Assessment of trace metal and PAH concentrations in soils from peri-industrial regions: lessons from a survey in the Walloon region (Belgium)

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Presentation Outline

1. Background concentrations in the Wallonia context

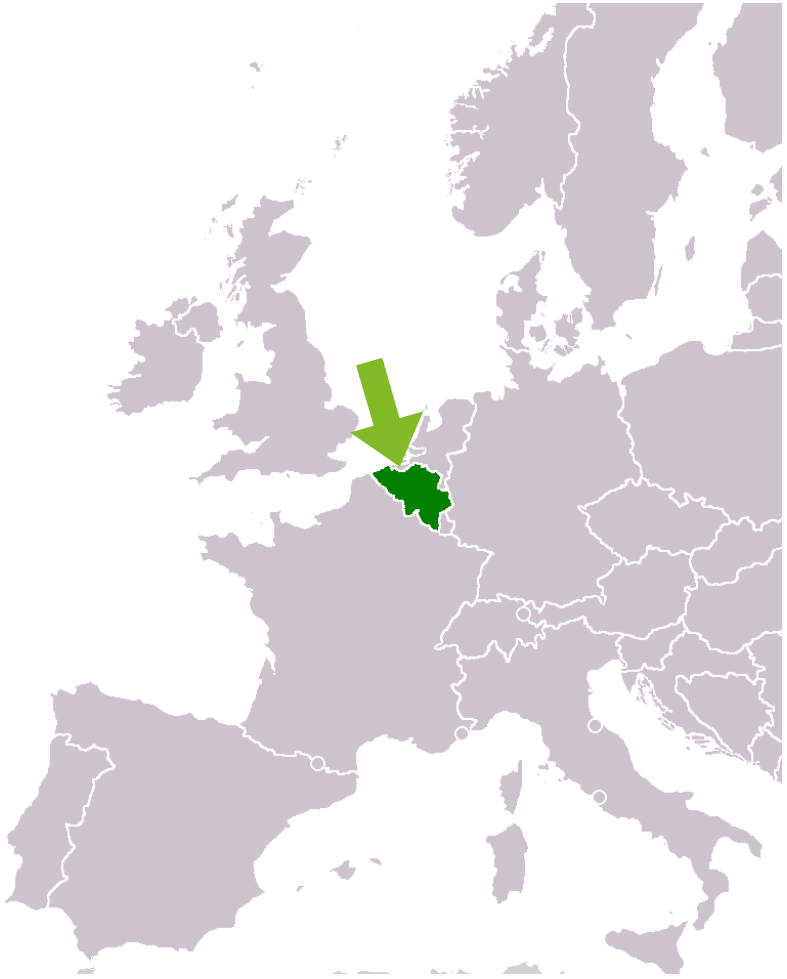
2. The study POLLUSOL 2 : soils of urban and industrial areas

