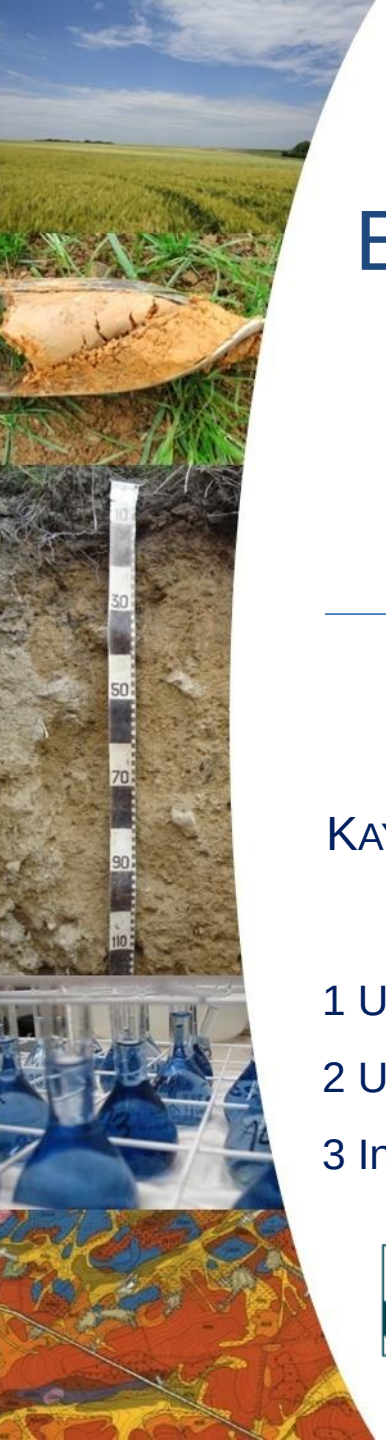

Experimental assessment of copper and cobalt phytoavailability in soils from metalliferous ecosystems in Katanga

ISMOM 2015

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2015
Année internationale des sols

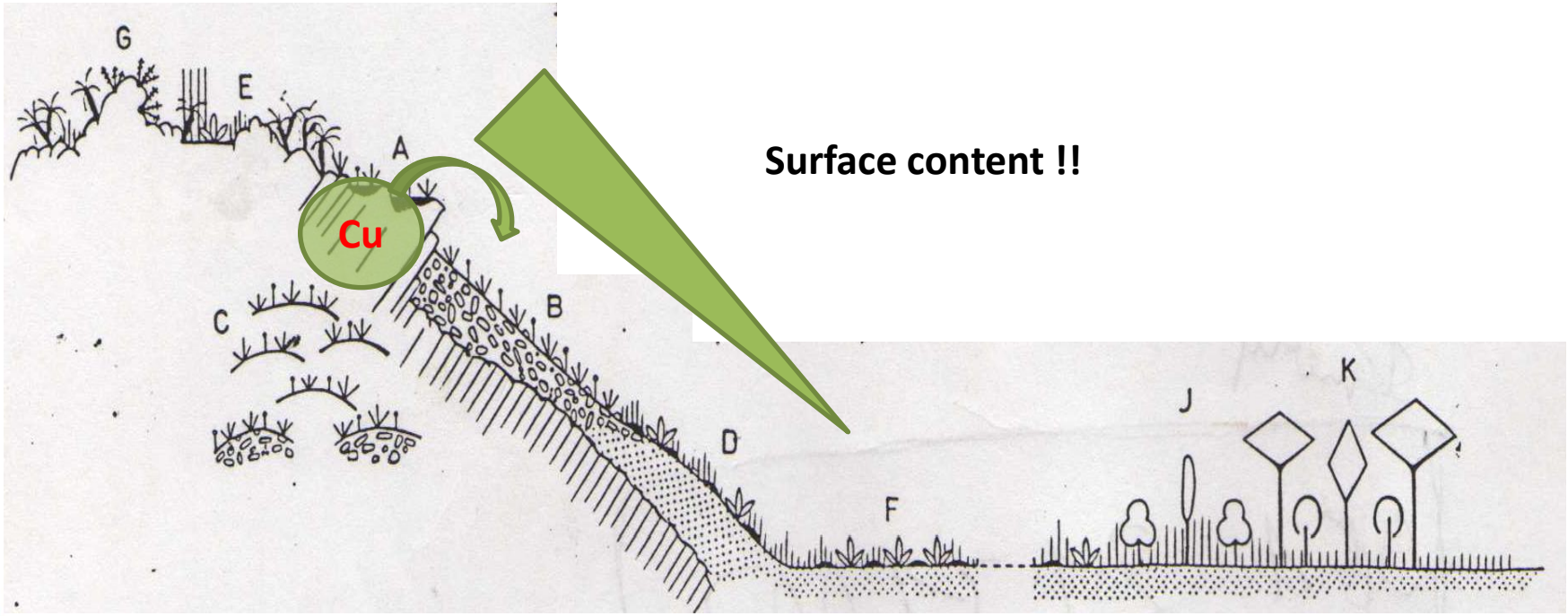
Introduction

Introduction

Introduction

Total content
-Maximum: 38,000 ppm
-Minimum: 300 ppm

Normal Cu content of Miombo forest soil
-Mean: 55 ppm
-Maximum: 325 ppm
-Minimum: 15 ppm

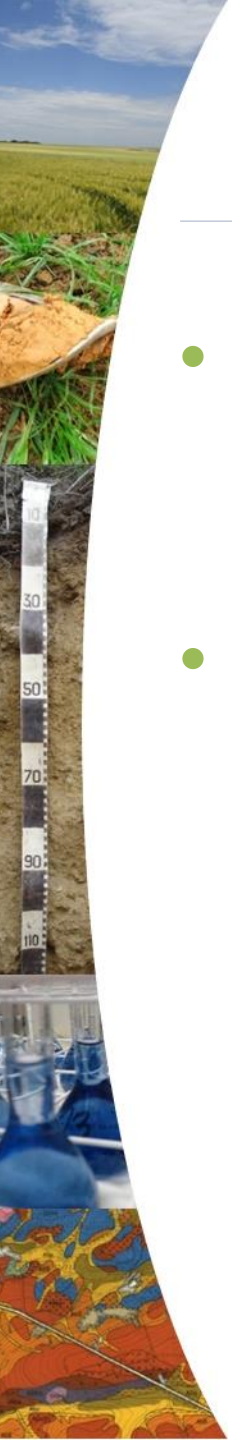


Surface content !!

