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Effect of the type of contamination and land use on soil enzymatic activities: results of the french « Bioindicators program »

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Abstract

Since many decades, enzymatic activities are used to assess the effects of land use changes, agricultural practices and soil contamination on soil functioning. A lot of studies point out contradictory results depending notably on the methodology used, as well as soil characteristics...

To overcome the lack of consensus concerning indicators available to assess soil quality and functioning, the national research program "Bioindicators" (overseen by ADEME) was set up in France to develop and assay biological indicators (2006–2012). We aimed at standardizing and emphasizing the number of biochemical measurements, and developed miniaturized colorimetric methods to obtain a great enzymatic dataset.

Thirteen activities (from three laboratories) were measured within this programme, in 47 modalities of 13 experimental sites differing in terms of land use (Corine land cover), contamination type – Polycyclic Aromatic Hydrocarbons or metals – and pollution levels (Vibrisse 8th decile). This dataset allows an analysis of the effect of atmospheric or added contamination gradients on the enzymatic activities.

Our objectives are to point out the sensitivity of enzymes for each type of pollution and land use, to offer the most appropriate panel for a sensible analysis. Data were analysed for the all datasets, each site and each land use.

Our main conclusions are as follows: enzymes are more sensitive to metallic contamination than to organic ones; enzymes are good indicators of metal bioavailability; alkaline phosphatase and arylamidase are the most relevant enzymes to assess the effect of soil contamination.

OBJECTIVES

- Calibrate the bioindicators on the basis of referential values
- Provide relevant biological tools (sensitivity, accessibility, cost, ...) depending on the purpose :

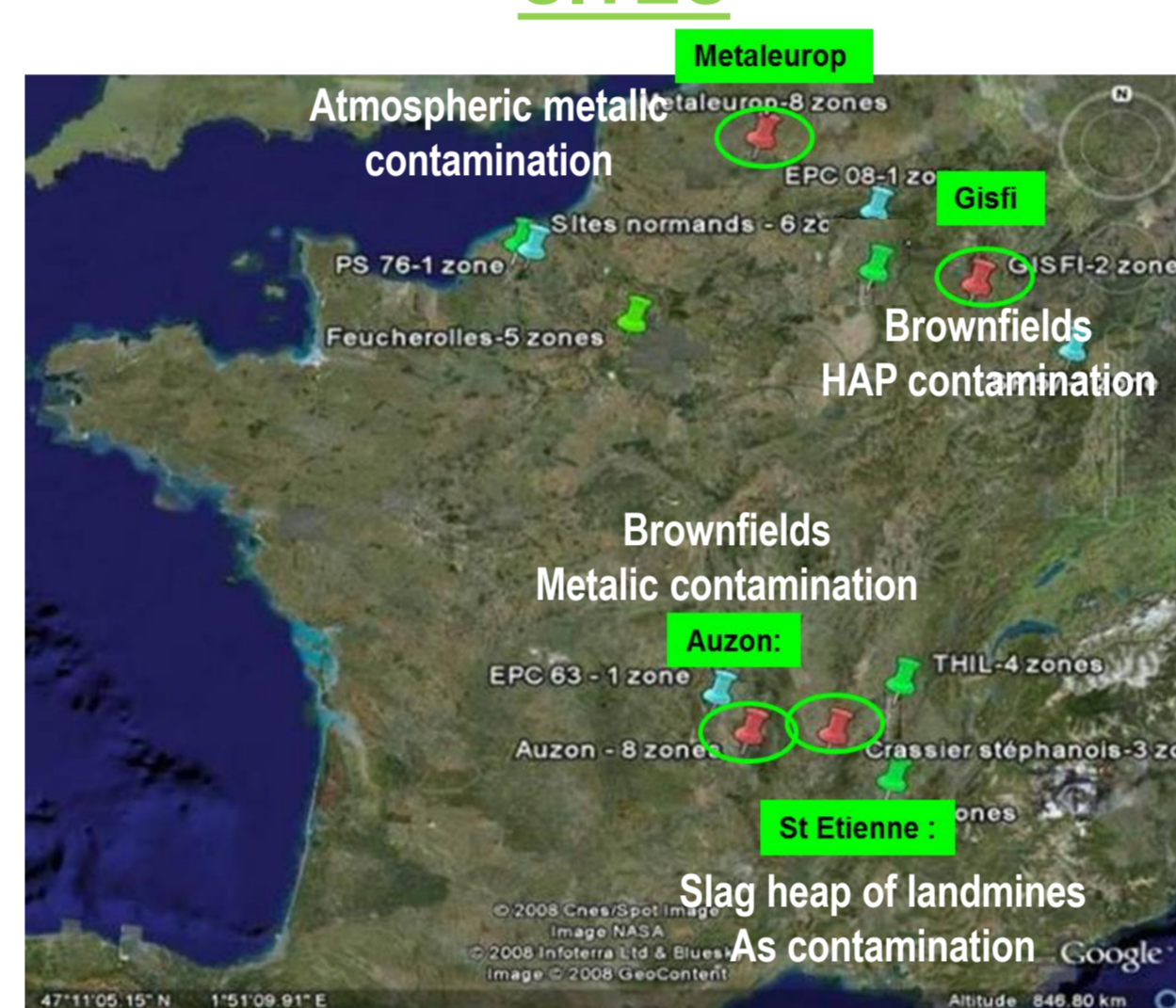
- soil monitoring
- characterization
- risk assessment

