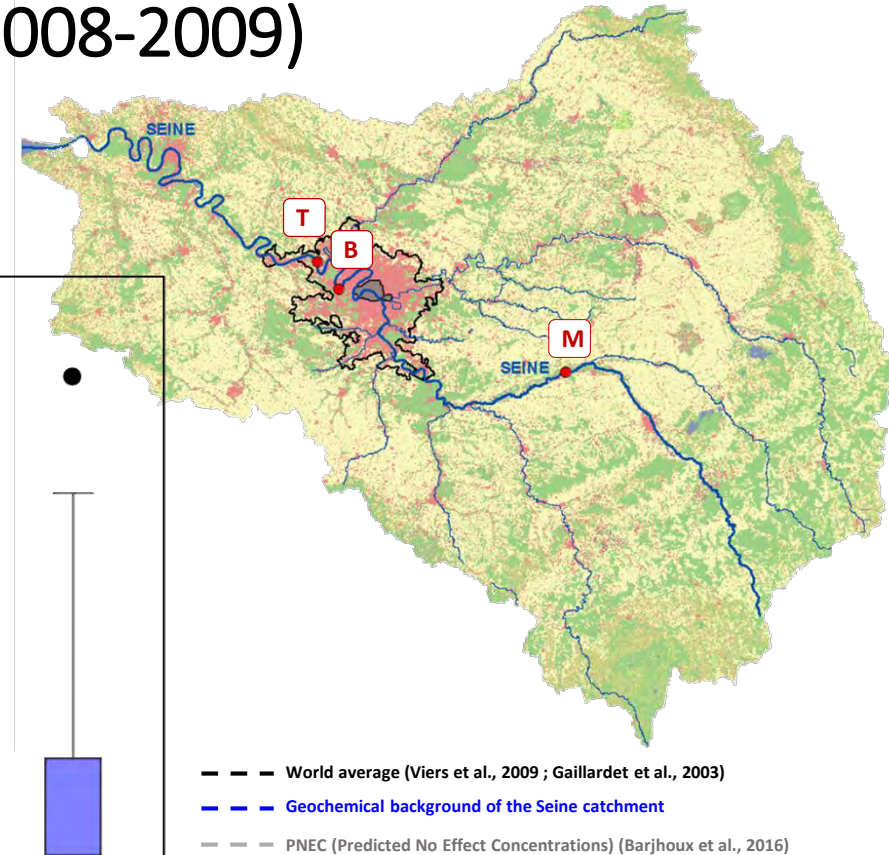
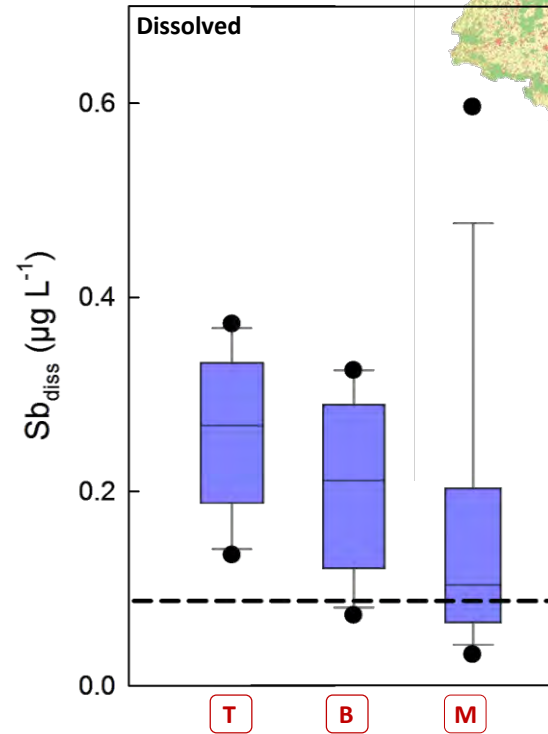
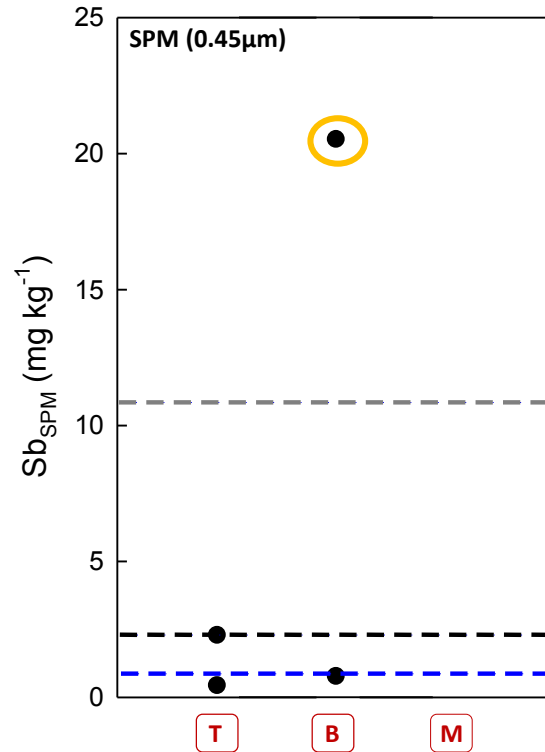
- In the vicinity of Paris city
- The urbanized Yverres and Orge tributaries

