Eaux de chaussées
Polluants provenant de l‘usure des pneus

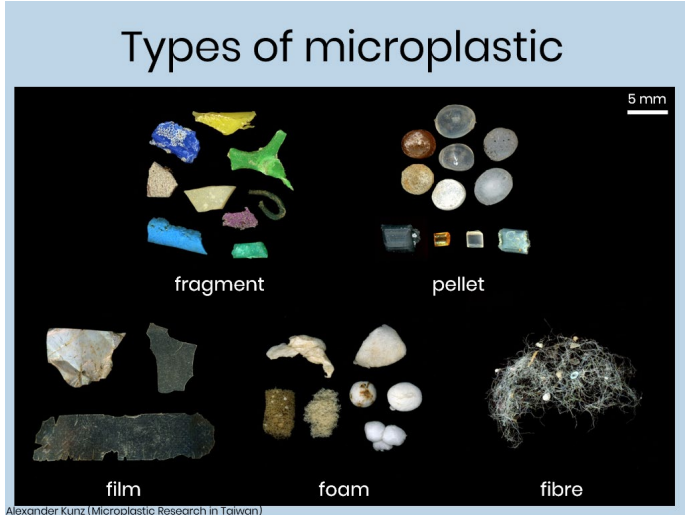
Lausanne, 30.4.24, Benoit Ferrari (Ecotox) & Florian Breider (EPFL)

oekotoxzentrum
centre ecotox

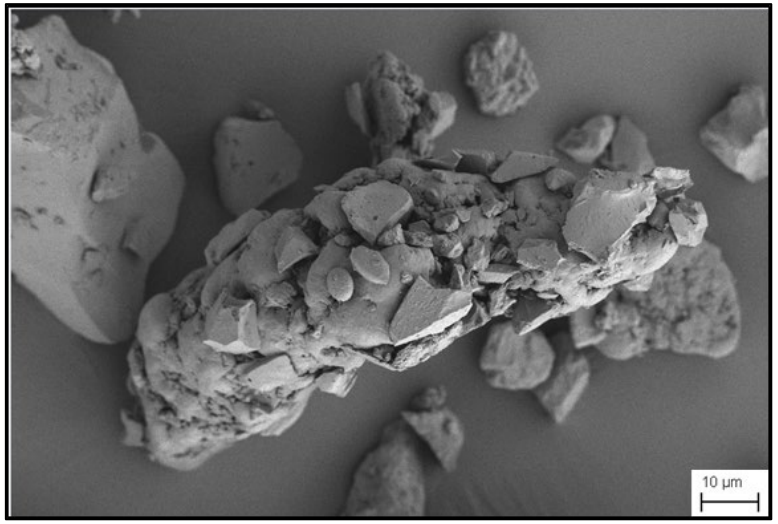
EPFL

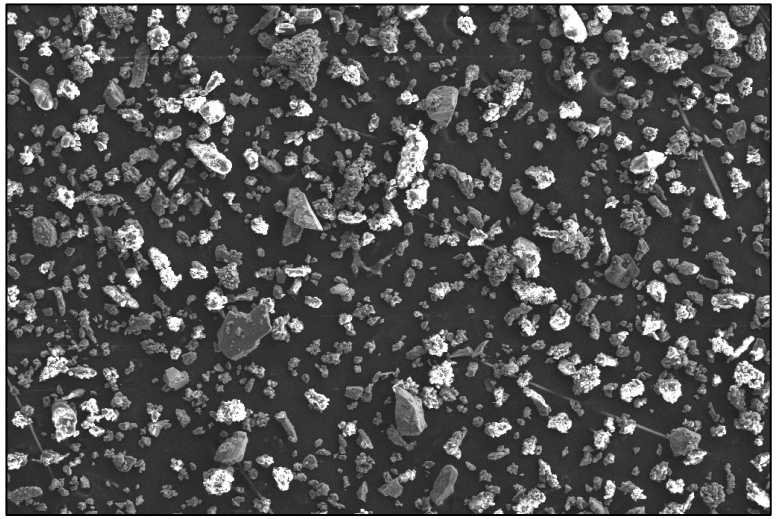
vsa.ch/kontakt

Particules d’usure des pneus et de la route



Les particules d’usure des pneus et de la route sont un catégorie particulière de microplastiques

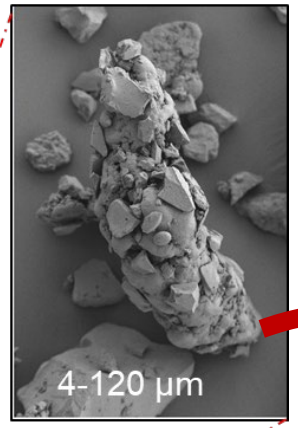


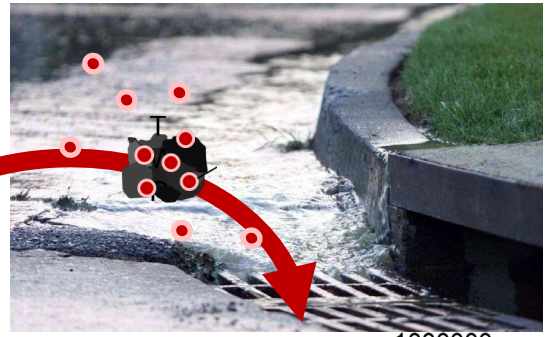


24 – 93 %

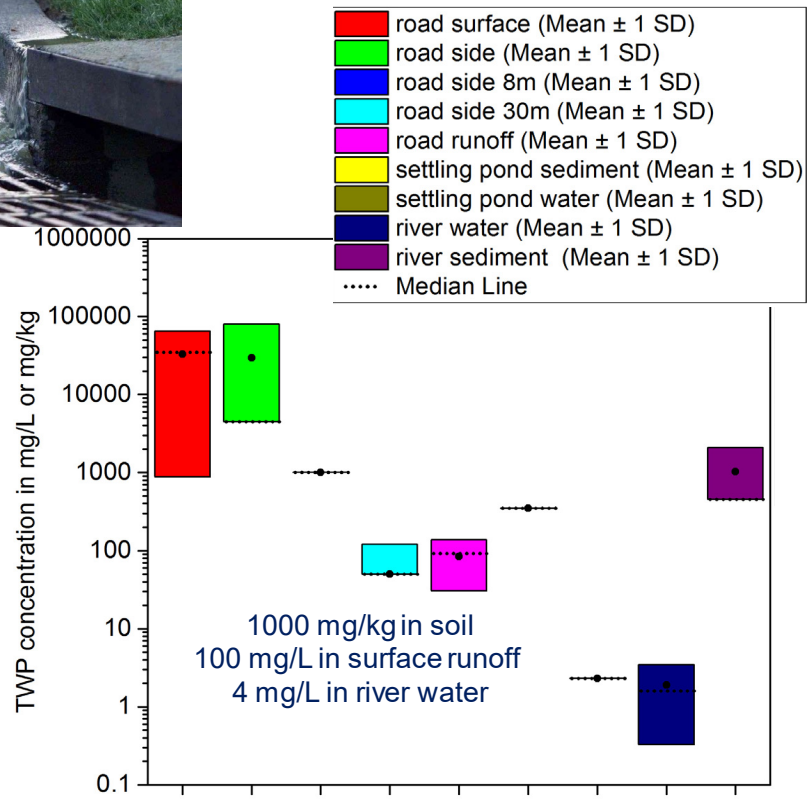
Polluants provenant de l‘usure des pneus

Particules d’usure des pneus et de la route (TRWP)



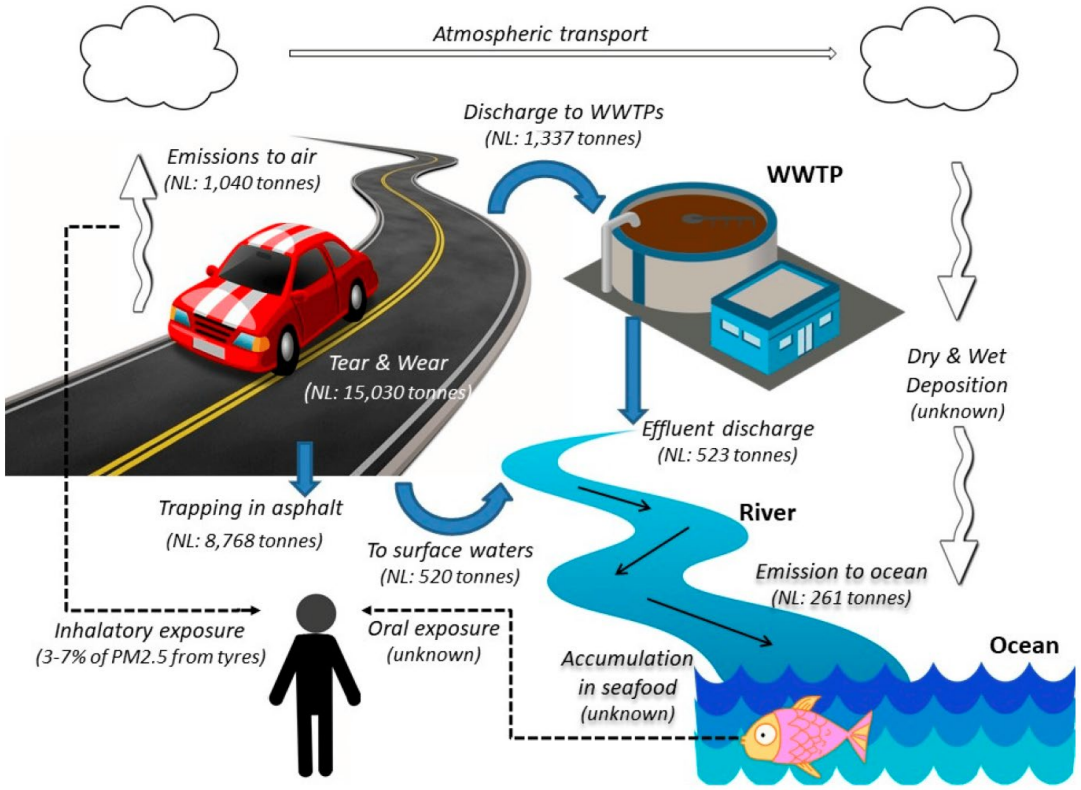


Thorpe et al., 2008;
Wagner et al., 2018:
Panko et al., 2013;
Kreider et al., 2010