Transfer the tools to stakeholders (policy makers, farmers, technical advisers...)

Identify enzyme or group of enzyme with high potential of indication

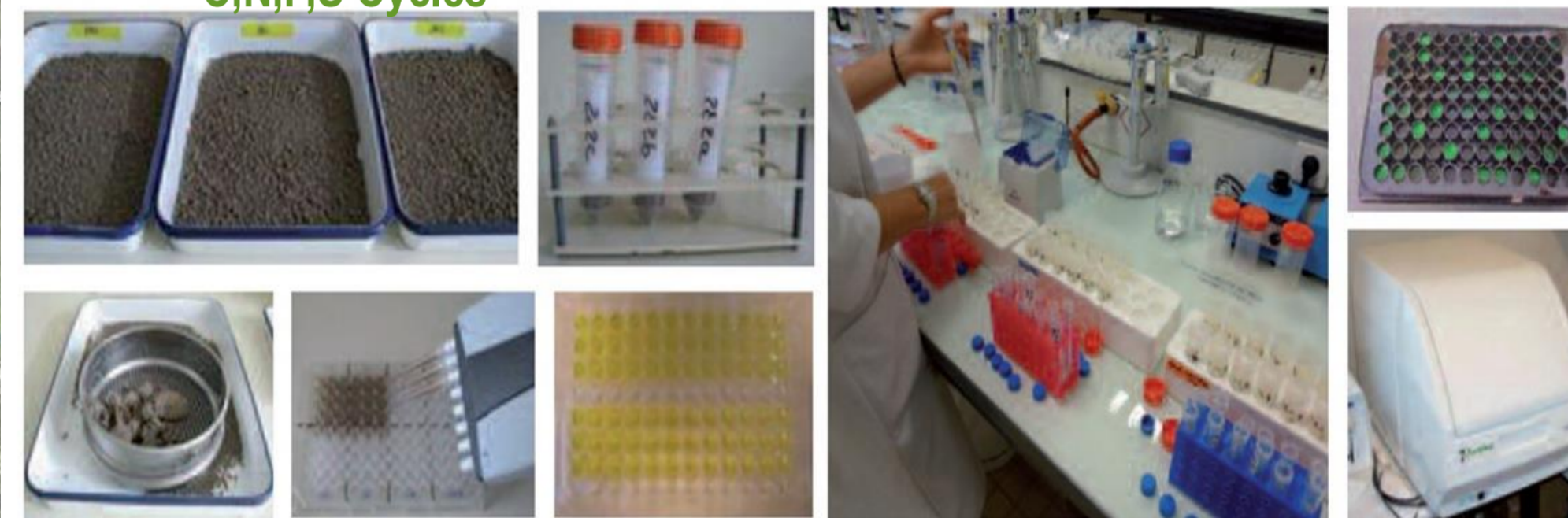