3. Analysis of the effect of
   - land use,
   - atmospheric deposition,
   - technogenic materials,

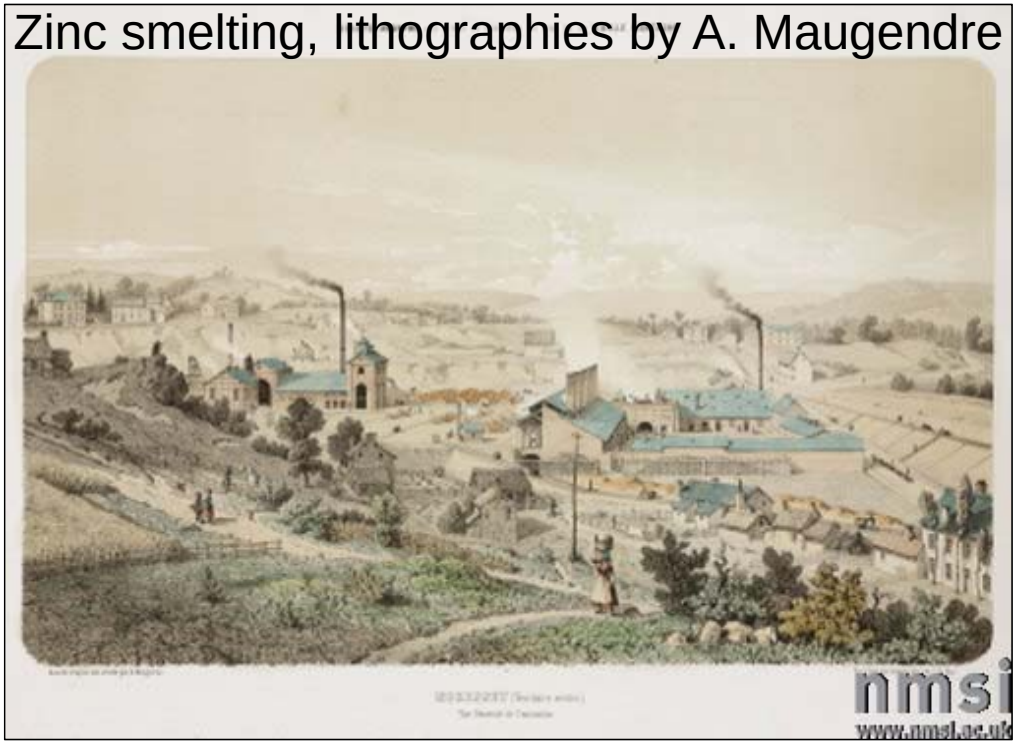
   on pollutant concentrations

4. Conclusions and perspectives

Belgium and the Walloon region



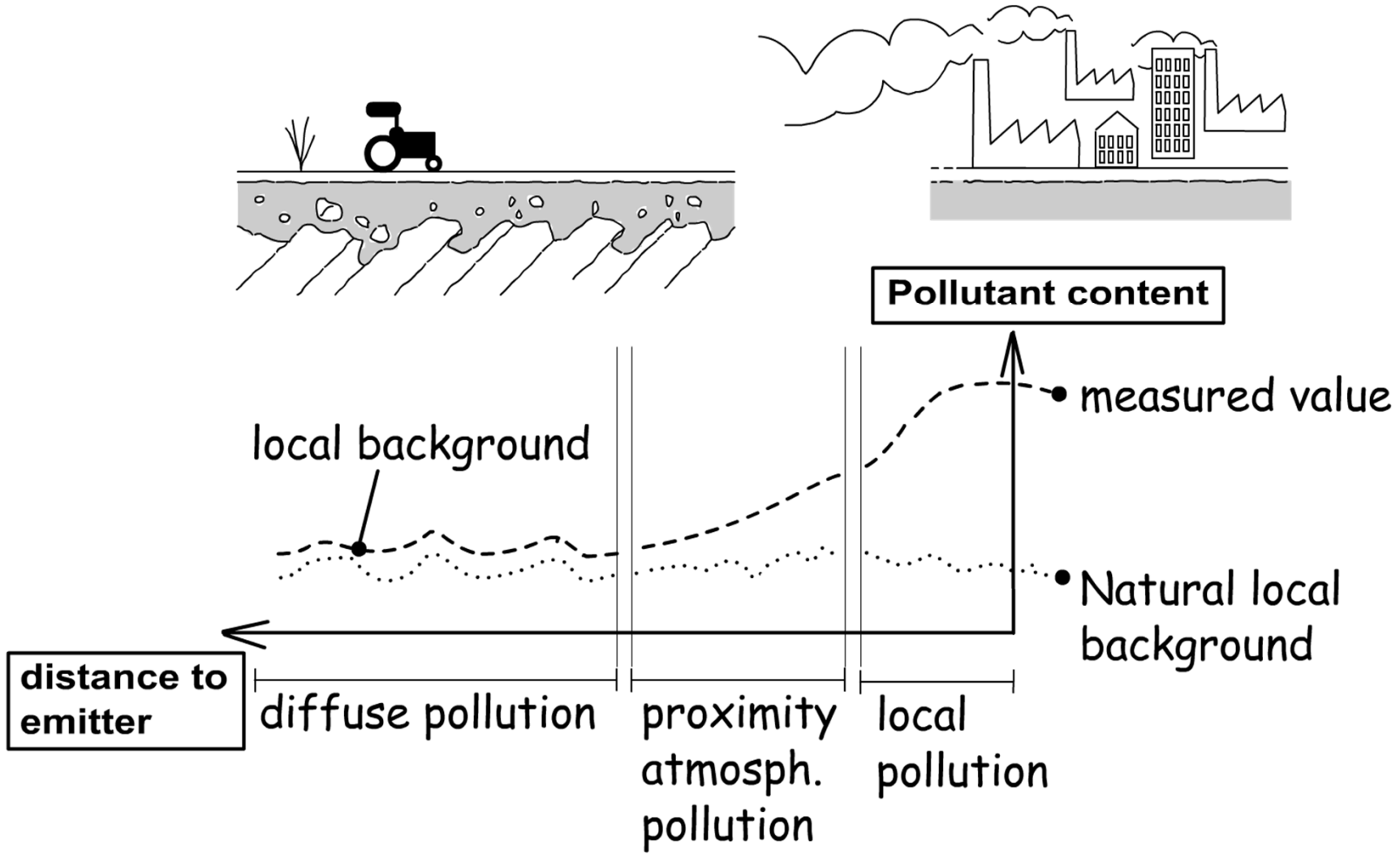
Wallonia : long history of industrial activity