Downstream ← Upstream

Downstream ← Upstream

Sb partitioning along the Seine River (2008-2009)

- ● ➔ Sediment, SPM and dissolved samples sampled monthly during one year (2008-2009)



Some **high Sb_{SPM} concentrations** to Bougival (downstream of Paris)

➔ **Urban runoff** as a potential source of Sb to the Seine River in urbanized areas

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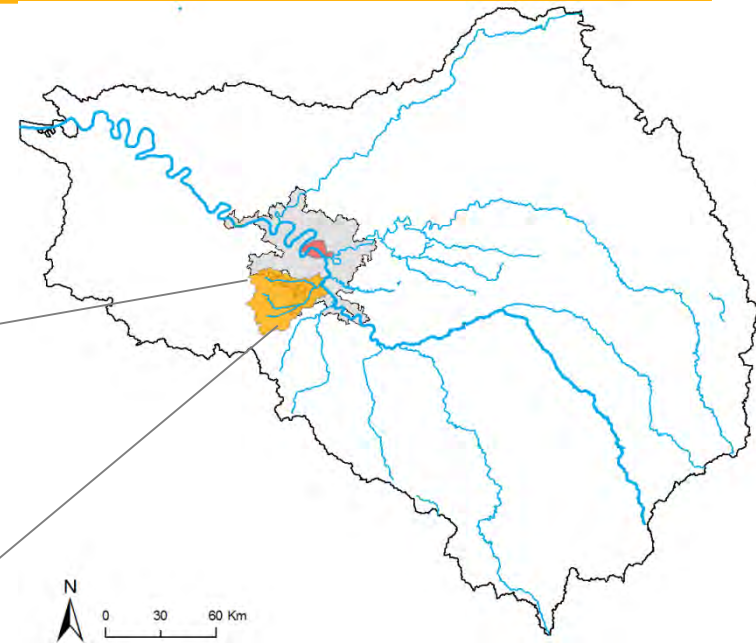
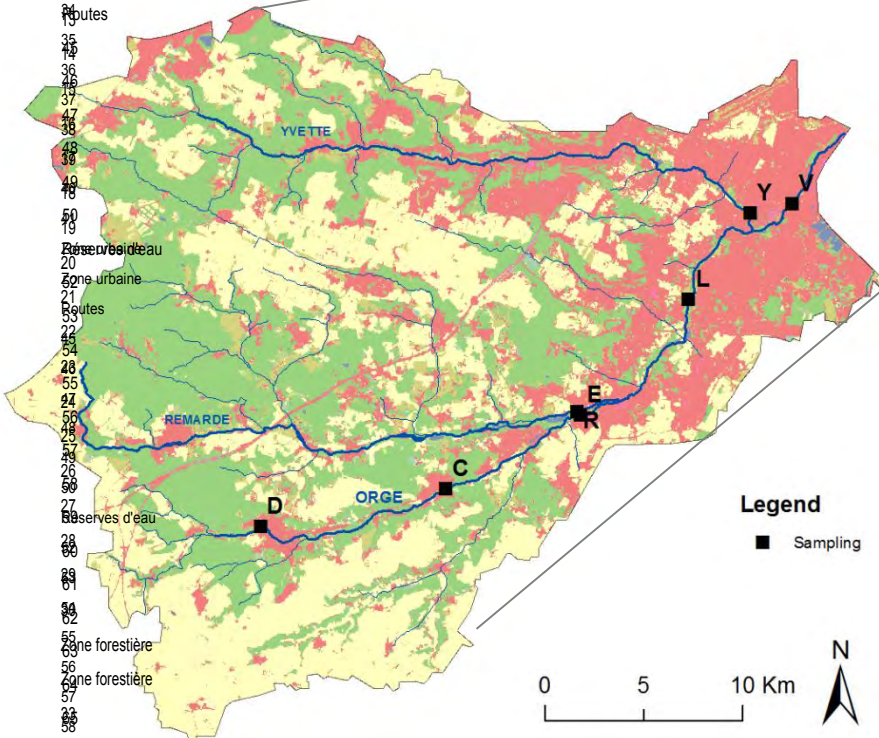
4