METHODS

SITES



ENZYMES

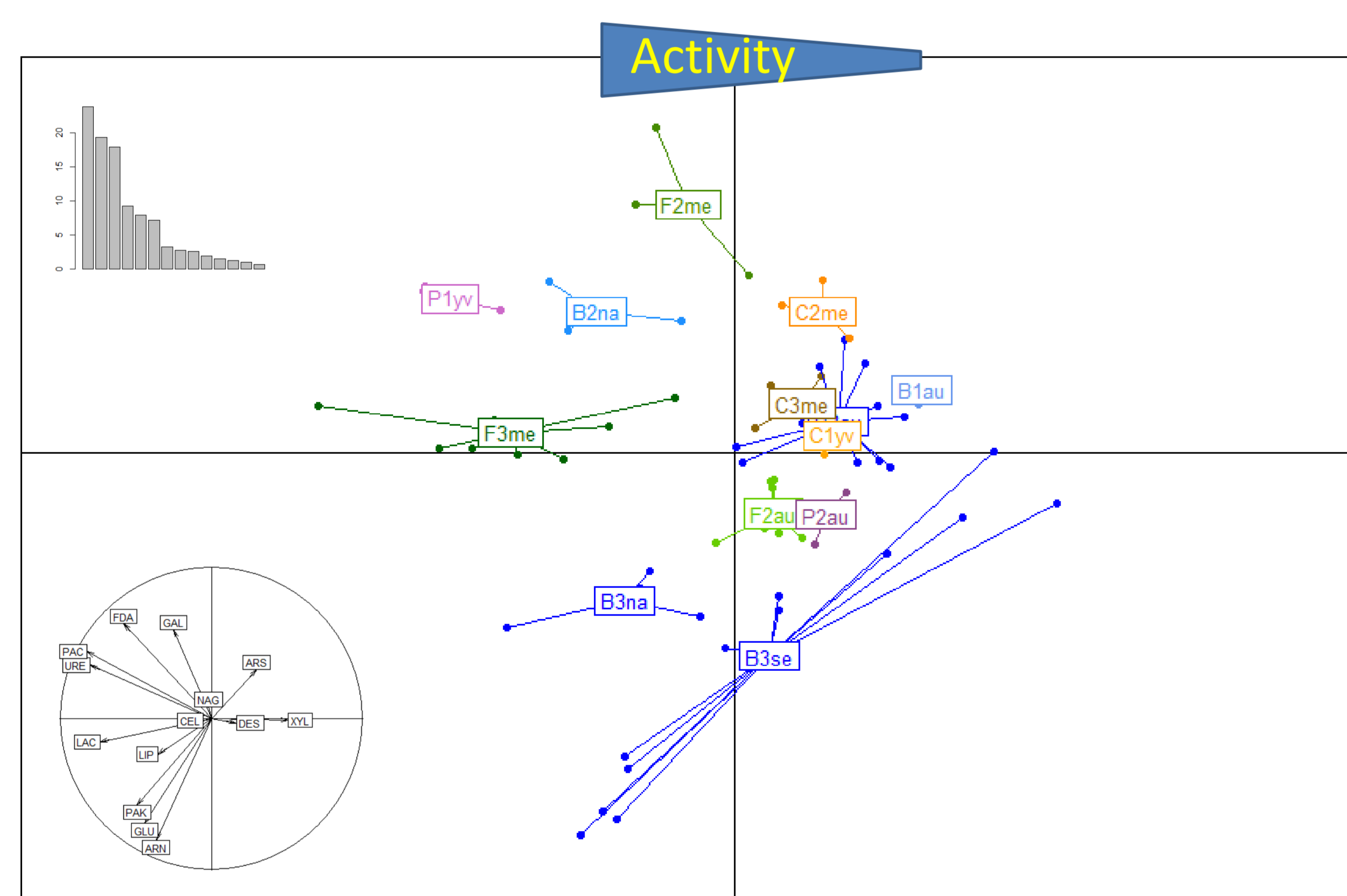
13 enzymatic activities involved in the different nutrient cycling
Global Activity
C,N,P,S Cycles