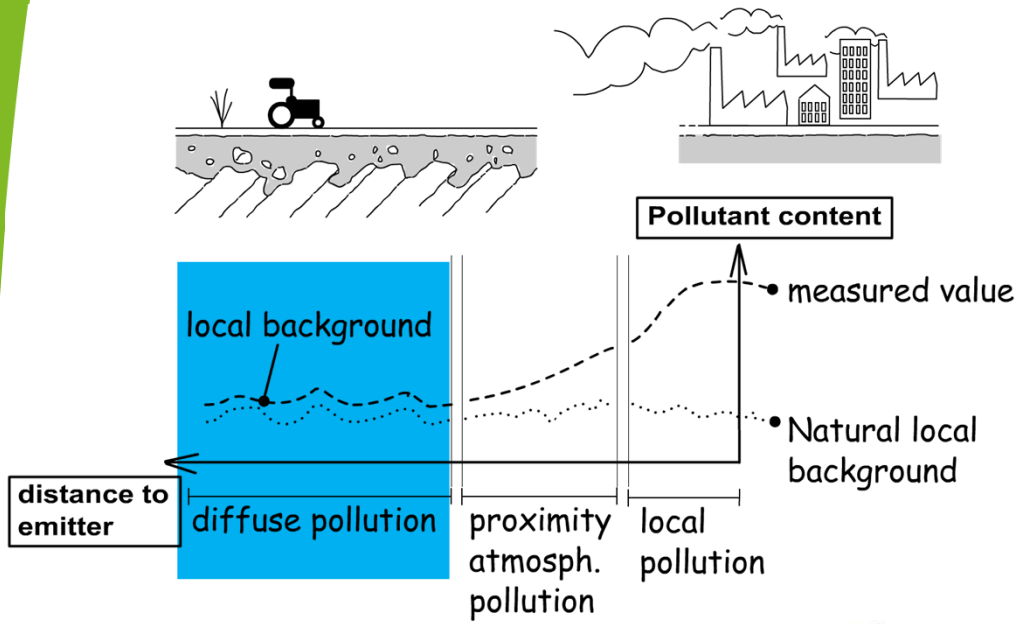
Angleur, Liège industrial area, 1855

Seraing, Liège industrial area, 2012

Background concentrations



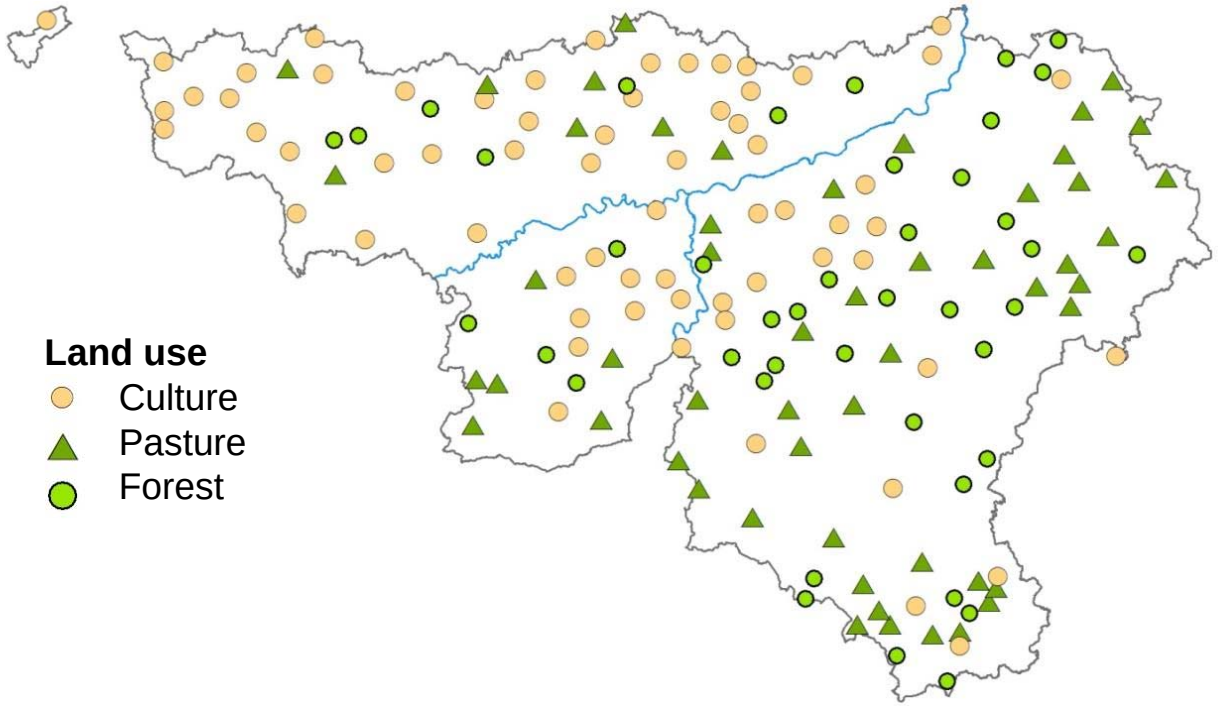
POLLUSOL 1 : “natural” reference state



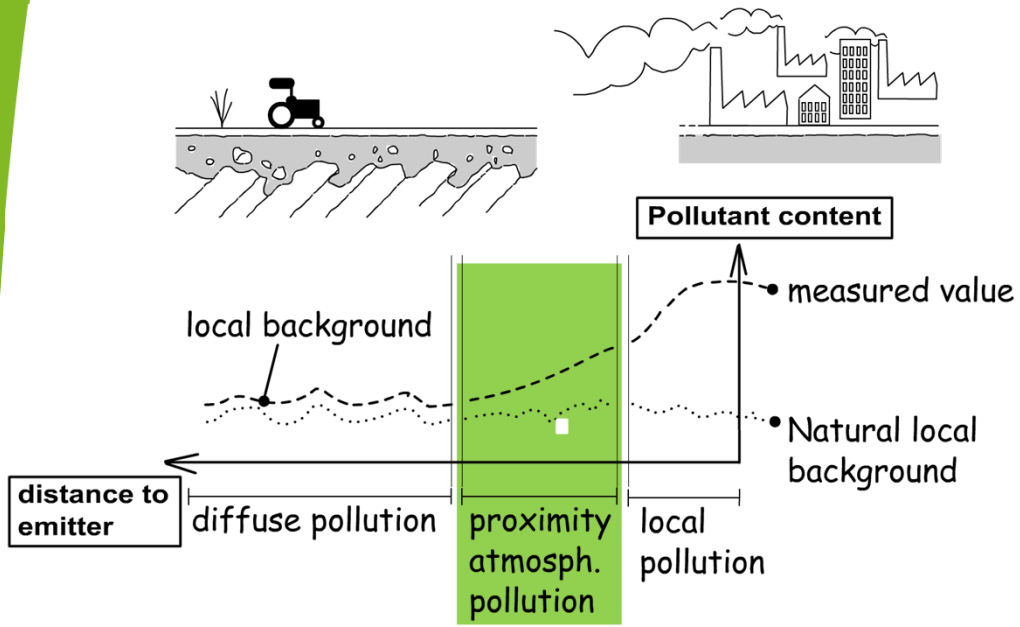
➔ 163 points, 3 depth, stratified sampling (soil, geology, land use)

Trace metal elements : As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Zn

+ Major elements : Fe, Al, Ca, Mg, Na, K, P, etc.