Polluants provenant de l'usure des pneus

Taux d'émission :
2 – 10 mg/km/veh.
0.8kg/Cap/IR
6 000 000 T/A dans le monde

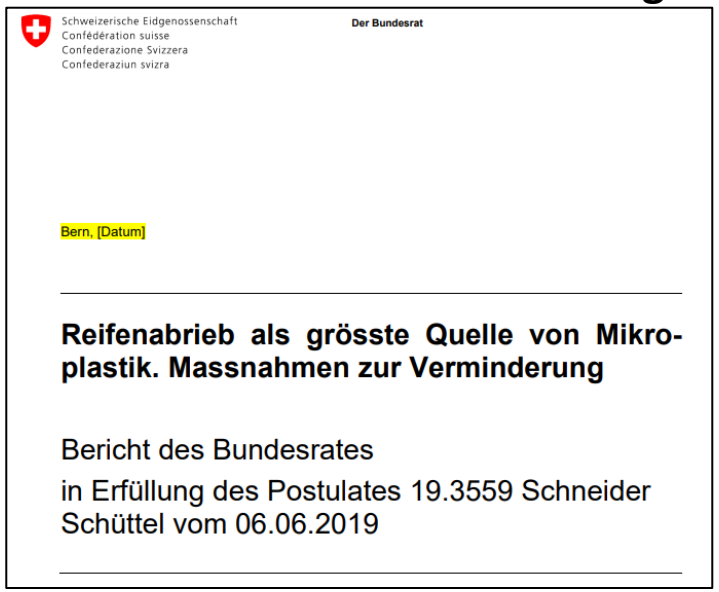


Kole et al. (2017)

Pays-Bas

Baensch-Baltruschat et al. (2021)

Allemagne



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Der Bundesrat

Bern, [Datum]

Reifenabrieb als grösste Quelle von Mikroplastik. Massnahmen zur Verminderung

Bericht des Bundesrates
in Erfüllung des Postulates 19.3559 Schneider Schüttel vom 06.06.2019

Report from Swiss Federal Council (2023)

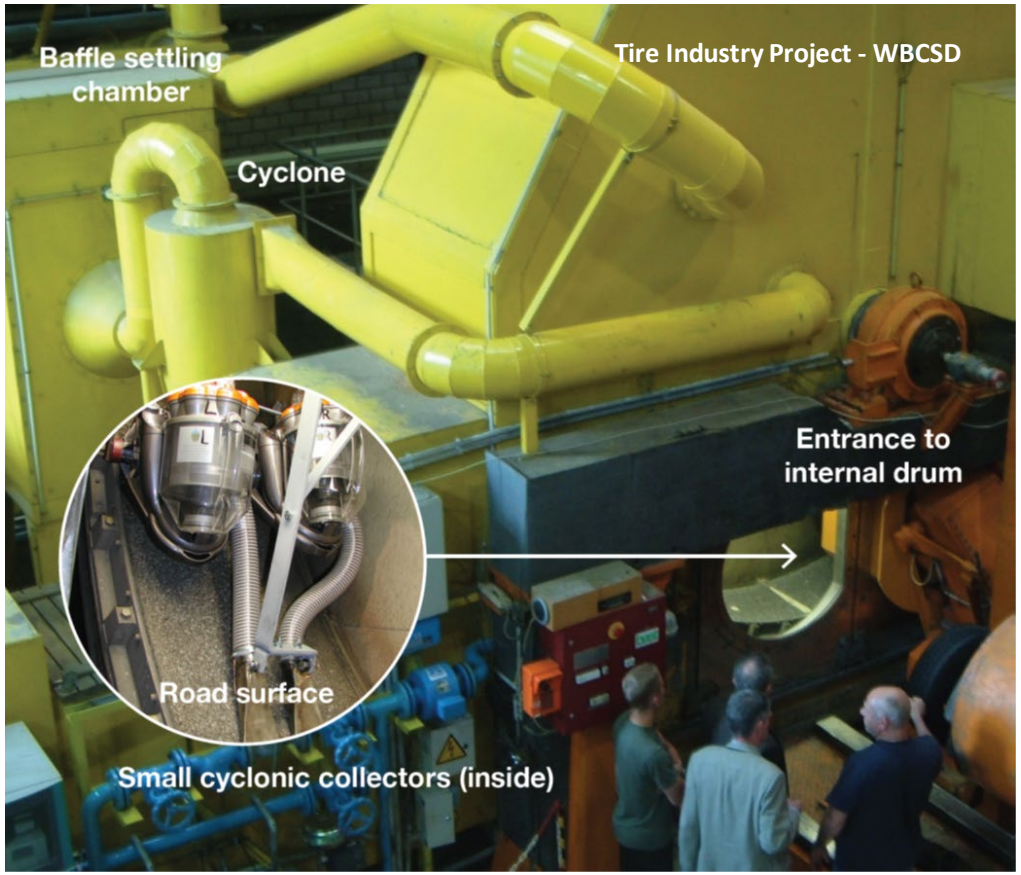
Suisse

➡ 13 – 21 kt/a

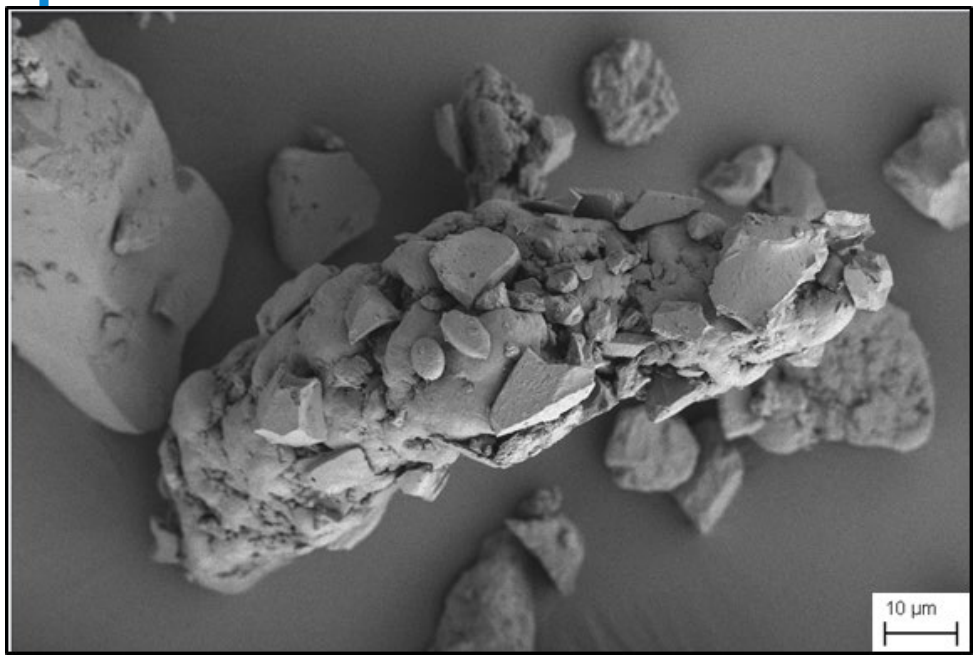
16 – 39 % eau superficielle

36 – 57 % sol

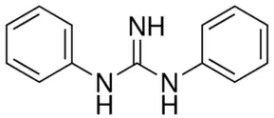
Particules d'usure des pneus et de la route
Caractéristiques physiques et chimiques



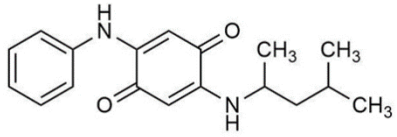
Karlsruhe Institute of Technology (KIT)



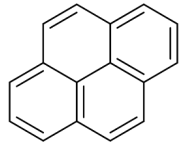
Thibault Masset / EPFL



1,3-diphenylguanidine
Vulcanization accelerator

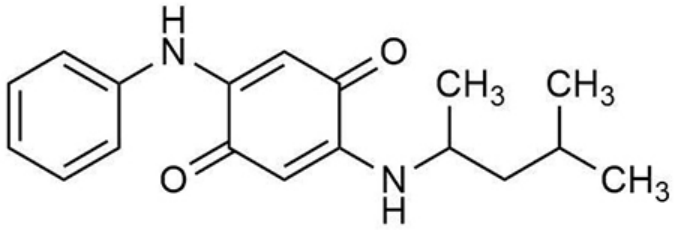


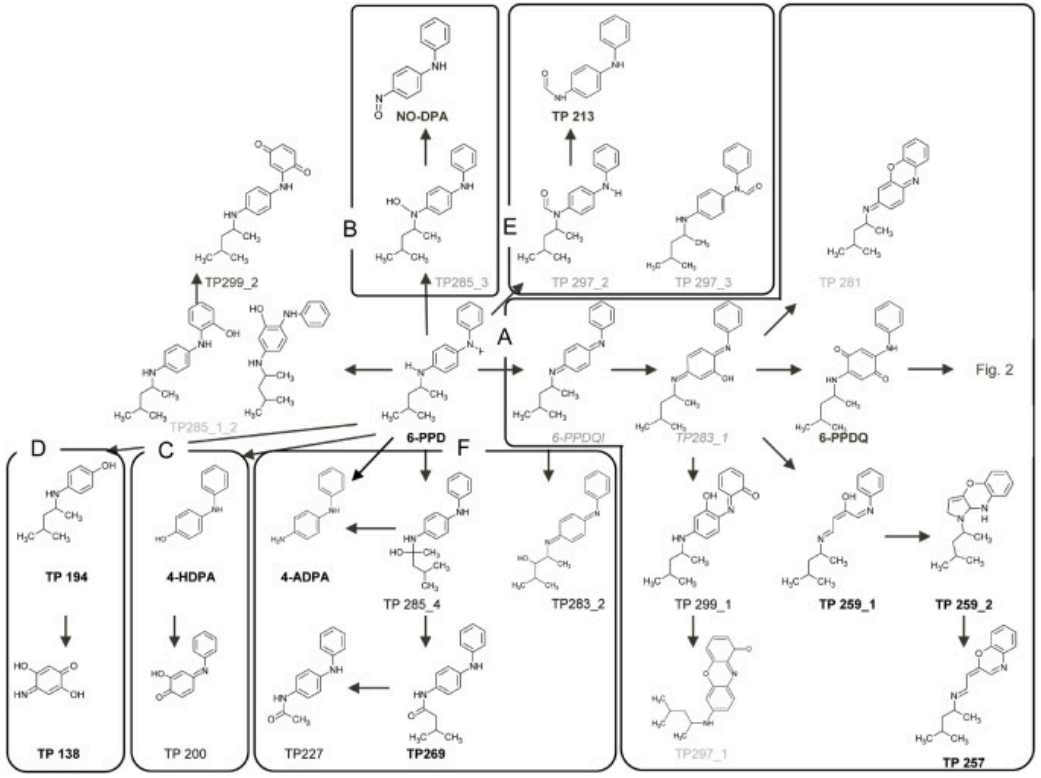
6PPD-Quinone
Transformation product of 6PPD