Peut-on prouver la relation entre contamination et urbanisation ?

Sb in the Seine River - focus on the Orge subcatchment

- 1300 km²
- 30 km to the south of Paris
- Variable anthropogenic pressures (forest, agricultural and industrial activities)
- Upstream to downstream gradient of urbanization

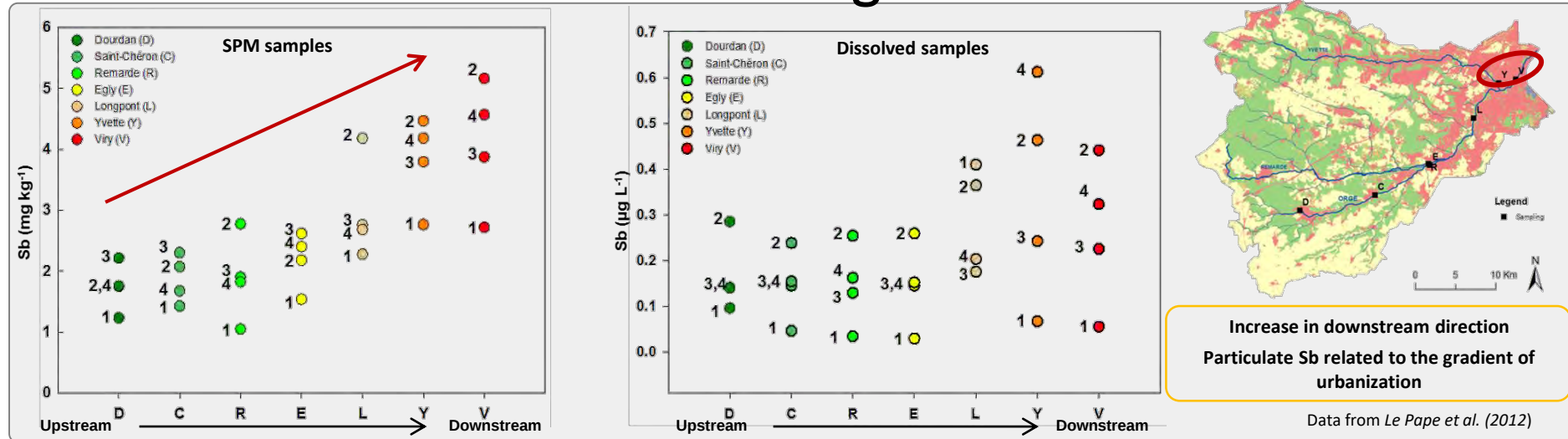
- Zone forestière
- Zone agricole
- Zone urbaine
- Entier river