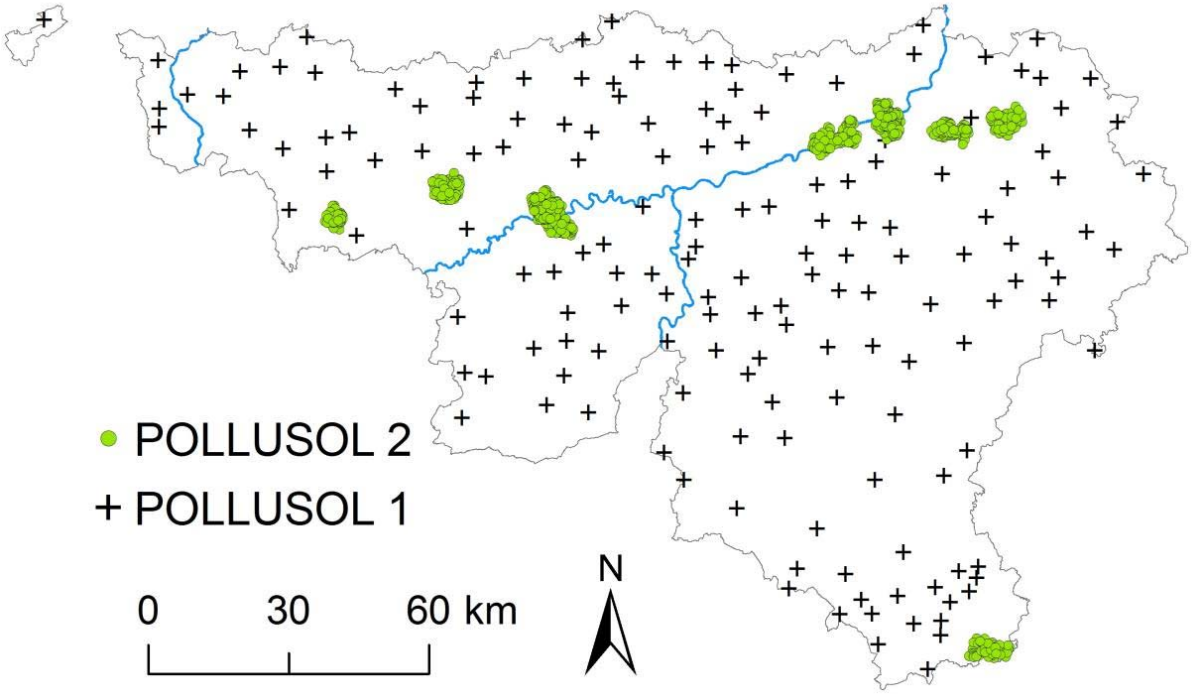


POLLUSOL 2 : urban and industrial areas



796 sampling points on 8 study areas :

- 398 vegetable garden (topsoil)
- 398 agricultural soils, forestry soils and parks (topsoil and deep horizon)



POLLUSOL 2 : collection and analysis of soils from urban and peri-industrial area

