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Christine Lors, Jean-François Ponge, Denis Damidot

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IMT Lille Douai
École Mines-Télécom
IMT-Université de Lille

Environmental hazard assessment of coal tar polluted soils through a multidisciplinary approach combining chemistry, ecotoxicology and microscopy

Industrial activities have led to the discharge of a wide range of hazardous chemicals in soils, such as coal tars which are always composed of hundreds of organic compounds (PAHs, BTEX,...), but also of some inorganic compounds. Environmental hazard assessment of soils contaminated with coal tar are generally investigated by a multidisciplinary approach coupled chemical and ecotoxicological analysis. However, a direct correlation between chemical analysis and results of ecotoxicological bioassays is generally not observed.

The aim of this work is to **deepen the relationships** between **PAHs concentration** and **ecoscores** calculated from a battery of specifically selected bioassays including solid and liquid phase bioassays (Lors et al., 2010 & 2011). First, **PAHs distribution** is measured on several **fraction of soils**, and, second, parameters governing the release of PAHs to soil water are investigated by **microscopic** techniques.

Authors

LORS Christine ⁽¹⁾
PONGE J.F. ⁽²⁾
DAMIDOT Denis ⁽¹⁾

Institutions

⁽¹⁾ IMT Lille Douai
(Douai, France)
⁽²⁾ Muséum National
d'histoire Naturelle
(Paris, France)



References

Lors C. et al., 2010.
Environ. Pollut., 158:
2640-2647.

Lors C. et al., 2011.
Environ. Pollut., 159:
2974-2981.

Soil 3 and Soil 3T:
before and after
biotreatment

SOILS

Soil 2: after
biotreatment

Chemical analyses

- Separation of soil into 6 fractions: < 2, 2-20, 20-50, 50-200, > 2000 μm
- T.O.C. (TOCmeter)
- 16 (US-EPA) PAHs (ASE + HPLC-UV detector)

Ecotoxicological analyses

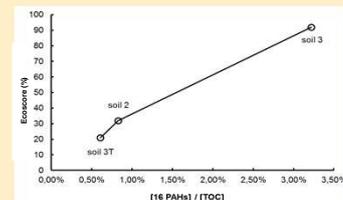
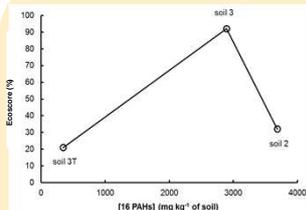
- Ecoscores calculated from the results of bioassays selected by Lors et al. (2011): Microtox, springtail avoidance, algal growth, lettuce germination, springtail reproduction, micronucleus test

Microscopical analyses

- Impregnation of the soil fraction with epoxy resin in circular molds
- Polishing the surface of samples with several diamond-covered disks
- Observations under a scanning electron microscope

Characterization of soils

- ✓ In all the soils, the fraction 200-2000 μm (coarser particles) contains the majority of TOC and PAHs.
- ✓ **2-4/5-6 ratio** is expected to decrease with the **advancement of degradation**.



- ✓ Biotreatment decreased PAHs concentration resulting in decreased ecotoxicity.
- ✓ Soil 2 was much less ecotoxic than soil 3 despite amount of PAHs (3.7 g.kg⁻¹).

Conc. (mg.kg ⁻¹)	Soil 2	Soil 3	Soil 3T
	In the 200 – 200 μm fraction		
16 PAHs	2155	2444	283
TOC	325	78	43
2-4/5-6 ratio	1.12	8.47	2.83
PAHs/TOC (%)	0.66	3.15	0.67

- ✓ **Ecoscores do not correlate** with [16PAHs], but increase almost linearly with [16 PAHs] / [TOC].
- ✓ This ratio estimates [16 PAHs] of coal tar particles.
- Bioavailability of PAHs is linked to their release from coal tar particles to soil pore water, depending to diffusion process.

Microscopic observations

- ✓ Most of the **coal tar particles** present a **network of connected internal pores** open to the surface, but in variable amounts depending on the origin of the coal tars.

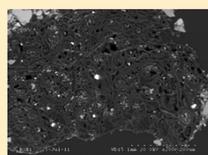
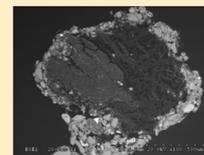
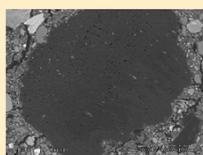
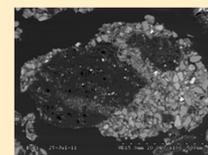
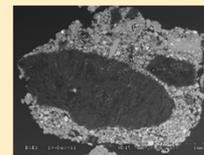
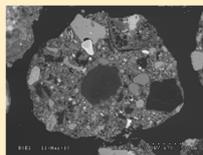
- ✓ The pore network evolves during biodegradation process: an **increase of the amount of interconnected porosity** is observed **due to the microbial consumption** of organic compounds in coal tar particles (Soil 3T compared to Soil 3).

- ✓ **Diffusion of PAHs** from coal tar particles to soil water depends on the gradient of PAHs content between coal tar particles and soil water and on the surface of coal tar particles in contact with soil water.

Soil 2

Soil 3

Soil 3T



Conclusions

- ✓ The **environmental hazard** of soils is depending on the chemical properties of organic particles, but also the **amount of open porosity** of the particles.
- ✓ **Microscopy** can be a **complementary method** to chemical and ecotoxicological analysis to assess the best strategy of remediation.

For more details, see **article Lors C. et al., 2017 published in Environ. Sci. Pollut. Res., 121: 19-25.**