(Duvigneaud & Denayer De-Smet, 1963)

Introduction

What will be restaured back after the ore mining?



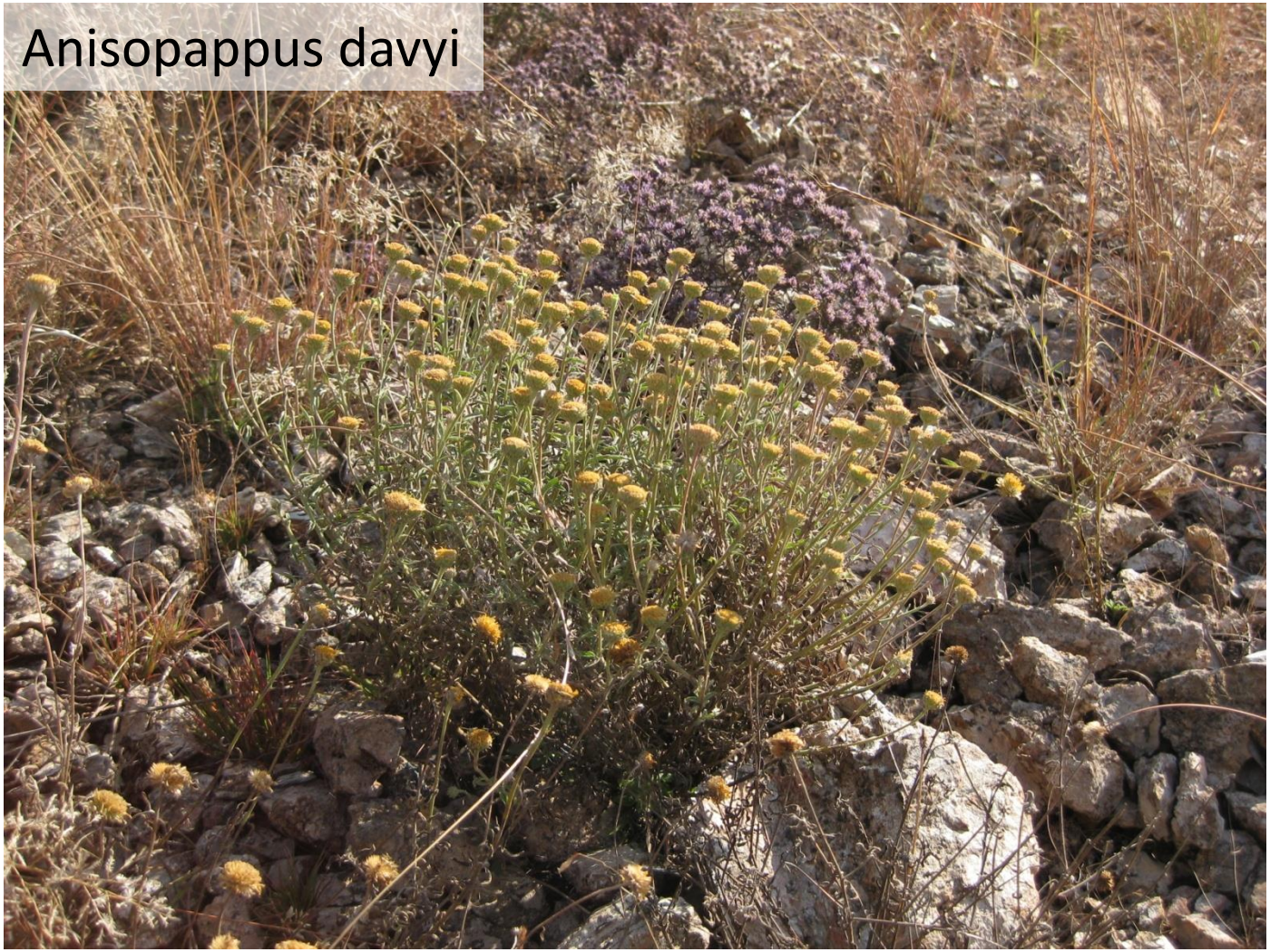
Introduction

- **General objective :** Evaluation of mobility of Cu and Co in metalliferous ecosystems from the copper-belt in Katanga (RDCongo)
- **Specific objectives:**
  - Characterization of vertical and toposequential distributions of TE content in soils;
  - Investigation of plant-soil relationships on site;
  - Experimental assessment of contaminant reaction in soils (lysimeter study)
  - Experimental assessment of TE bioavailability (pot experiment)

Introduction

- **Specific objectives:**
  - Experimental assessment of TE bioavailability:
    - How much are Cu and Co available for plants ?
      → Use of an indicator test plant adapted to local conditions
    - What are the factors that drive the availability in the metalliferous ecosystems ?
      → Selection and chemical characterization of soil under various vegetation units
      → Comparison with plant growth and accumulation