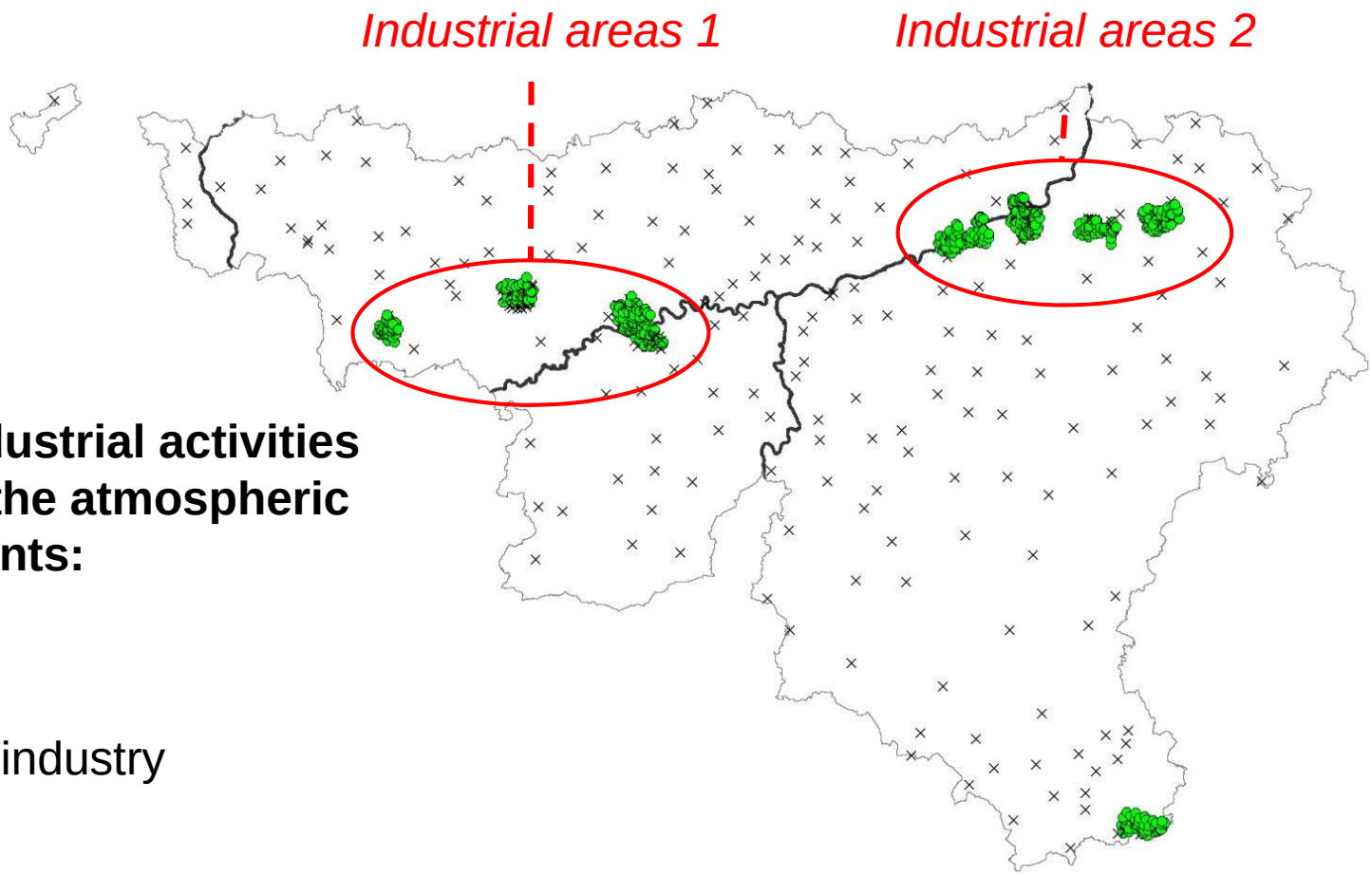
Description of sampling sites

Description of soil cores

Preparation of samples for analysis:

- General properties (pH, organic matter, etc.).
- Pseudototales concentration (aqua regia extraction) for major elements (Fe, Al, Ca, ...) and trace (As, Cd, Cu, Sb, Tl, Zn ...).
- Concentration of organic pollutants (PAHs, BTEX, EOX, ...).

POLLUSOL 2 : Location of sampling points