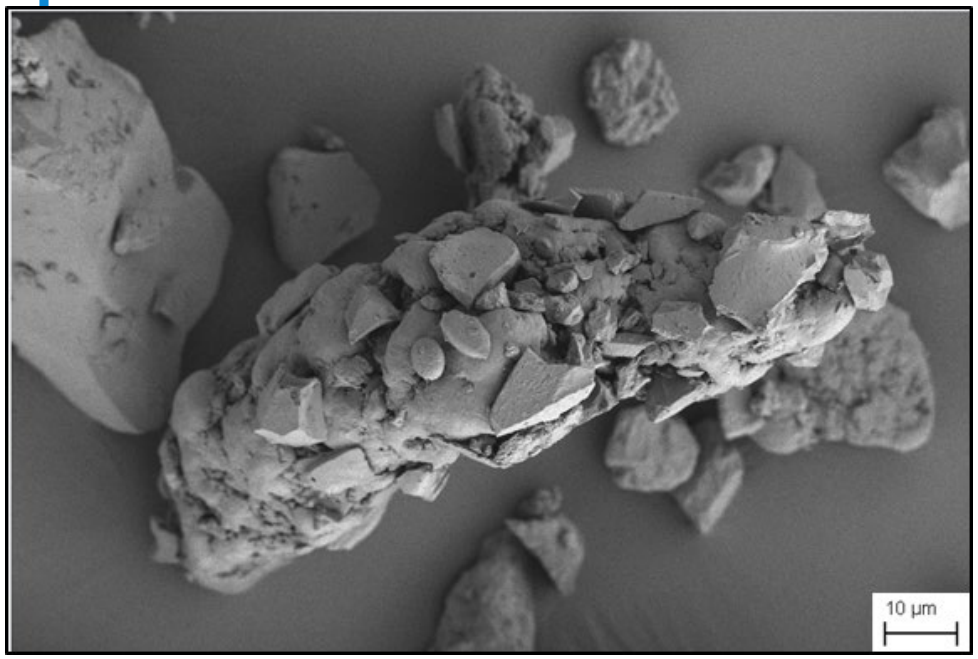


Pyrene
PAH

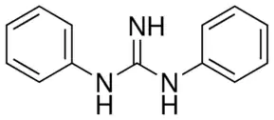
Particules d'usure des pneus et de la route
Caractéristiques physiques et chimiques



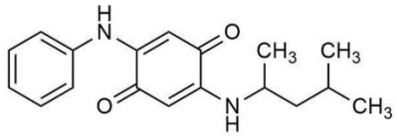




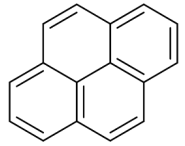
Thibault Masset / EPFL



1,3-diphenylguanidine
Vulcanization accelerator



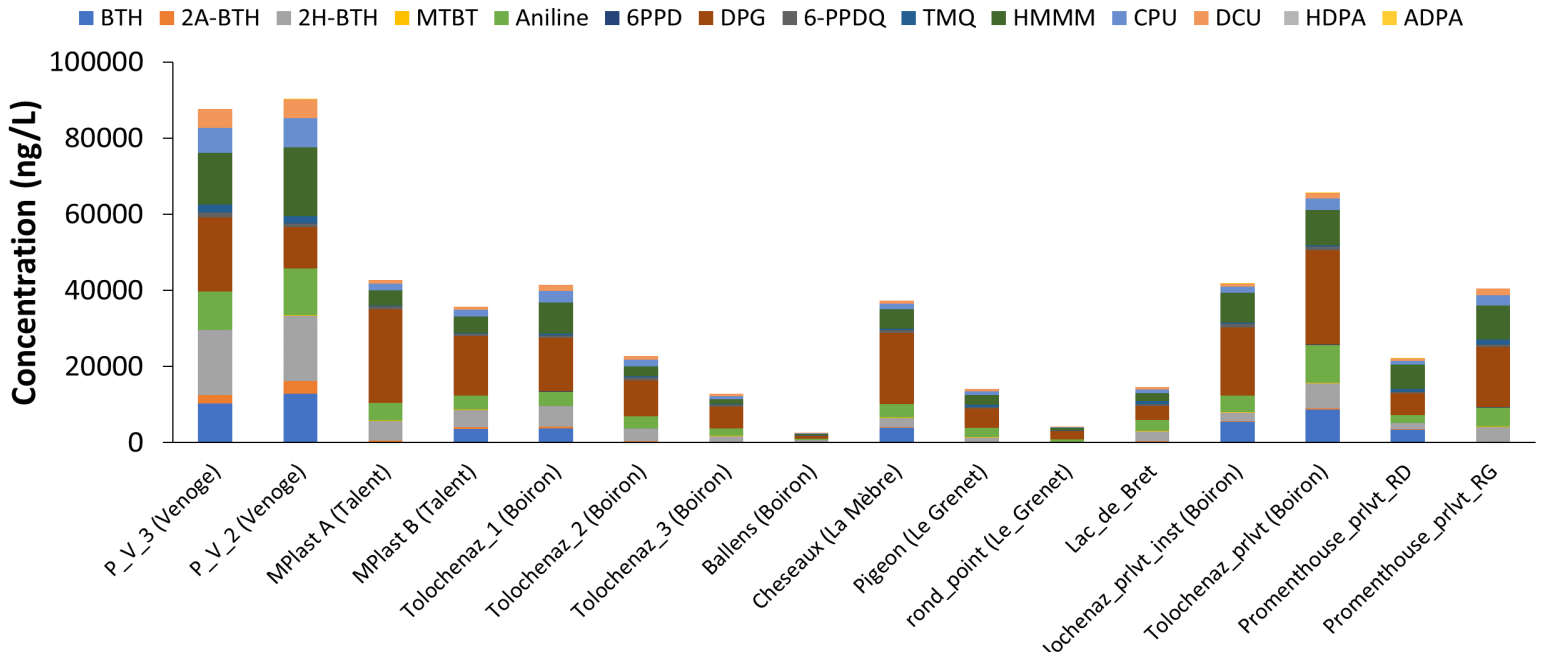
6PPD-Quinone
Transformation product of 6PPD

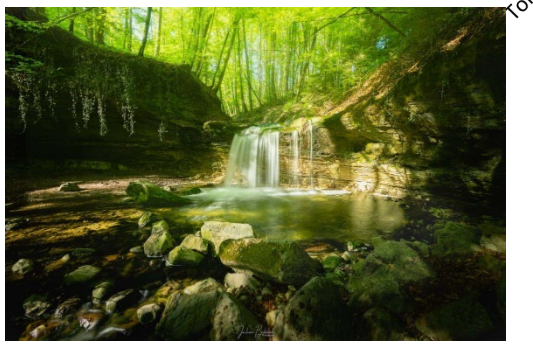


Pyrene
PAH

Polluants provenant de l‘usure des pneus dans l‘environnement

Concentration de produits chimiques associés aux pneus dans l’eau des rivières à proximité des zones urbaines

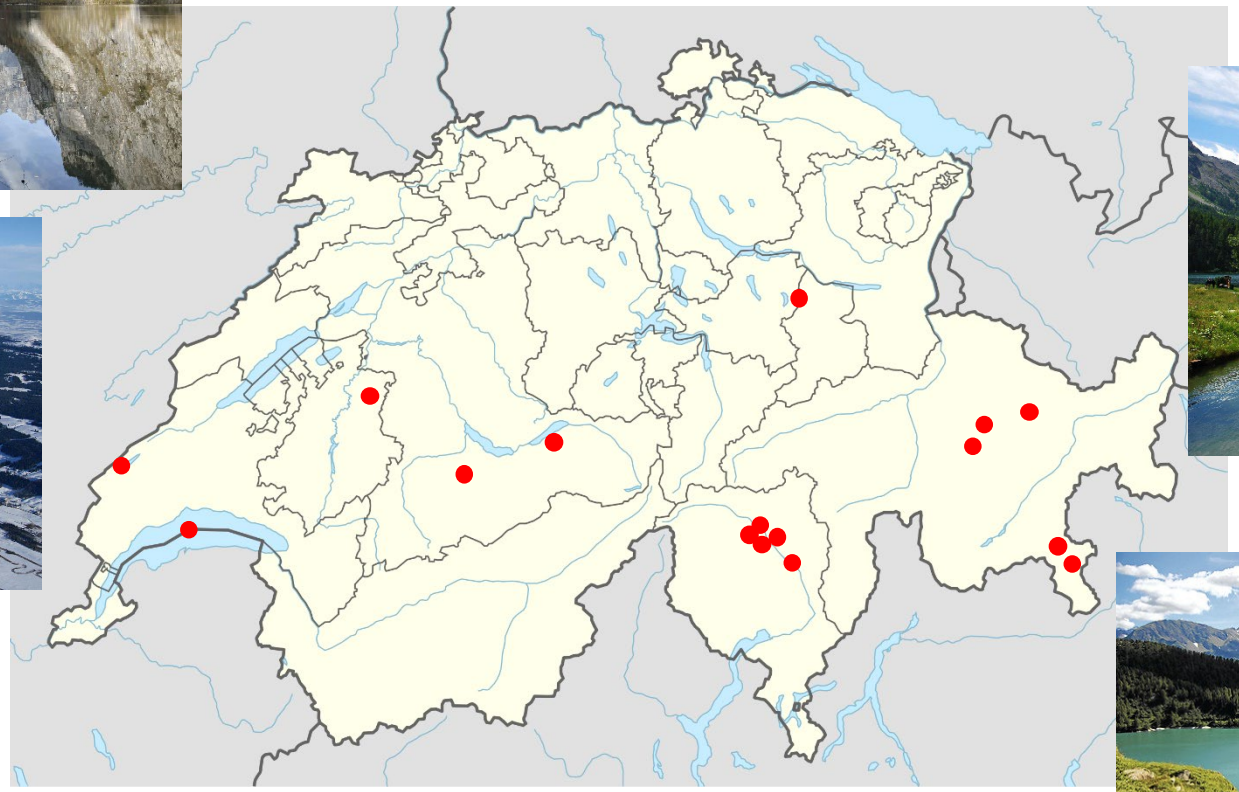




Masset et al., in prep.