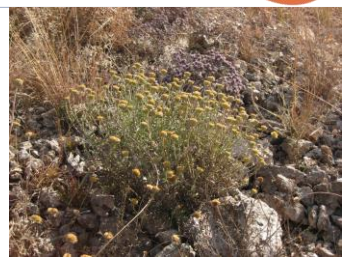
M&M: the tested plant

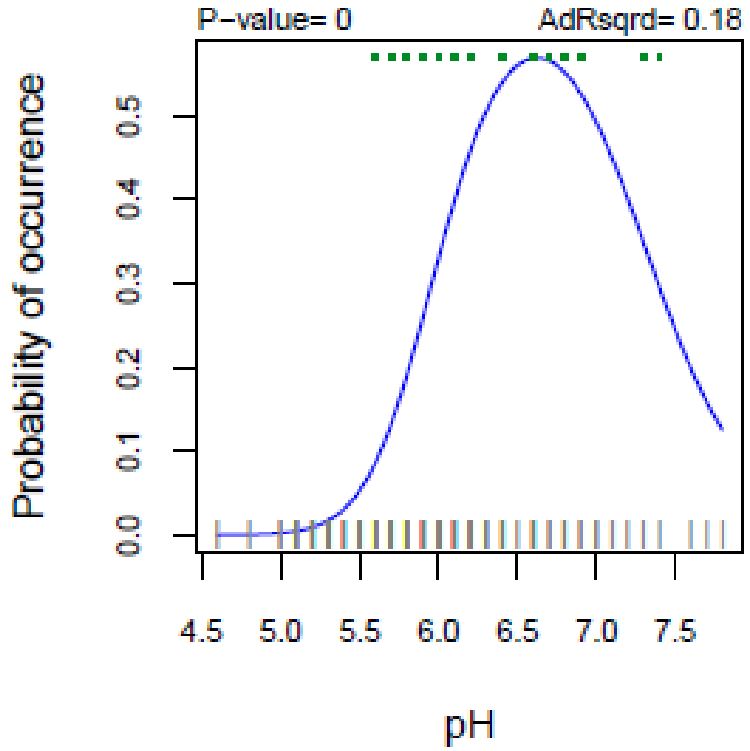


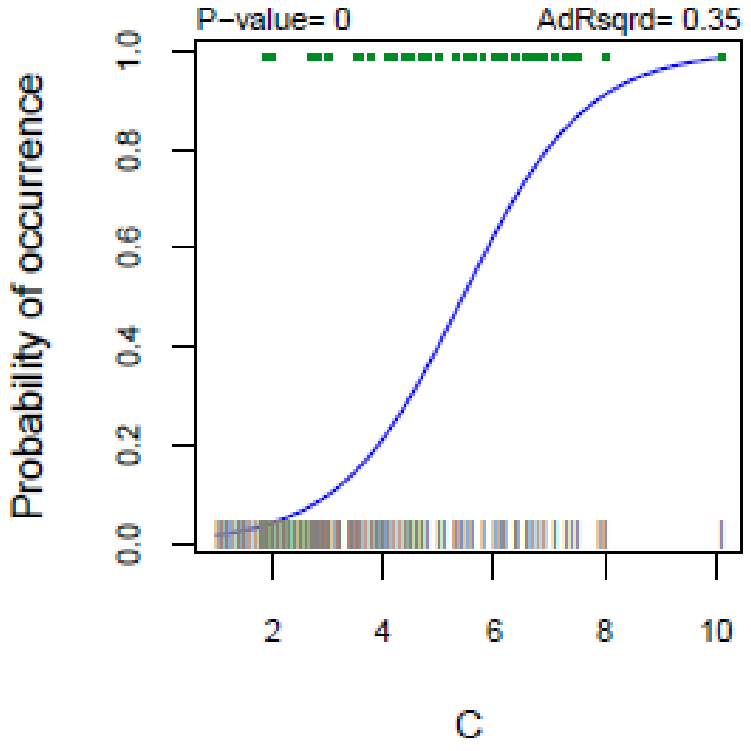
(See: http://www.copperflora.org)