Predominant industrial activities responsible for the atmospheric fallout of pollutants:

Industrial areas 1

- Coal and steel industry

Industrial areas 2

- Coal and steel industry
- Nonferrous metal smelting plants (Zn, Pb)

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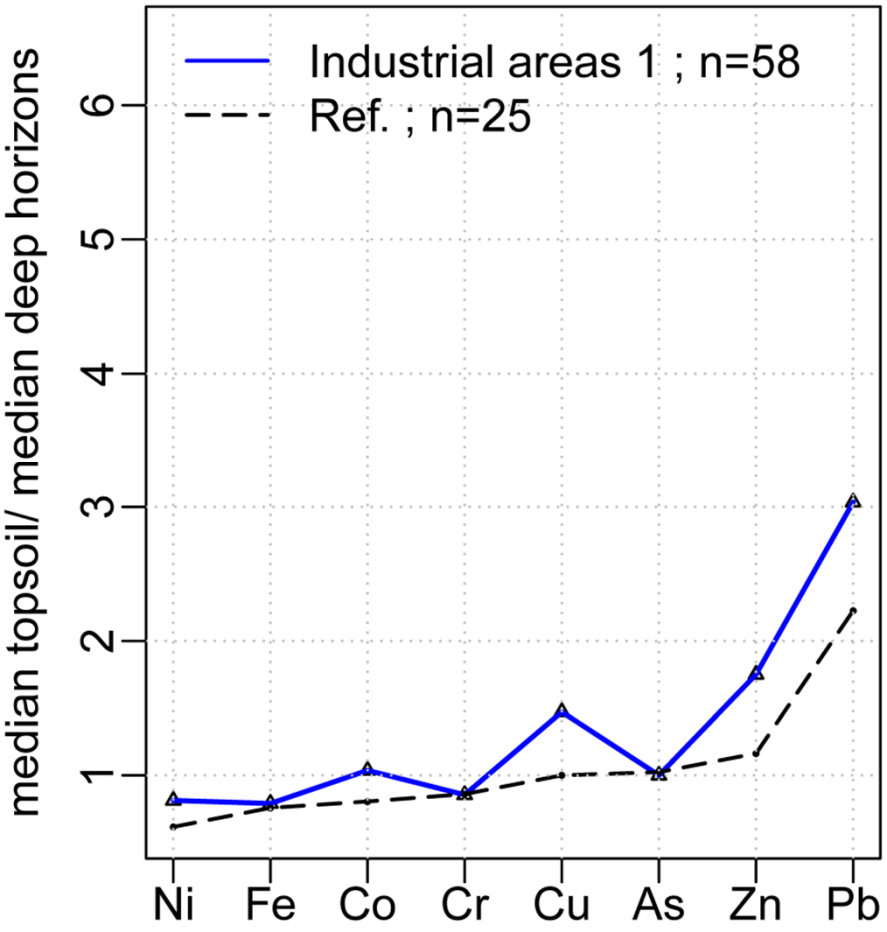
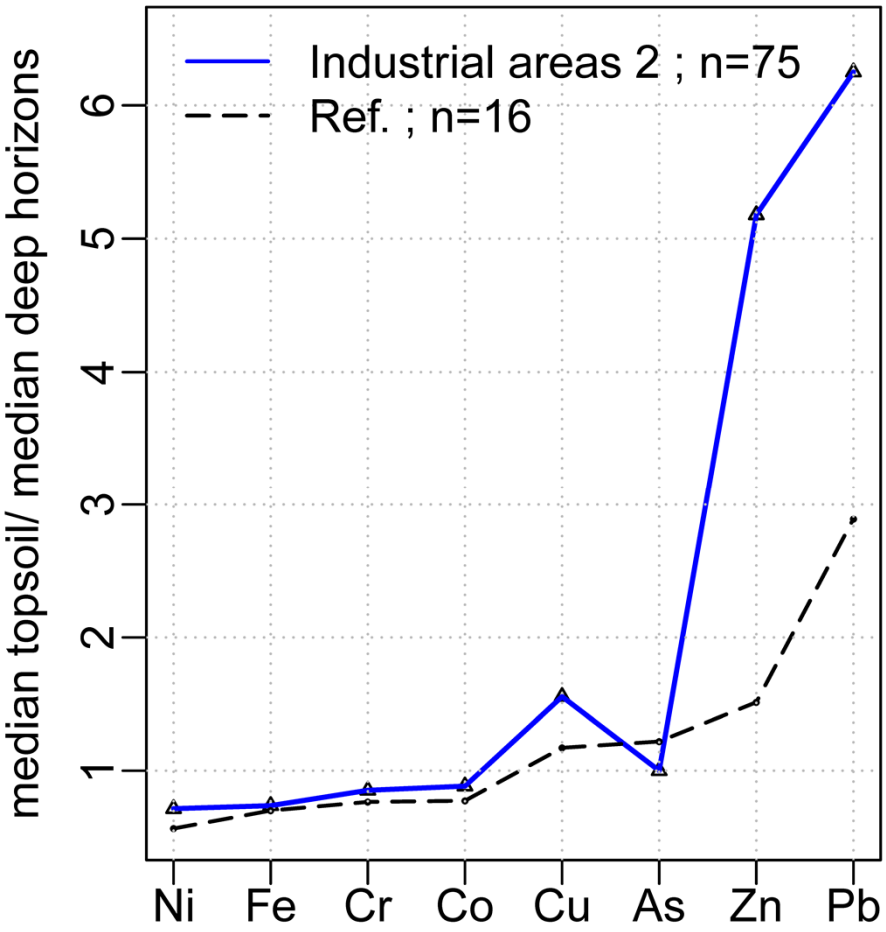
Proximal atmospheric deposition of pollutant : Topsoil enrichment ratio (farmland)