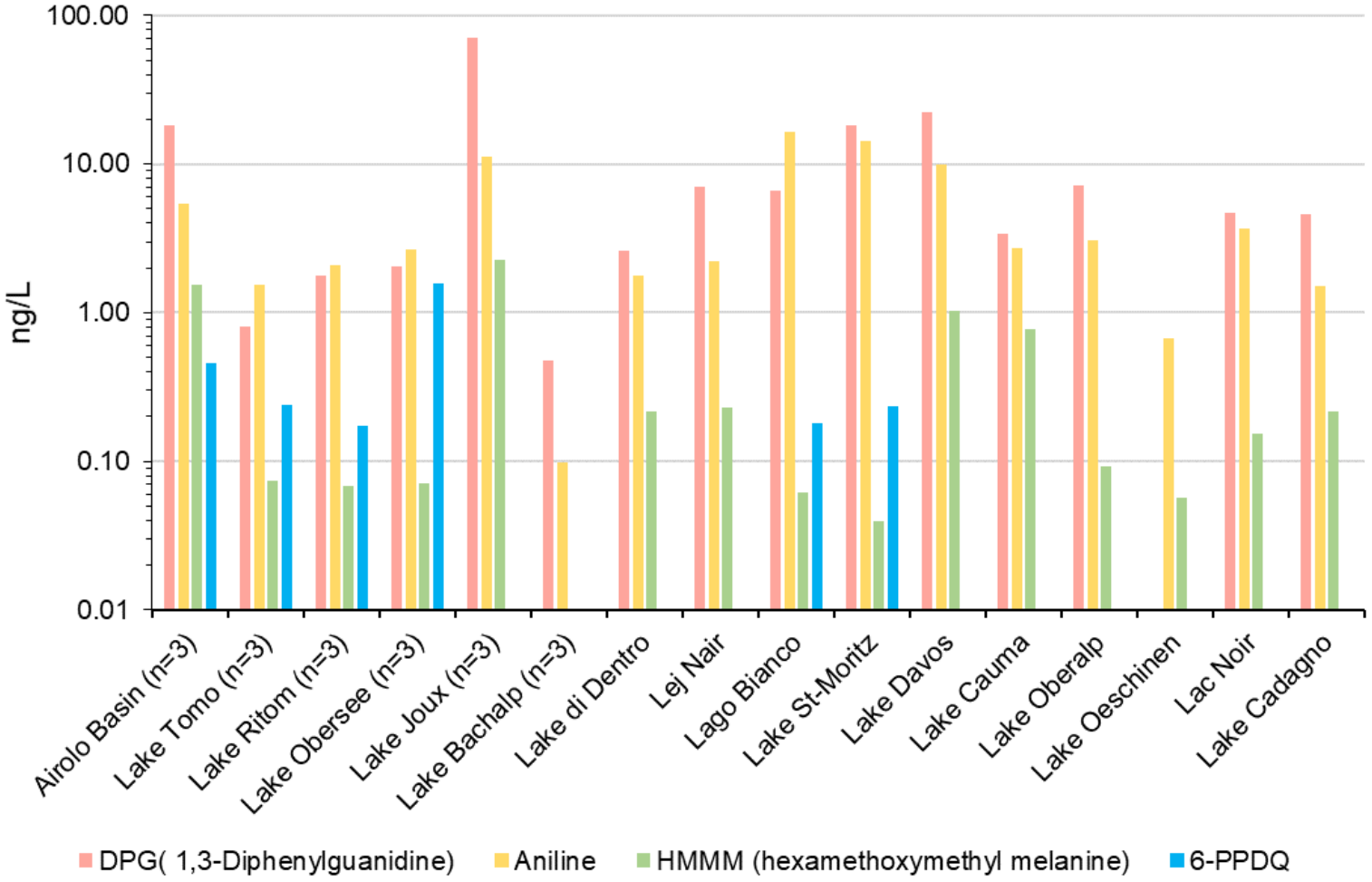
Polluants provenant de l‘usure des pneus dans l‘environnement

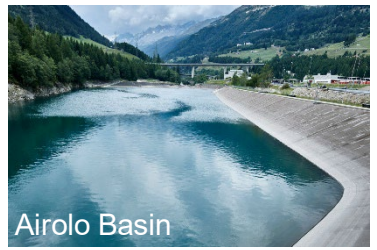
Échantillonnage dans 16 lacs alpins en Suisse (2023)



Polluants provenant de l‘usure des pneus dans l‘environnement

Concentration de produits chimiques associés aux pneus dans l’eau de 16 lacs alpins en Suisse

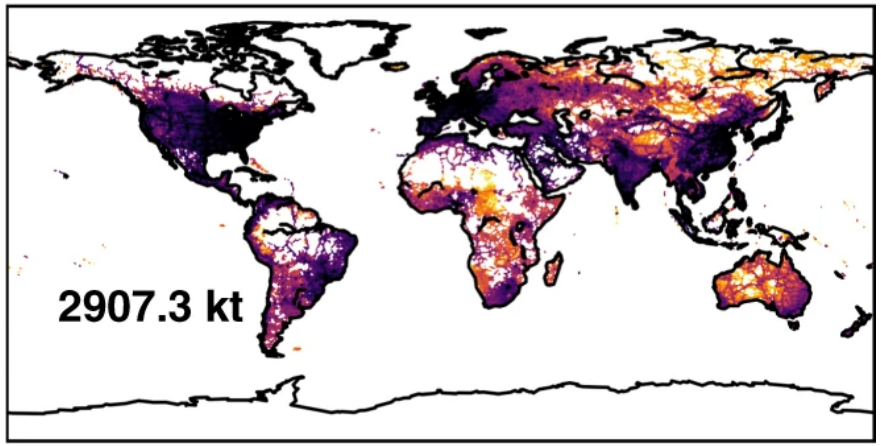




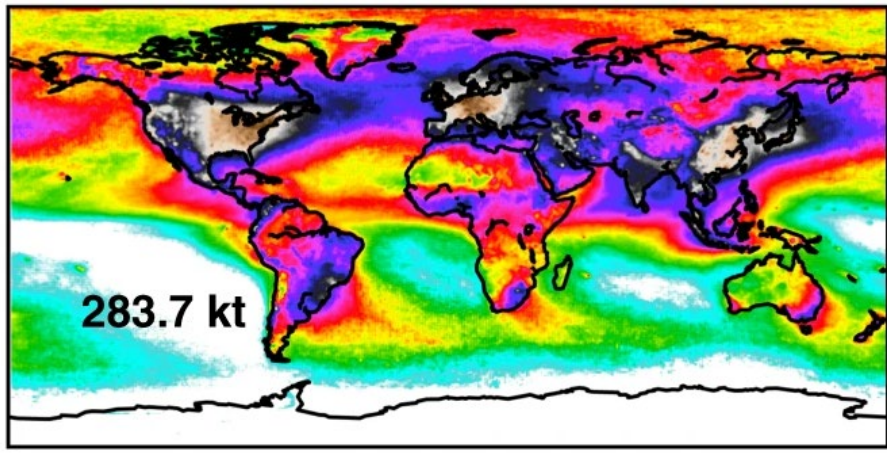
Masset et al., in prep.

Polluants provenant de l‘usure des pneus dans l‘environnement

a Émissions annuelles de TWP



b Dépôt annuel de TWP < 10µm



Evangeliou et al. (2020)

nature communications

Article | Open access | Published: 22 June 2023

Occurrence and backtracking of microplastic mass loads including tire wear particles in northern Atlantic air

Isabel Goßmann, Dorte Herzke, Andreas Held, Janina Schulz, Vladimir Nikiforov, Christoph Georgi, Nikolaos Evangeliou, Sabine Eckhardt, Gunnar Gerdts, Oliver Wurl & Barbara M. Scholz-Böttcher

ELSEVIER

Environmental Research

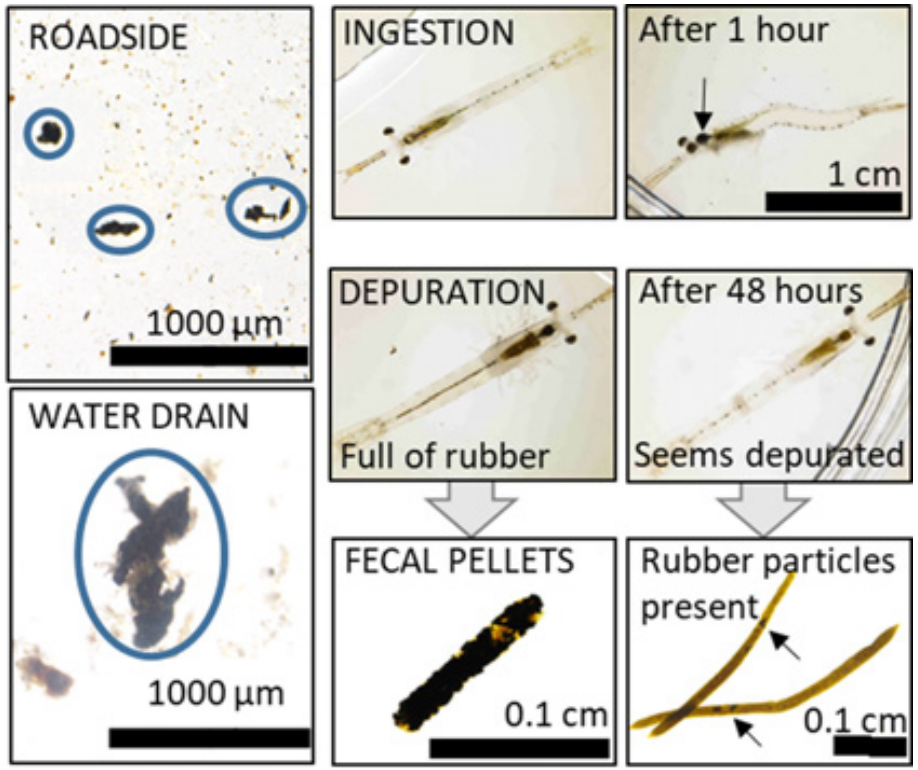
Volume 208, 15 May 2022, 112741

Nanoplastics measurements in Northern and Southern polar ice

Dušan Materić [a], Helle Astrid Kjær [b], Paul Vallelonga [b], Jean-Louis Tison [c], Thomas Röckmann [a], Rupert Holzinger [a]