M&M: the tested plant

Tolerance and accumulation according to Lange et al. (2014). *Plant Soil.*

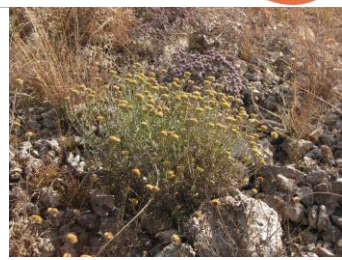


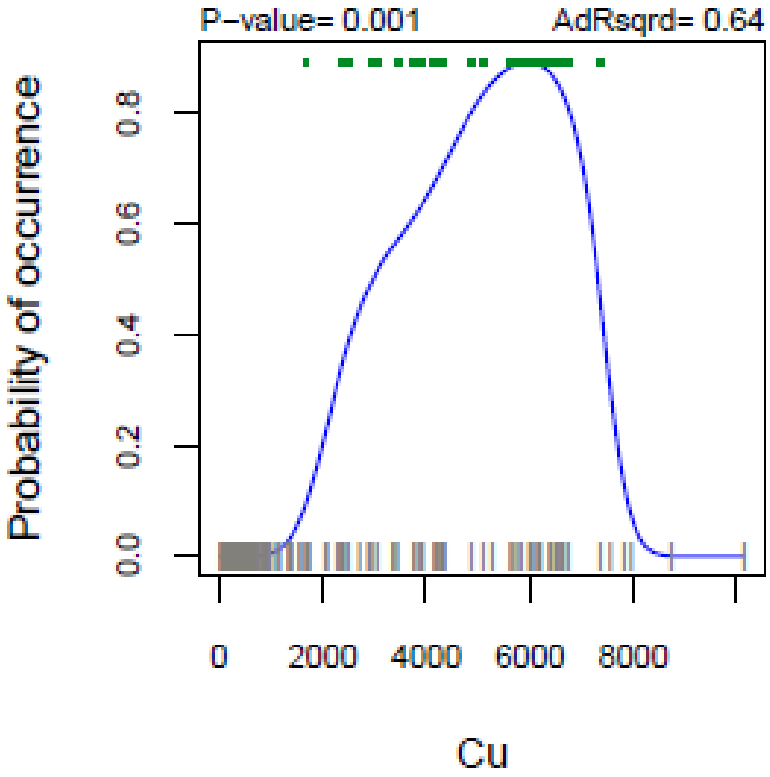


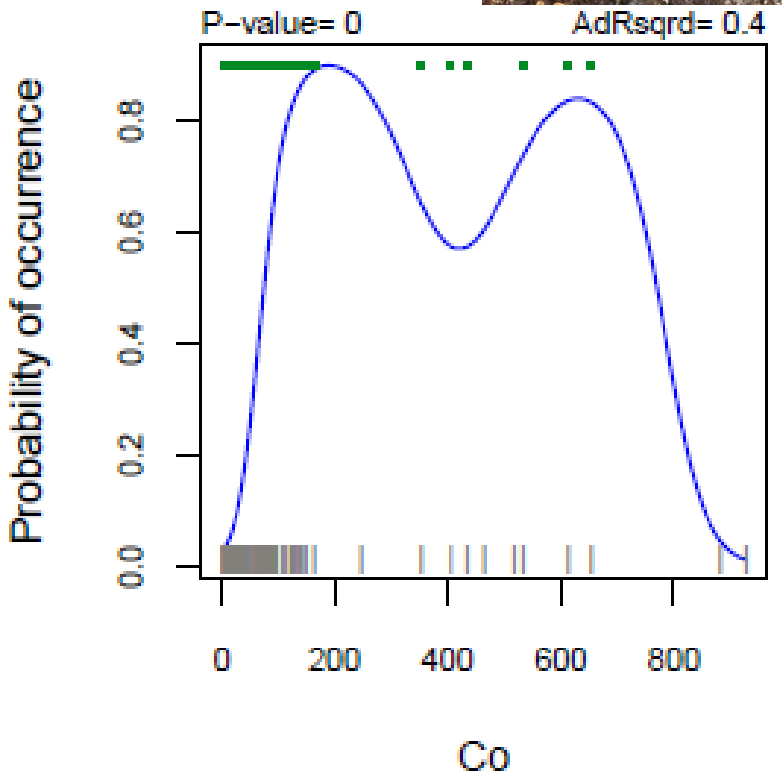


Non-parametric estimation of probability of occurrence with GAM (*unpublished*)

M&M: the tested plant



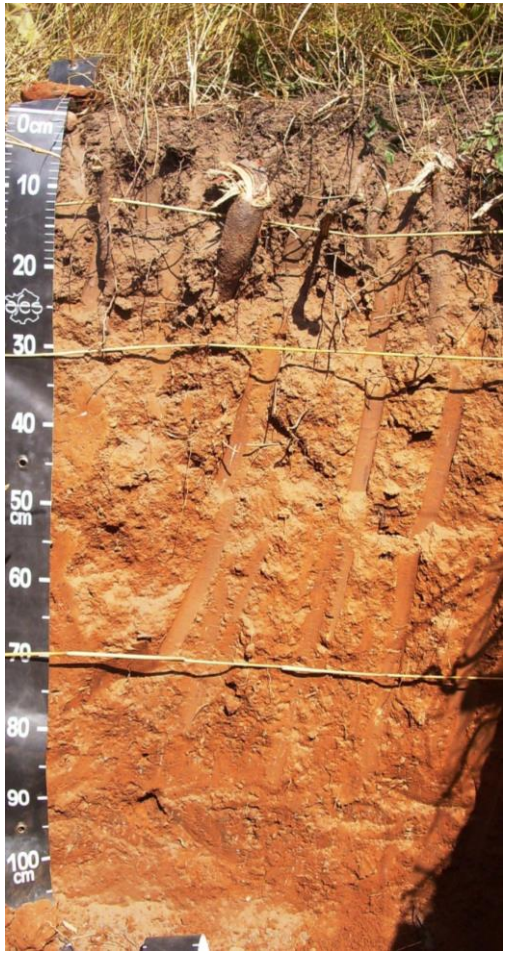


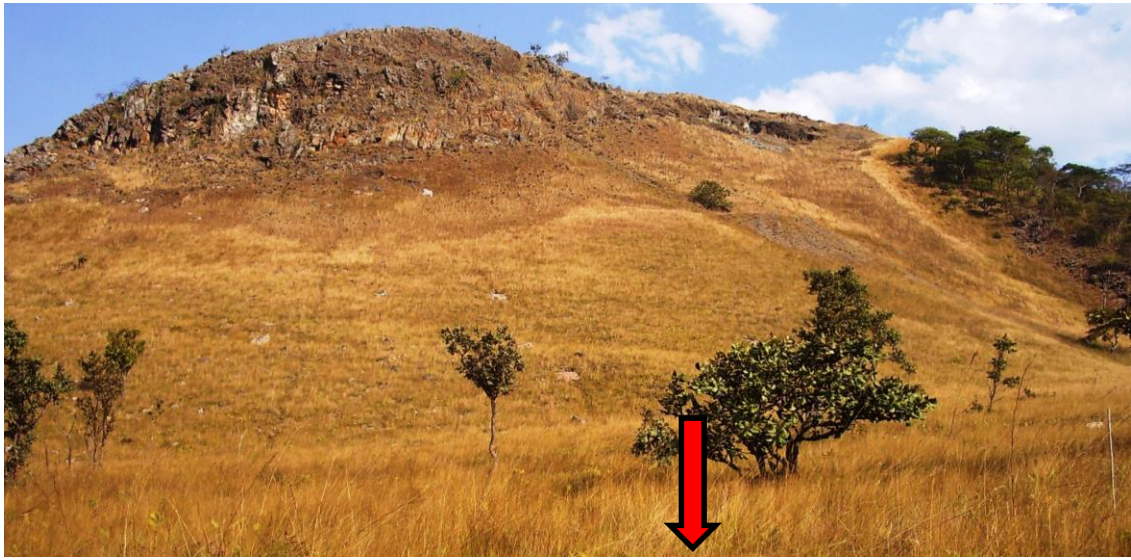


Non-parametric estimation of probability of occurrence with GAM (*unpublished*)