Topsoil enrichment ratio = median (topsoil / deep horizons) concentration

Industrial areas 1



Industrial areas 2



Proximal atmospheric deposition of pollutant
Topsoil enrichment (farmland)

Topsoil enrichment (mg/kg) = median industrial area – median Ref.

Topsoil enrichment (%) = *Topsoil enrichment (mg/kg)* / median Ref.

	Industrial areas 1		Industrial areas 2	
	Topsoil enrichment		Topsoil enrichment	
	(mg/kg)	(%)	(mg/kg)	(%)
Cd	/	/	1.5	150
Co	/	/	2.7	35
Cr	/	/	3.4	13
Cu	5	43	10	87
Ni	6.5	48	/	/
Pb	11	46	55	75
Zn	17	29	213	178
PAH (16 EPA)	0.68	3400	0.355	3450

"/ " + As, Hg : no proximal atmospheric deposition effect (wilcoxon test, alpha=0.05)

Land-use effect

Selection of soil (backfill soil excluded) :

	Farmland	Vegetable garden	Forest
Indu. areas 1	n=62	n=39	n=15
Indu. areas 2	n=78	n=65	n=53

For each industrial areas : pairwise comparisons between the 3 groups

Wilcoxon test, alpha=0.05

Land-use effect

Gardens > farmland > forests

Gardens enrichment : organic amendments, Bordeaux mixture (Cu), ash used as fertilizers (Ba, Co, Cr, Ni), compost from household waste (Cu, Cd, Zn).

Pollutant	Industrial areas	Gardens compared to forests	Gardens compared to farmland	Farmland compared to forests
Ba	**1**	**+251 %**	**+94 %**	+80 %
	2	**+247 %**	**+83 %**	+89 %
Cd	**1**	**+268 %**	**+60 %**	+130 %
	2	**+91 %**	**+27 %**	+51 %
Co	**1**	+62 %	+28 %	/
	2	+88 %	+24 %	+51 %
Cr	**1**	+54 %	+39 %	/
	2	+61 %	+24 %	+29 %
Cu	**1**	**+264 %**	**+131 %**	/
	2	**+76 %**	**+98 %**	/
Ni	**1**	+77 %	+30 %	/
	2	+68 %	+36 %	+23 %
Zn	**1**	**+212 %**	**+120 %**	+41 %
	2	**+238 %**	**+102 %**	+68 %