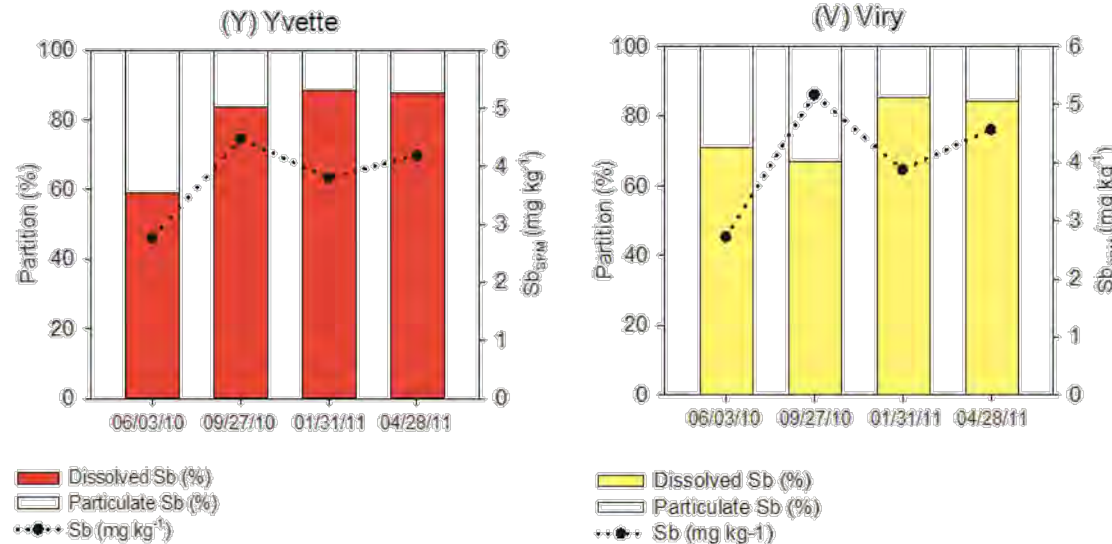
Sampling (2010-2011)

7 monitoring stations
Suspended sediment
Dissolved samples

Sb in the Seine River - focus on the Orge subcatchment



Focus on the downstream urbanized Orge catchment



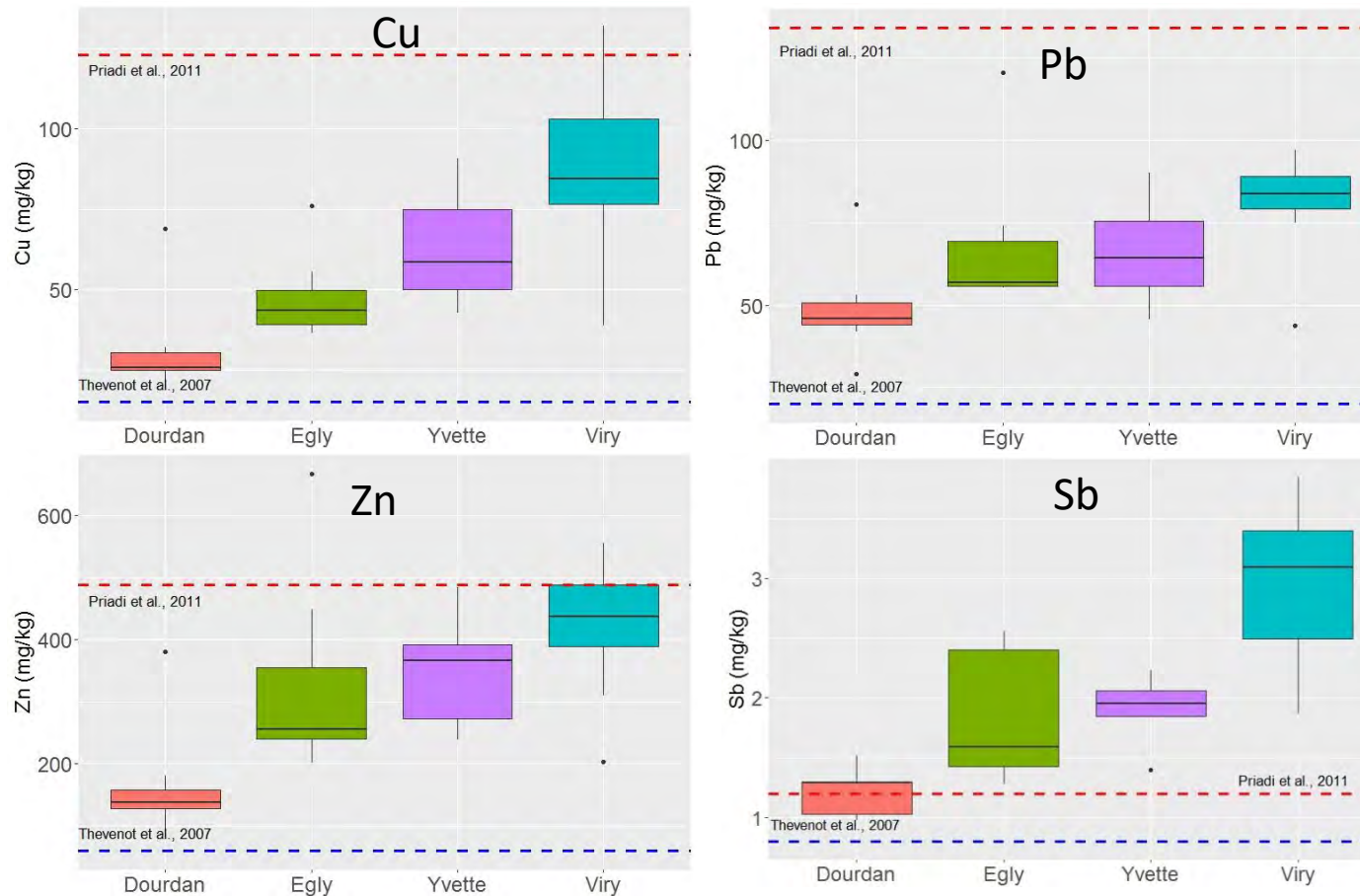
- Particulate Sb contribution higher than along the Seine River (12-41%)
- Urban runoff as a source of particulate Sb
- Urban Sb is less soluble than « natural » Sb