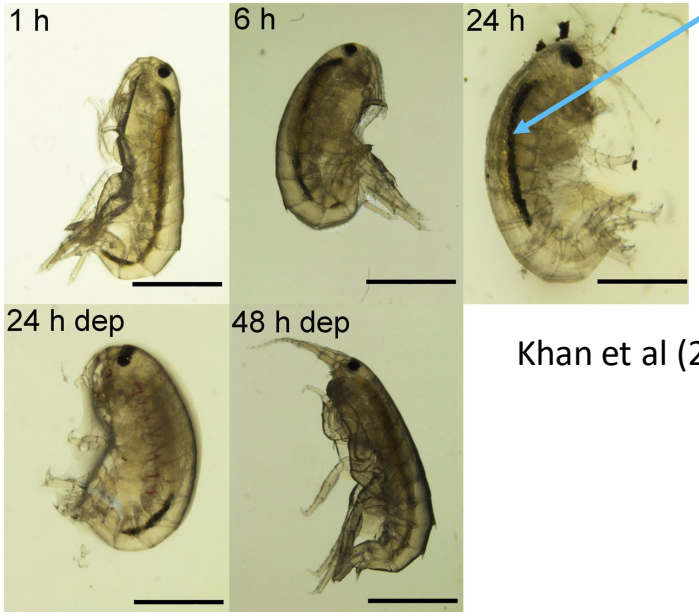
Exposition des organismes aux particules de pneus

Exemples: Crevettes



Halle et al (2020)

Particules de pneus dans le tube digestif

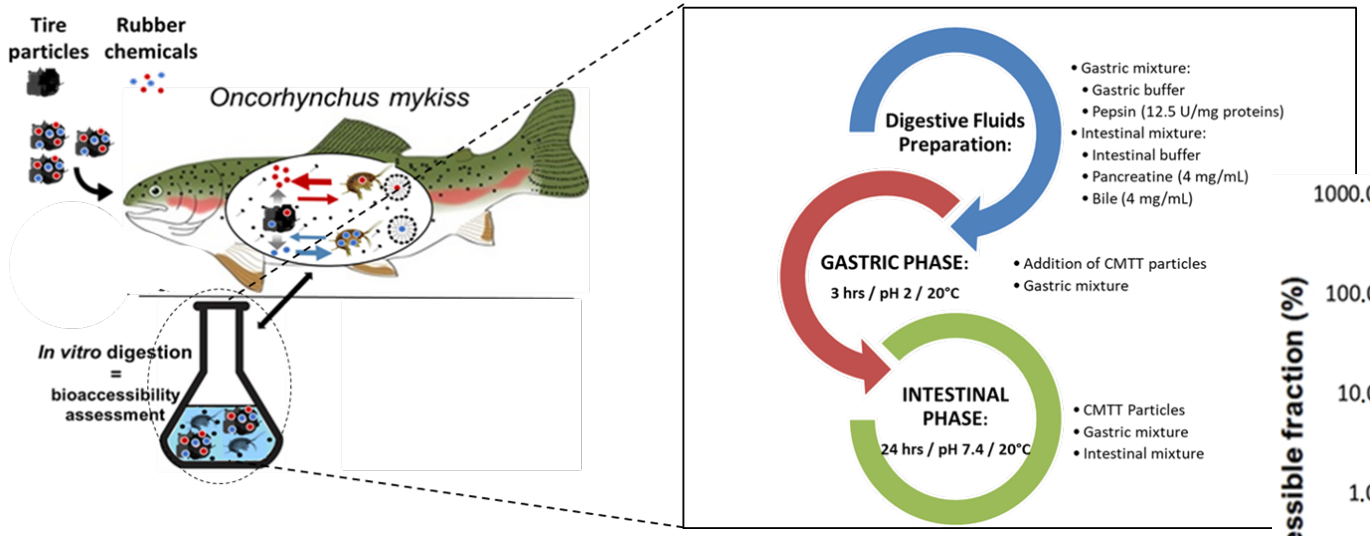


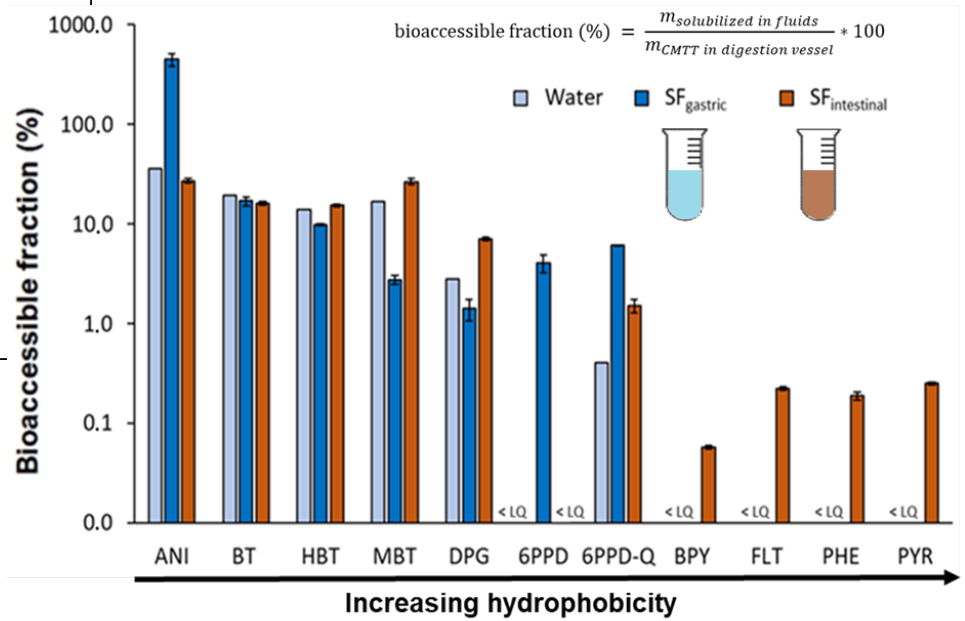
Khan et al (2019)

- Les particules de pneus peuvent être ingérées par les organismes

Exposition des organismes aux particules de pneus

Digestion *in vitro* des particules et liberation des additifs (tube digestif de truite)





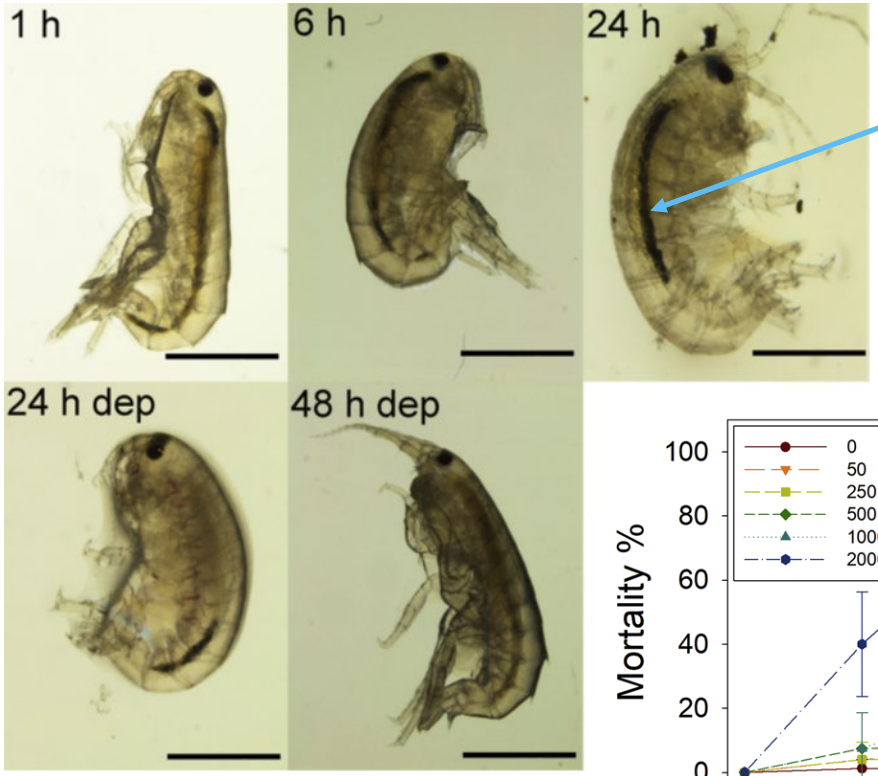
- La digestion pourrait entraîner l'exposition à un cocktail de substances chimiques en plus de l'exposition directe aux particules et aux substances dans l'environnement

ANI: aniline, **BT:** benzothiazole, **HBT:** hydroxybenzothiazole, **MBT:** mercaptobenzothiazole, **DPG:** 1,3-diphenylguanidine, **6PPD:** N-(1,3-dimethylbutyl)-N'-phenyl-1,4-phenylenediamine, **6PPD-Q:** 6PPD-Quinone, **PHE:** Phenanthrene, **FLT:** Fluoranthene, **PYR:** Pyrene, **BPY:** Benzo(g,h,i)perylene