M&M: the soils

Four major vegetation units : steppe on dembo, deep ferralsol





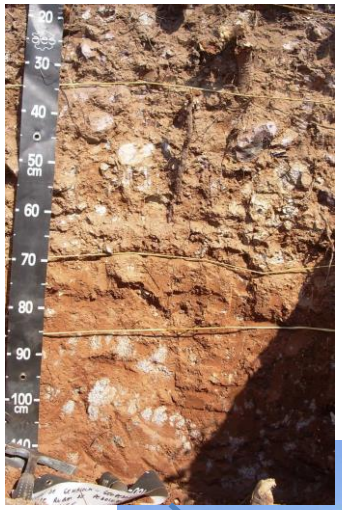
0-10cm

Soil A

M&M: the soils

Four major vegetation units : steppes and swards on slopes, on rocks

B
F
H



C
D
G

E

M&M: the soils

Two reference soils: Ferralsoil under miombo / contaminated by atmospheric deposition

M&M: the pot experiment

Pre-germination

5pots / per soil

12 plants / per pot

M&M: chemical analysis

Soils of vegetation units:

pH_{H2O}, $pH_{KCl,}$ TOC, Granulometry, C.E.C. ;

Total (HF+$HClO_4$+HCl) : Cu, Co, Zn, Mn, Al, Fe;

Available (CH_3COONH_4+EDTA) : P, Na, K, Mg, Ca, Cu, Co;

Soluble (0.01M $CaCl_2$): Cu, Co

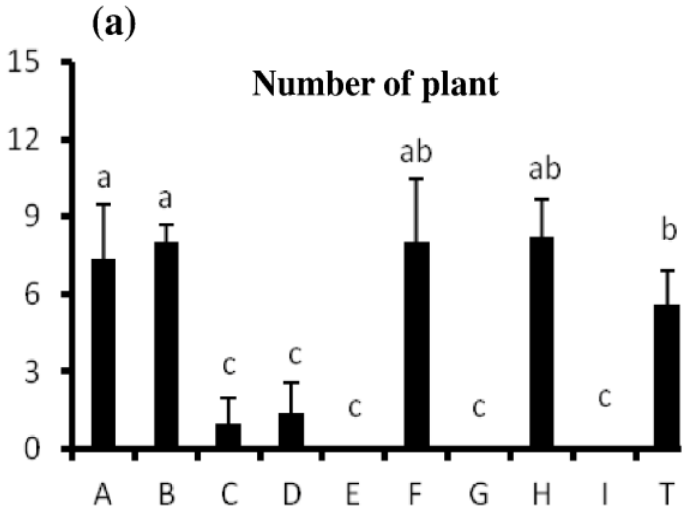
WHAM : INORG, ORG, FeOX, MnOX

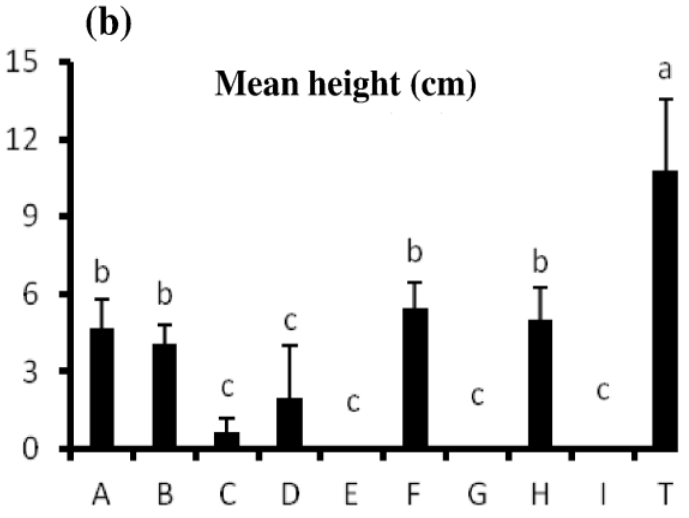
Plant roots and shoots:

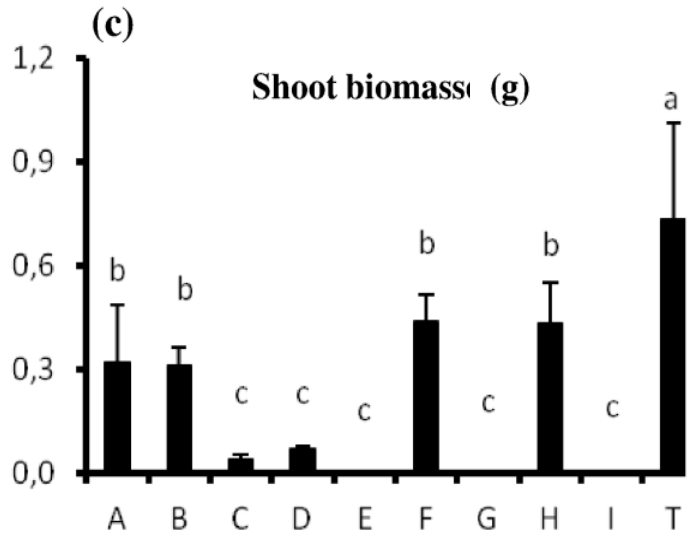
Total (HNO_3+$HClO_4$) : Cu, Co, Zn, Pb

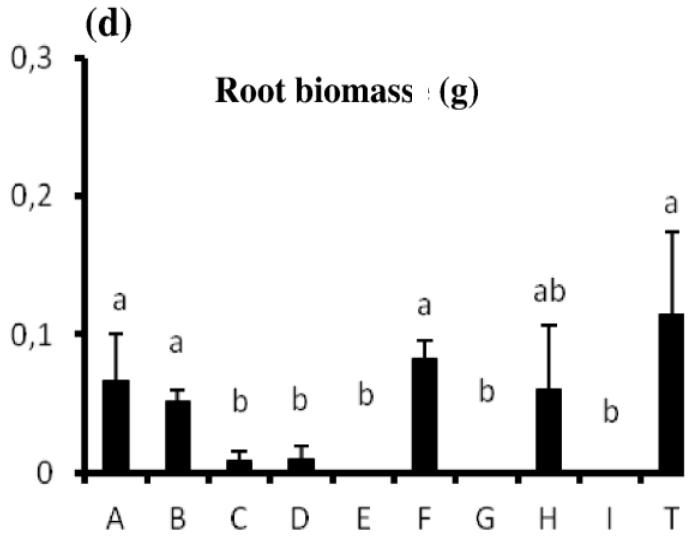
Survival; plant height.

Results


(a)
Number of plant
15
12
9
6
3
0
a a c c c ab c ab c b
A B C D E F G H I T


(b)
Mean height (cm)
15
12
9
6
3
0
b b c c c b c b c a
A B C D E F G H I T


(c)
Shoot biomass (g)
1,2
0,9
0,6
0,3
0,0
b b c c c b c b c a
A B C D E F G H I T