"/" : Non significant

Land-use effect

Industrial areas 1 : As, Hg, Pb, PAH

Garden = forests > farmland

Garden enrichment : compost from household waste (Pb, Hg)

	Gardens compared to farmland	Forests compared to farmland
As	+37 %	/
Hg	+104 %	+126 %
Pb	+194 %	+100 %
PAH	**+281 %**	**+249 %**
O.M.	**+96 %**	**+75 %**

"/" : Non significant

Industrial areas 2 :
As, Hg, Pb, Sn, Sb, PAH

Forests > gardens > farmland

Organic amendments, compost from household waste (Pb, PAH)

Difference between the two industrial areas is explained by differences in soil properties, particularly the organic matter (O. M.) content.

	Forests compared to farmland	Forests compared to gardens	Gardens compared to farmland
As	+61 **%**	/	+43 **%**
Hg	+166 **%**	+83 **%**	+46 **%**
Pb	**+166 %**	**+33 %**	**+100 %**
Sb	+125 **%**	+41 **%**	+59 **%**
Sn	+35 **%**	/	+32 **%**
PAH	**+330 %**	**+43 %**	**+200 %**
O.M.	**+198 %**	**+151 %**	**+19 %**

"/" : Non significant

Technogenic substrate effect

Selection of the deep horizons from soils in filling materials (123)

31 types of technogenic substrates, grouped into seven categories:

Categories	Occurrence
Coal	24
Coal-bearing shale	15
Construction (1) : brick, cement, concrete	33
Construction (2) : other than (1) : e.g. roof tiles, plaster, plastics, etc.	26
Coal combustion ash	9
Slags (steel, blast furnace, foundry, etc.)	14
Industrial waste (other than slags)	10

Technogenic substrate effect

Stepwise regression between volumic fraction of technogenic material categories and pollutants concentrations :

Categories	Main pollutants associated
Coal	As, Cd, Sb
Coal-bearing shale	Cu, Hg
Construction (1) : brick, cement, concrete	Cd, Hg, Pb, Sb, Sn, Zn, PAH
Construction (2) : other than (1)	Cd, Cu, Pb, Sn, PAH
Coal combustion ash	/
Slags (steel, blast furnace, foundry, etc.)	As
Industrial waste (other than slags)	PAH

Conclusions and perspectives

In industrial areas of Wallonia,

- land use,
- atmospheric deposition,
- technogenic materials,

affect greatly pollutant baseline concentrations

This results has been established thanks to the specifications the sampling and analyzing scheme :

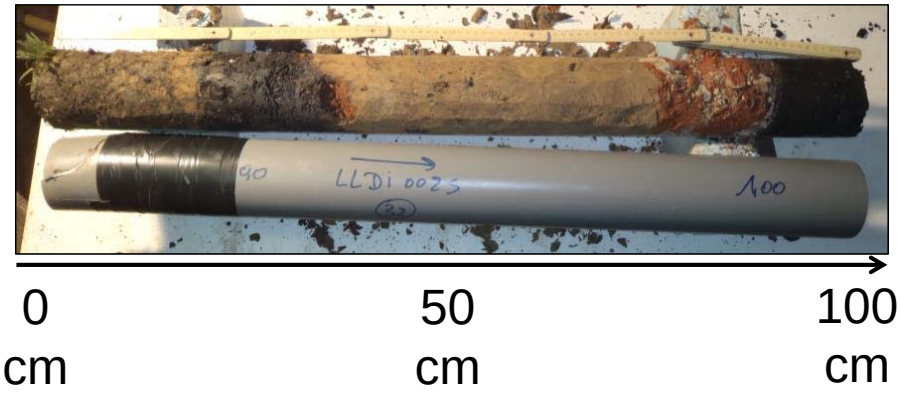
1. Detailed **description** of soil profiles

➔ distinguish between natural and artificial profile

=essential to characterize the land use and atmospheric deposition effects

➔Identify the nature of the artifacts

=essential to characterize the effect of technogenic materials



Conclusions and perspectives

2. Analysis of topsoil **and deep horizons**
➔useful to characterize the effect of atmospheric deposition
(calculate the topsoil enrichement)
➔essential to characterize the effect of technogenic materials
(limit interference with atmo. deposition)

3. Distribution of sampling points in **different industrial contexts**
➔useful for linking the atmospheric deposition with the type of industries

4. Stratified sampling of several soil types and **land uses**
➔ characterize the land use effect

Thank you for your attention !

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