Masset et al. (2022)

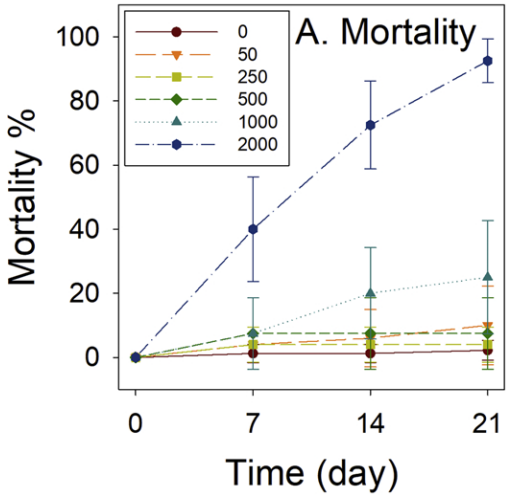
Effets des particules de pneus sur les organismes

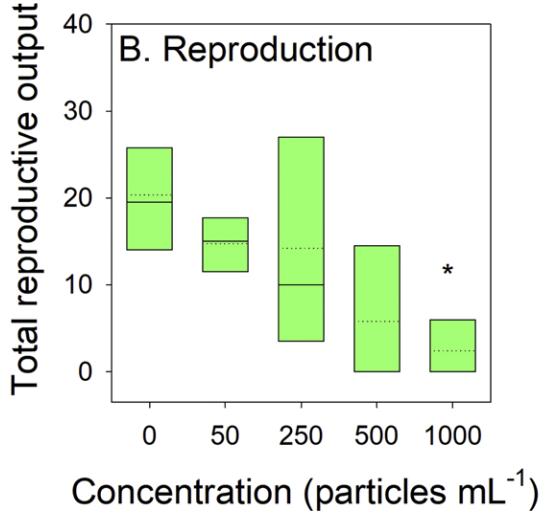
Amphipode *Hyllela azteca*

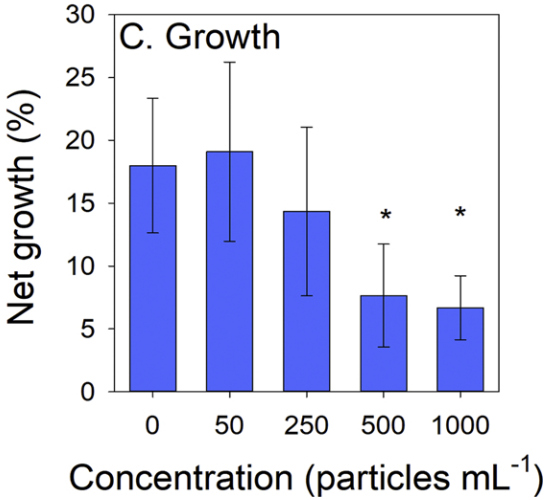


Particules de pneus dans le tube digestif

➢ Effets chroniques observés





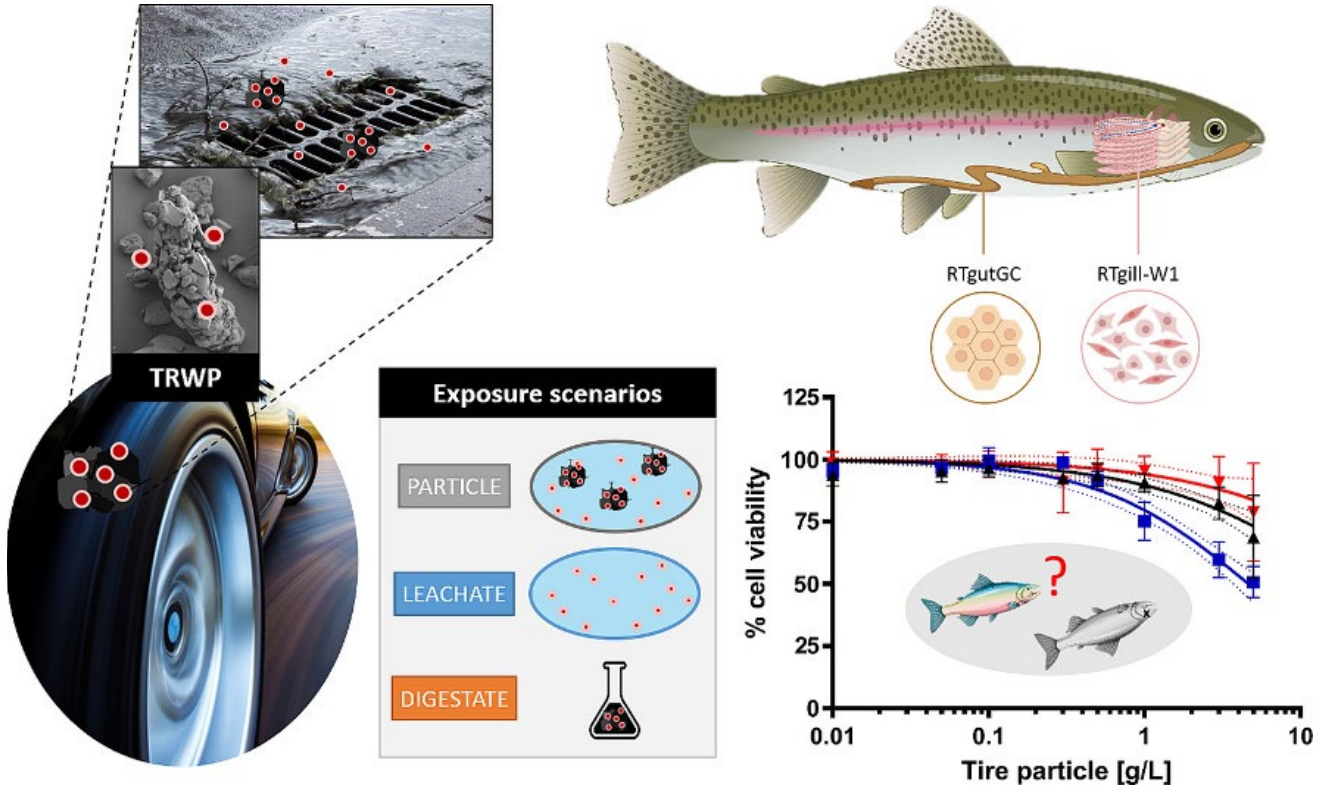


Khan et al (2019)

Effets des particules de pneus sur les organismes

Toxicité des particules sur les lignées cellulaires de truite arc-en-ciel

Intestins / Branchies



- Toxicité spécifique des particules de pneus, des lixiviats et du digestat *in vitro*
- La concentration de particules de pneus présentant une toxicité aiguë dépasse les concentrations dans l'environnement
- Les particules de pneus relarguent continuellement des substances chimiques -> Zn et 6PPD principaux facteurs de toxicité

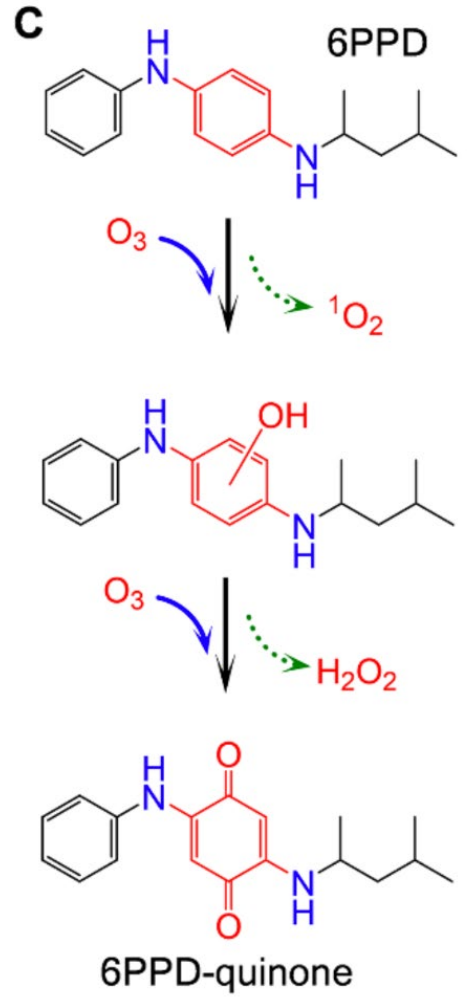
Dudefoi et al (2024)

Cas de la 6PPD et la 6PPD-Q

Salmon are dying from toxic stormwater runoff, Puget Sound area residents can help scientists figure out why

CNN US Crime + Justice Energy + Environment Extreme Weather Space + Science

Salmon have been dying mysteriously on the West Coast for years. Scientists think a chemical in tires may be responsible



Science

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HOME > SCIENCE > VOL. 371, NO. 6525 > A UBIQUITOUS TIRE RUBBER–DERIVED CHEMICAL INDUCES ACUTE MORTALITY IN COHO SALMON