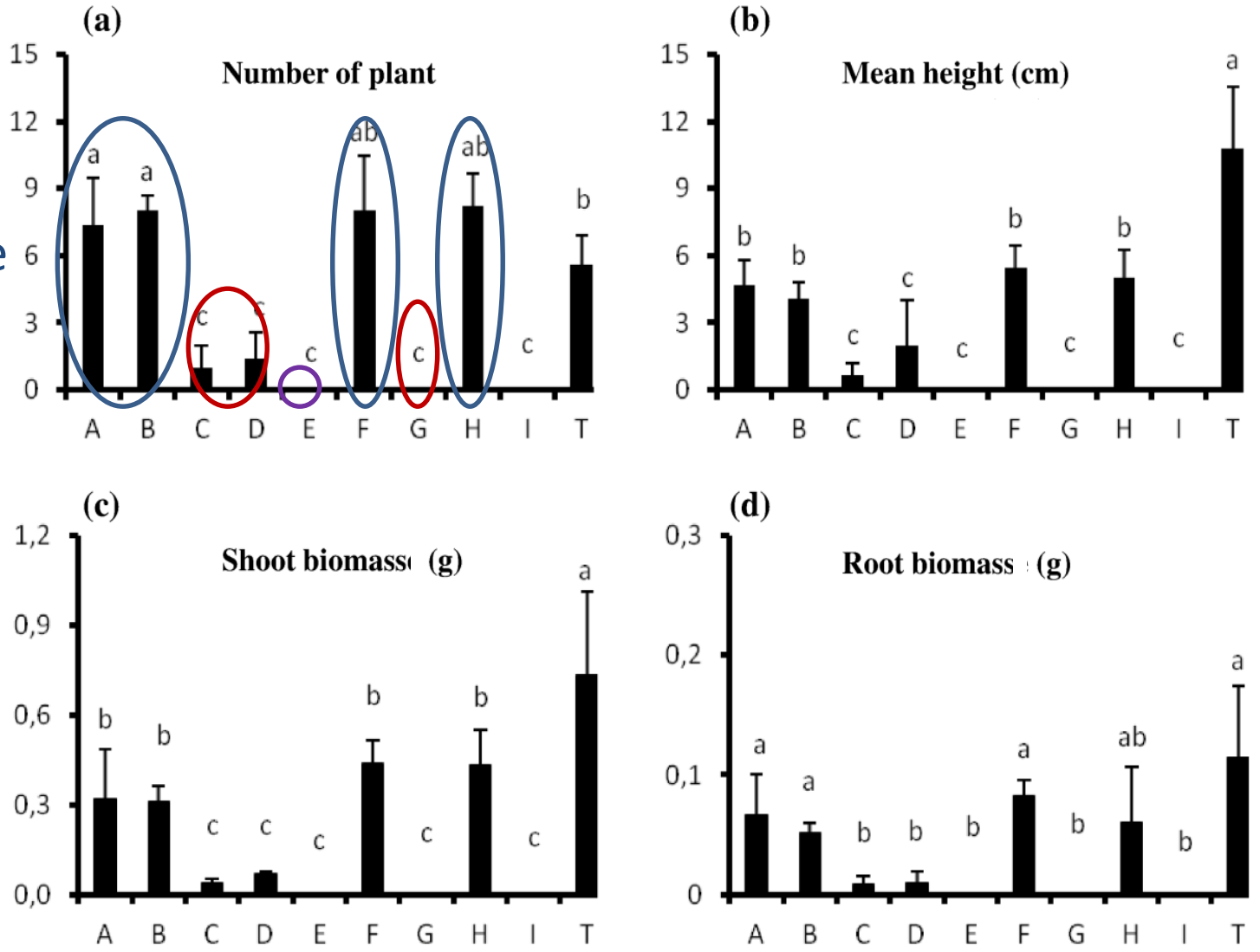

(d)
Root biomass (g)
0,3
0,2
0,1
0
a a b b b a b ab b a
A B C D E F G H I T

Results

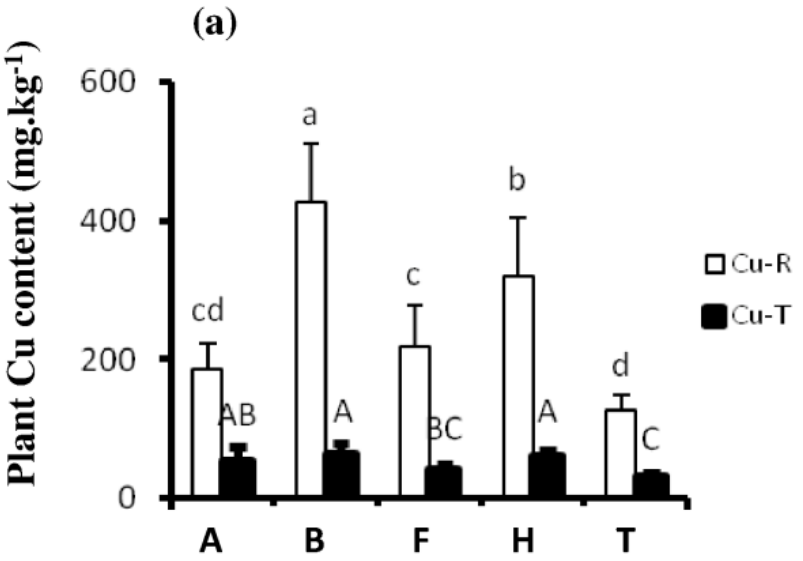
Steppe

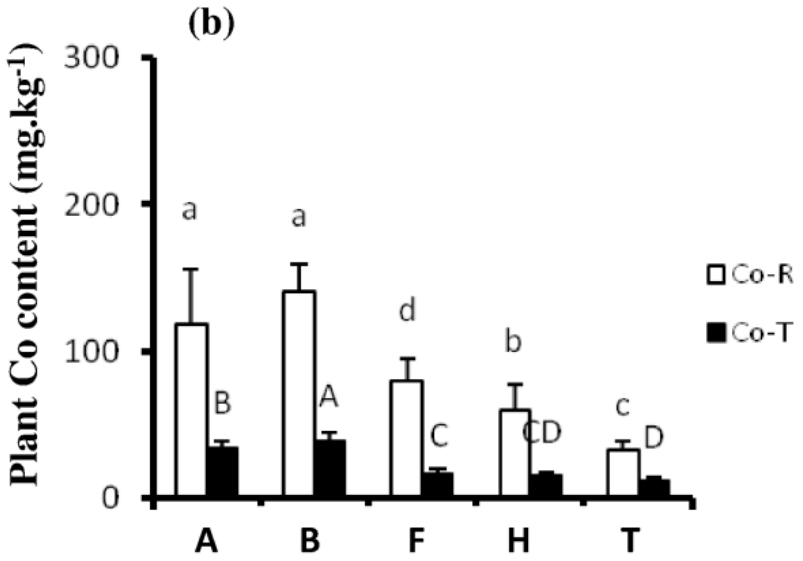
Sward

rocks



Results





→ A. davyi is not an hyper-accumulator (< 1000 µg/g Brookes et al.; < 300 µg/g Van der Ent et al)

→ Transfer factors : 0.15-0.30 for Cu and 0.20-0.40 for Co

→ Mineralomass: Roots < Shoots

Results

Unit	pH		TOC*	C	St	Sd	Nutrients (mg.100g^{-1})			
	H_2O	1N KCl	%	%			P	K	Mg	Ca
A	5.4	4.9	2.03	29.5	18.0	52.5	0.5	10.7	12.9	11.8
B	5.6	5.2	3.89	21.8	31.4	46.8	1.4	10.7	15.4	41.3
C	6.5	6.0	5.98	8.4	25.8	65.8	15.0	9.7	32.6	267.4
D	6.5	6.3	2.44	8.3	25.4	66.3	8.6	4.5	6.4	23.6
E	6.8	6.5	5.77	5.9	31.8	62.3	25.1	12.2	45.9	345.4
F	5.6	5.2	2.96	40.1	29.1	30.8	0.9	18.6	28.0	29.7
G	6.3	5.7	5.01	25.6	36.2	38.2	5.4	6.0	4.0	13.2
H	5.6	5.3	2.72	24.6	31.8	43.6	0.8	10.8	15.2	36.5
T	4.4	3.9	3.79	29.5	34.9	34.6	2.1	8.4	8.8	6.4
I	5.4	5.3	3.71	-	-	-	5.3	9.4	6.8	19.8