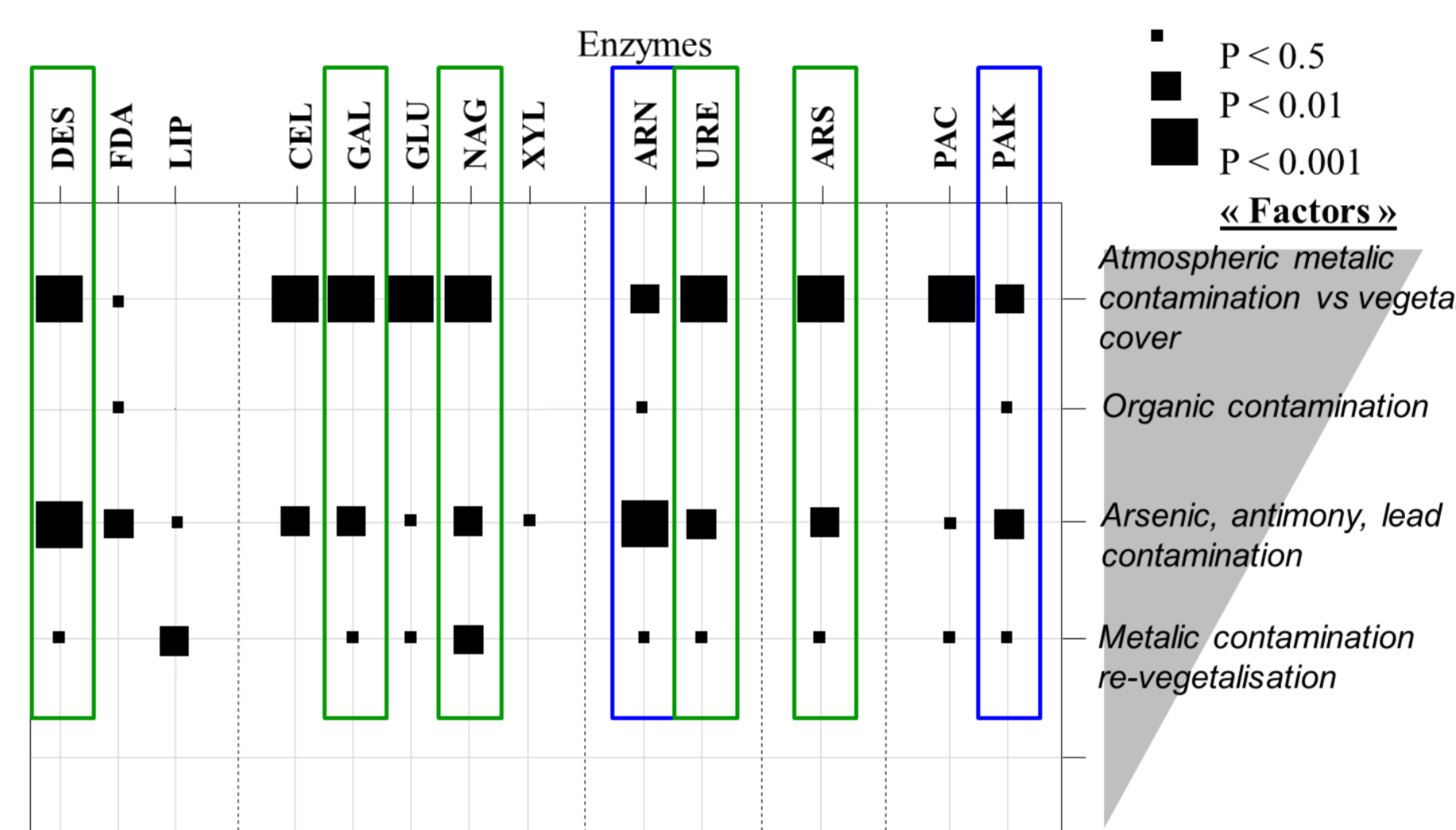
ANALYSIS

Enzymatic activities are expressed in mU/g of dry soil
Puglisi index (Puglisi and al. 2006) : AI = 7,87 β-GLU – 8,22 (ACP) – 0,49 URE
R project