REPORT

A ubiquitous tire rubber–derived chemical induces acute mortality in coho salmon

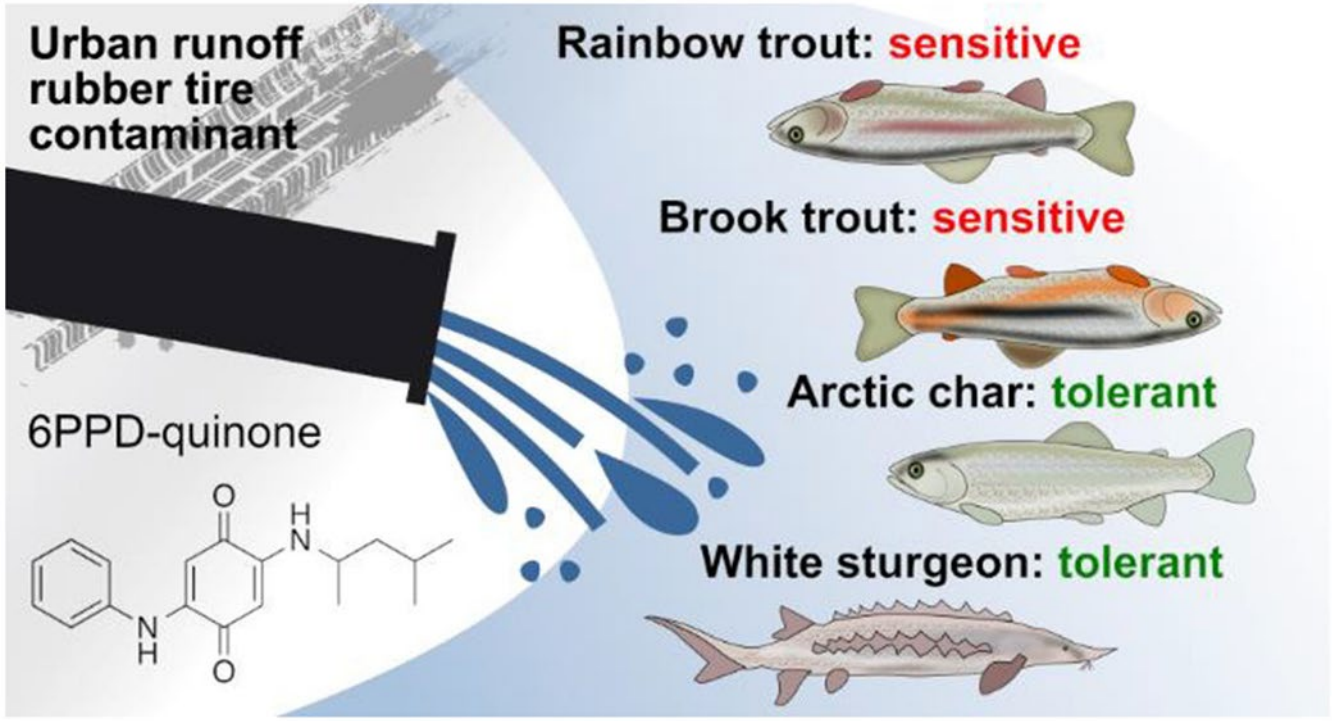
ZHENYU TIAN, HAOQI ZHAO, KATHERINE T. PETER, MELISSA GONZALEZ, JILL WETZEL, CHRISTOPHER WU, XIMIN HU, JASMINE PRAT, EMMA MUDROCK, [...] EDWARD P. KOLODZIEJ +18 authors Authors Info & Affiliations

The Guardian

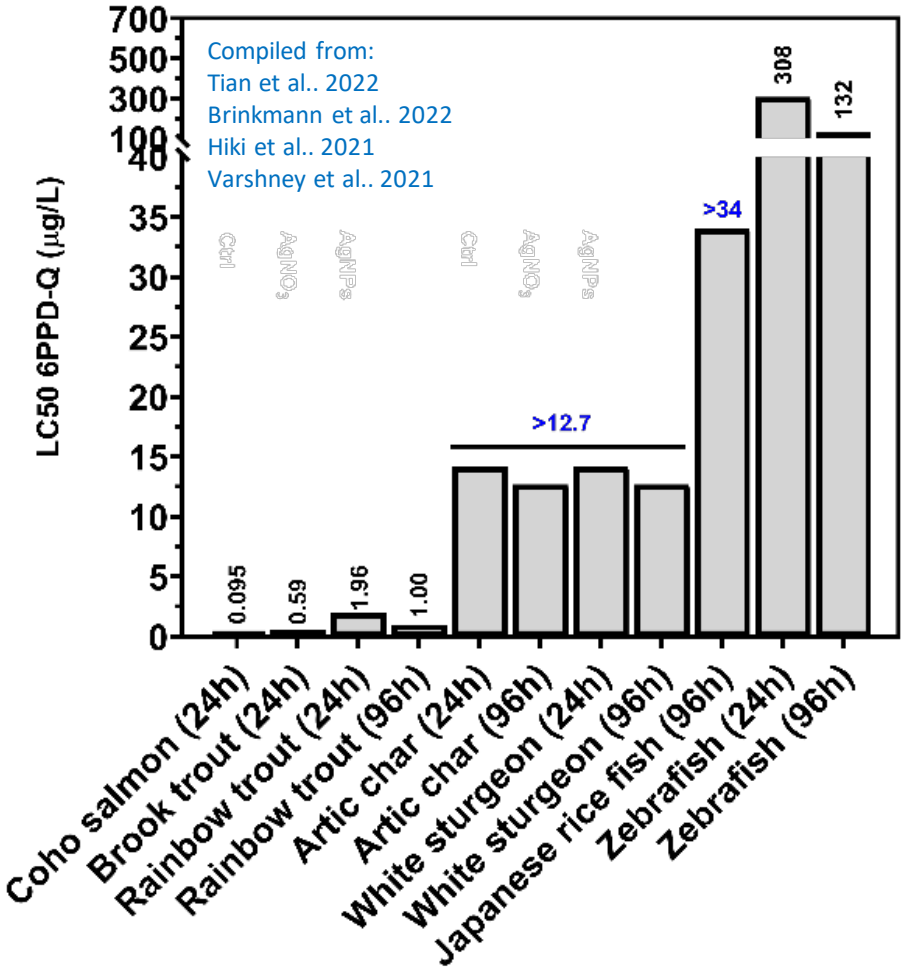
Pollution from car tires is killing off salmon on US west coast, study finds

Mass die-offs of coho salmon just before they are about to spawn have been traced to tire fragments washed into streams by rain

Cas de la 6PPD et la 6PPD-Q



Brinkmann et al (2022)

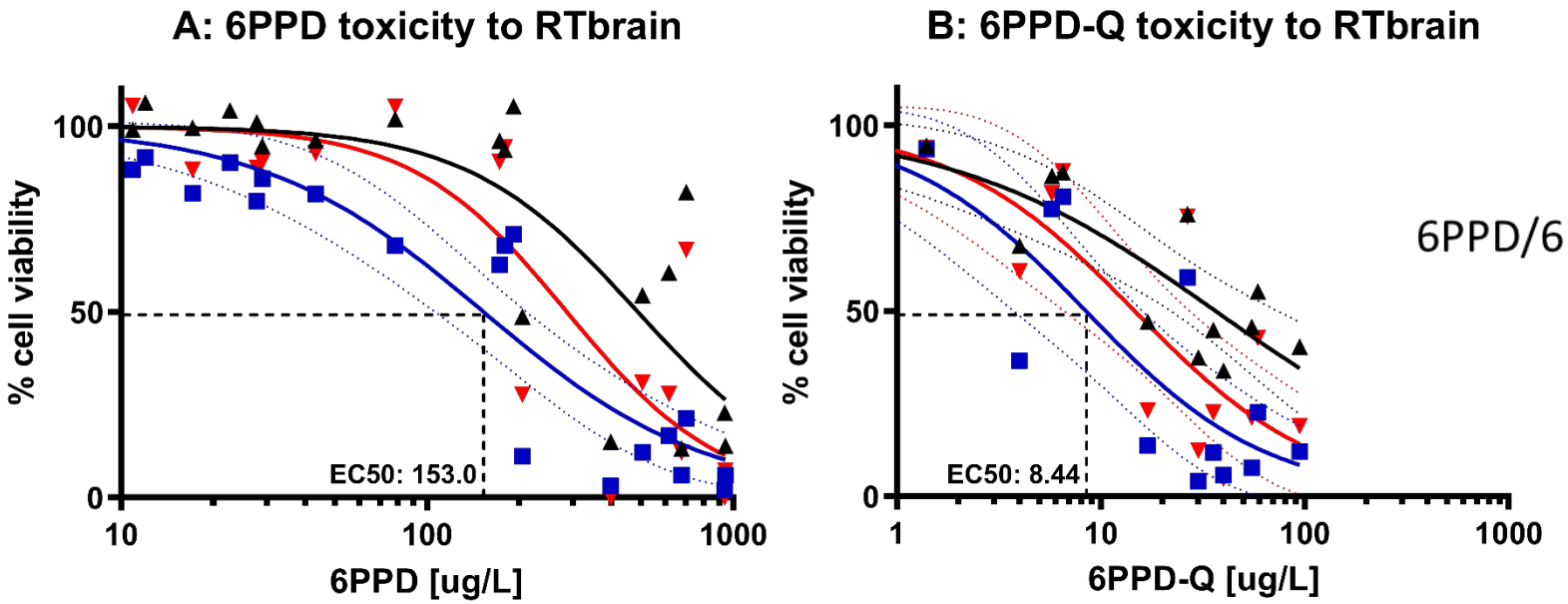


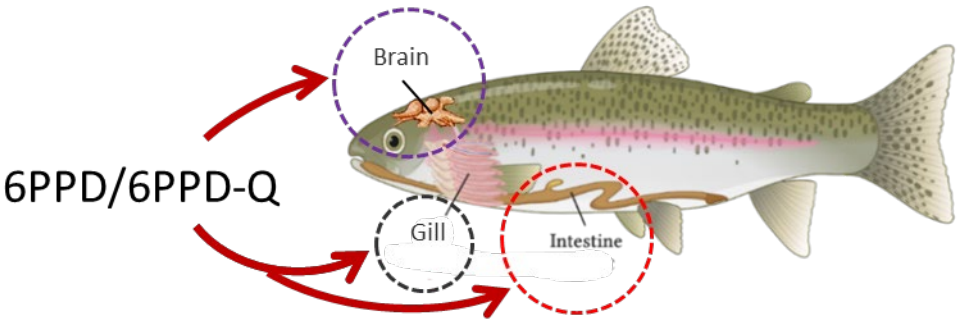
- Sensibilité spécifique des espèces à la 6PPD-Q
- Investigations en cours pour élucider les mécanismes sous-jacents

Cas de la 6PPD et la 6PPD-Q

Intestins / Branchies / cerveau

■ metabolic activity ▲ cell membrane integrity ▼ lysosomal integrity





Cell lines	6PPD EC50 (µg/L)	6PPD-Q EC50 (µg/L)
RTgill-W1	121.5 (64.6-228.6)	not more than 25% toxicity up to 6200
RTgutGC	177.2 (159.0-197.5)	not more than 25% toxicity up to 1500
RTbrain	153.0 (109.8-213.4)	8.44 (4.32-16.48)

- Sensibilité spécifique des tissus à la 6PPD-Q
- Mode d'action: Neurotoxicité?