Few laboratory studies exist on antimony interactions with solid phases. However, published data on antimony partition between solid and dissolved phases in **natural waters** clearly indicate that antimony is present nearly exclusively in the dissolved phase.

Fillela et al., *Earth Sc Rev.*, (59)2002, 265-285

Contamination of the river due to road dust sediments

→ Urban influence on particle contamination in Zn, Sb, Cu, Pb, Ag



➤ Urban discharge of contaminants downstream

----- SEINE juste après Paris

----- Bruit de fond géochimique

Data from Claire FROGER, PhD

→ Ni, As, Cr from geochemical background : no increase

Résultats déjà produits par le WP-2.3

Conséquences environnementales de l'introduction de l'antimoine lors de l'interdiction de l'amiante dans les freins de véhicules à moteur, 2000 en France :

- **La preuve de la contamination urbaine par l'antimoine**
Dans la région Ile-de-France

- **L'origine routière de cette contamination**
Grâce à l'étude dans le « labo de terrain » : bassin de l'Orge



Bassin de rétention des eaux de ruissellement d'une autoroute

Avec WP-TR : Prise de conscience & acceptabilité sociale

- Qu'est-ce qui fait « contamination » ? élaboration d'un questionnaire « grand public » en cours
- Comment y remédier, des pistes ? identification du public « acteurs » à interroger lors d'interviews (questionnaire guidé puis discussion libre) :
 - Association d'usagers, usagers à proximité de la rivière
 - Gestionnaire de bassin (Syndicat de l'Orge), responsable *prospectives/études/milieu* et agents de rivière
 - Collectivités territoriales

- C. Froger, S. Ayrault, C. Quantin, L. Bordier, G. Monvoisin, Spatial and temporal dynamic of the contamination in an urban catchment: Combining metal isotope geochemistry and radionuclide chronometers. International Conference on the Biogeochemistry of Trace Elements ICOBTE. ETH Zurich, Switzerland, July 16-20, 2017. Oral presentation
- S. Ayrault, M. Le Gall, C. Froger, C. Quantin. Insights in the Antimony pathways and behavior in urban environment. International Conference on the Biogeochemistry of Trace Elements ICOBTE. ETH Zurich, Switzerland, July 16-20, 2017. Oral presentation
- C. Froger, S. Ayrault, C. Quantin, L. Bordier, G. Monvoisin, Spatial and temporal dynamic of the contamination in an urban catchment: Combining metal isotope geochemistry and radionuclide chronometers. Goldschmidt, Paris, 14-18 August 2017. Oral presentation
- Claire Froger, Sophie Ayrault, Cécile Quantin, Olivier Evrard, Gaël Monvoisin, Louise Bordier, Irène Levèfre. Tracing road runoff contribution to river particulate contamination by coupling geochemistry and radionuclides chronometers. En preparation (Science of the Total Environment)



Confluent de l'Orge et du Mort Ru à Villiers-sur-Orge.



Bassin de rétention des eaux de ruissellement d'une autoroute

Merci

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