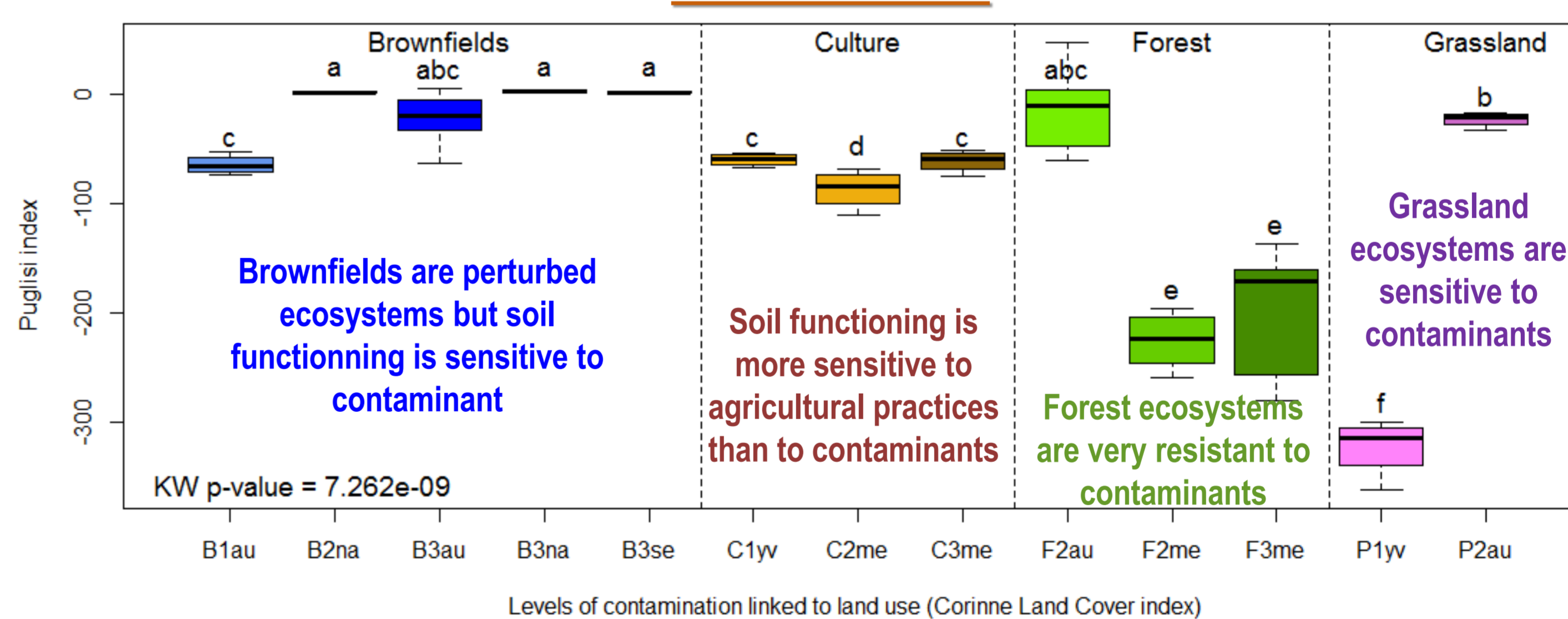
MAIN RESULTS



B=brownfield, C = annual culture, F = forest, P = Grassland
1,2,3 are for level of contamination
au, me, na, se,yv = different sites