Dudefoi et al (2023;2024)

Quelles solutions?

Remplacement

Les autorités, les groupes de recherche et l'industrie du pneu cherchent des produits chimiques alternatifs

NEWS RSS1

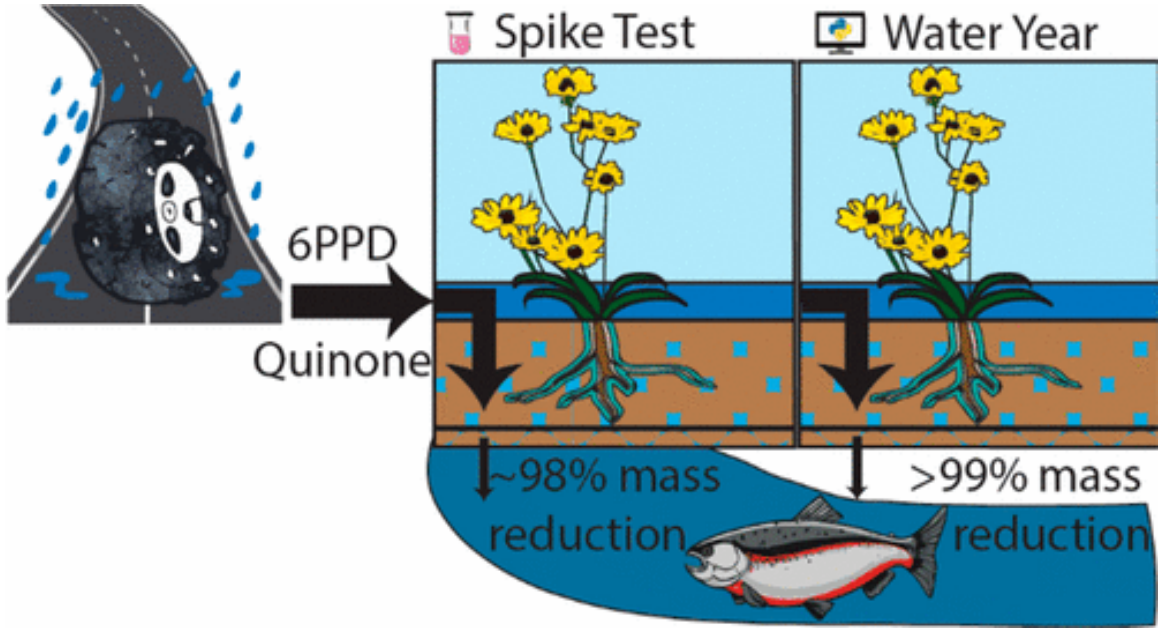
Tire manufacturers threatened with lawsuit over the use of 6PPD

DTSC Department of Toxic Substances Control

California Requires Tiremakers to Look for Safer Alternatives to Chemical that Kills Coho Salmon

Remplacements chimiques

Réduction



Rodgers et al. (2023)

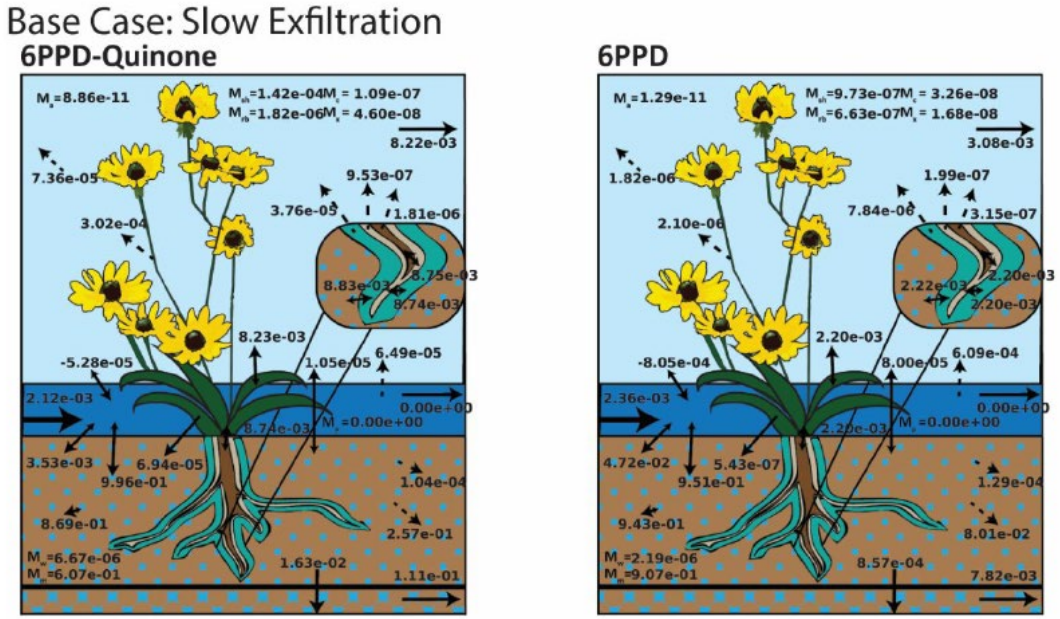
Les systèmes de biorétention peuvent contribuer à la décontamination des eaux

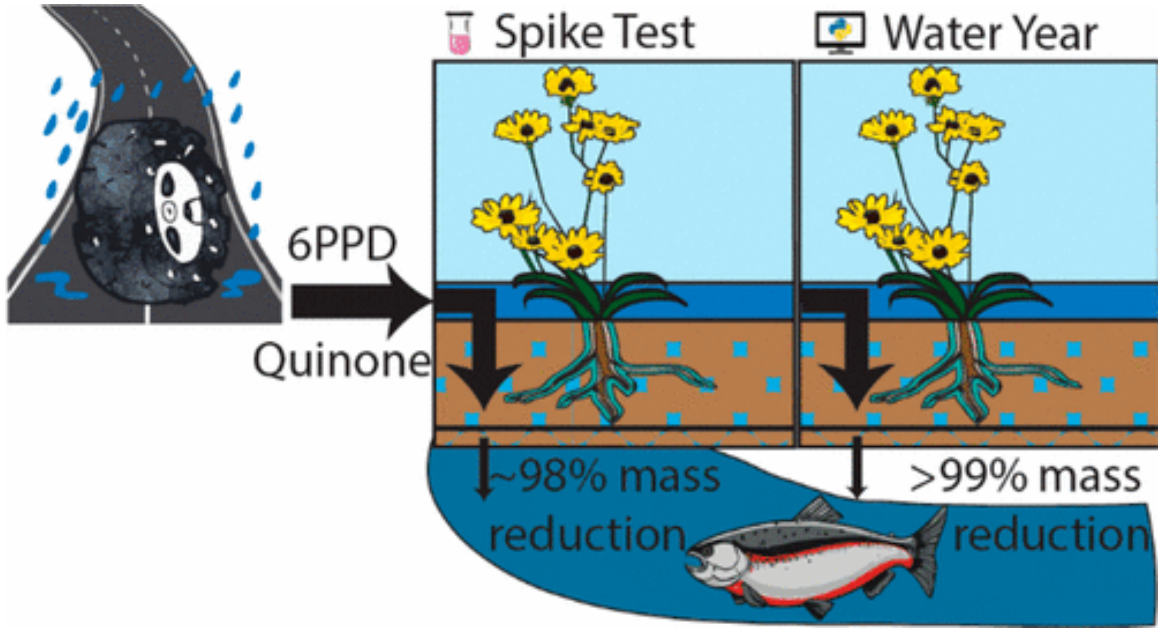
Traitement de l'eau, nettoyage des routes…

Quelles solutions?

Réduction

La demi-vie dans le sol pour la 6PPD-quinone (75 jours) versus 6PPD (~340 jours) signifie que la 6PPD-quinone produite à partir de la transformation de la 6PPD ne s'accumulerait probablement pas dans les systèmes de biorétention ou dans le sol en général





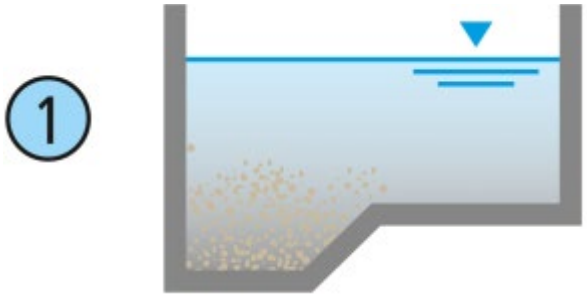
Rodgers et al. (2023)

Les systèmes de biorétention peuvent contributer à la décontamination des eaux

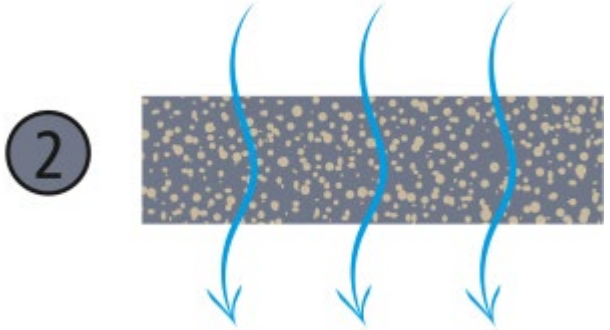
Quelles solutions?

Système de traitement et d'évacuation des eaux de chaussée (SETEC)

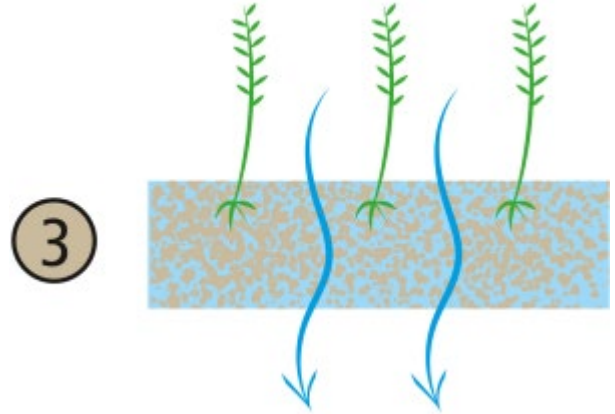
Bassin de rétention



Filtre à gravier



Filtre à sable végétalisé



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Merci de votre attention