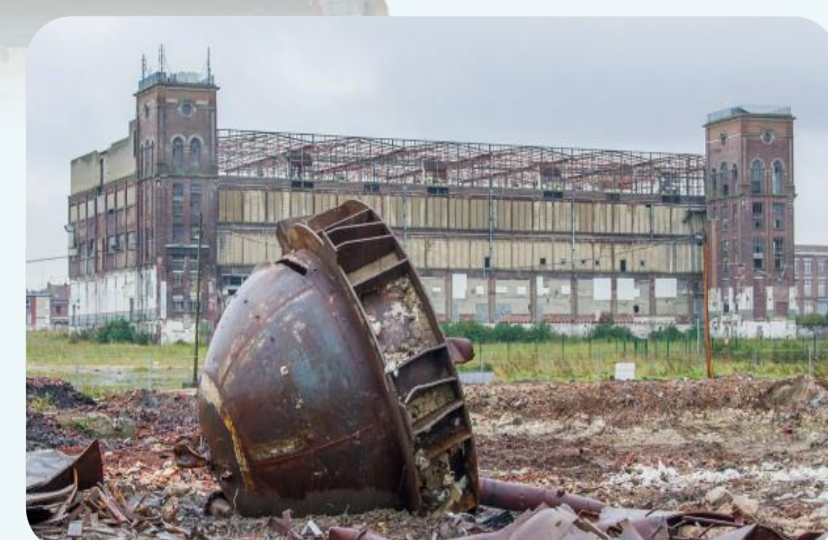


PUGLISI INDEX



CONCLUSIONS

- ❖ **ARN** and **AKP** are the most sensitive enzymes to all types of contaminations
- ❖ **NAG, URE, GAL, ARS, ARN, and AKP** are the most sensitive enzymes to metal contaminations
- ❖ **Puglisi index** allows to point out soil perturbation (agricultural soil/ grassland/ forest) and level of contamination (grassland, brownfields)
- ❖ **Forest ecosystem** is more resistant to contaminations



SOILS ENZYMES



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Enzymes	Codes	E.C. number	Substrates (buffer pH and concentration)	References
Global activities				
Dehydrogenase	DEH	1.1.1.1	2,3,5 triphenyltetrazolium chloride (pH 7: 0.12M)	Schaefer et al. 1963
Fluorescein diacetate	FDA	209.877.6	Fluorescein diacetate (pH 7.6: 1000 µg mL ⁻¹)	Adam & Duncan, 2001
C cycle				
Lipase	LIP	3.1.1.3	p-NP-palmitate (pH 8.5: 1 mM)	Gupta et al. 2002
Cellulase	CEL	3.2.1.4	p-NP-β-D-cellobioside (pH 6: 10 mM)	Trap et al. 2012
Galactosidase	GAL	3.2.1.23	p-NP-β-D-galactopyranoside (pH 7: 0.02 M)	Evazi & Tabatabai, 1988
N-acetylglucosaminidase	NAG	3.2.1.30	p-NP-N-acetylglucosamine (pH 6: 10 mM)	Trap et al. 2012
Xylanase	XYL	2.8.1.8	Xylan (pH 5.5: 12 g L ⁻¹)	Schinner & von Mers, 1990
β-glucosidase	GLU	3.2.1.21	p-NP-β-D-glucopyranoside (pH 6: 50 mM)	Evazi & Tabatabai, 1988
S cycle				
Arylsulfatase	ARYLS	3.1.6.1	p-NP-sulfate (pH 7: 25 mM)	Tabatabai & Bremner, 1970
N cycle				
Urease	URE	3.5.1.5	Urea (pH 7: 0.05 mM)	Sinsabaugh et al. 2000
Arylamidase	ARYLN	3.4.11.2	L-leucine β-naphthylamide (pH 8: 2 mM)	Martinez & Tabatabai, 2000
P cycle				
Acid phosphatase	ACP	3.1.3.2	p-NP-phosphate (pH 5: 50 mM)	Trap et al. 2012
Alkaline phosphatase	AKP	3.1.3.2	p-NP-phosphate (pH 9: 50 mM)	Trap et al. 2012
NP-nitrophenyl				