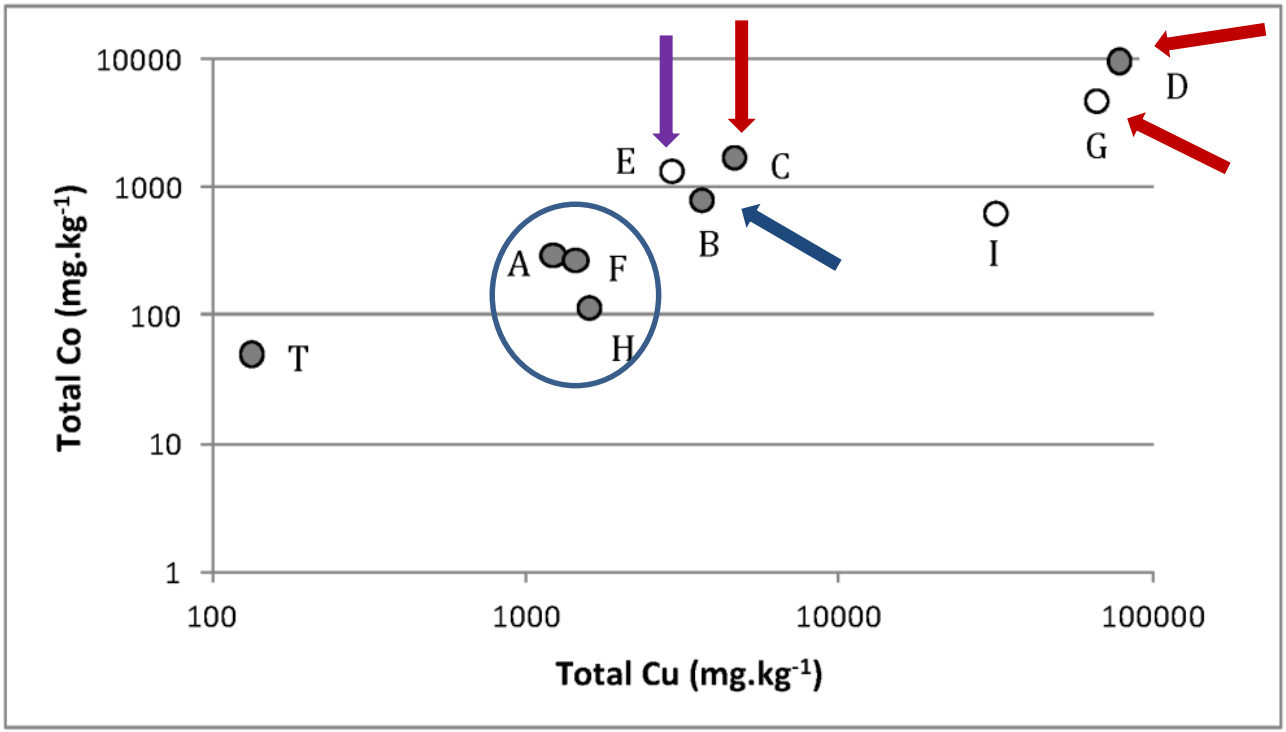
→ Swards and rocky steppe : neutral reaction – « eutrophic »

→ Steppes : slightly acidic and dystrophic

→ Non-contaminated reference : Very acidic

Results

(a)

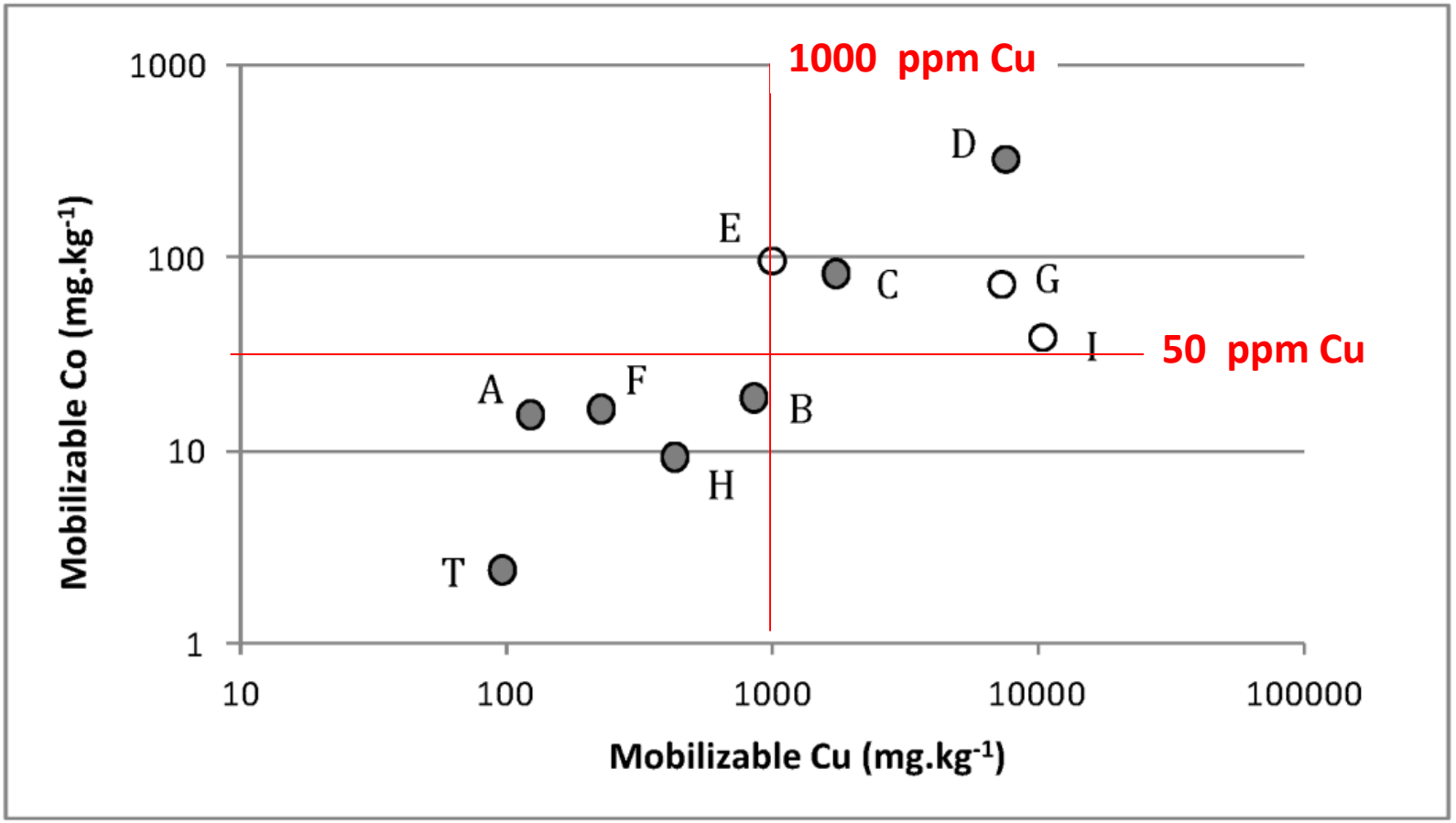


→ Linear correlation between total Cu and Co

→ Linear correlation between Total, available and soluble

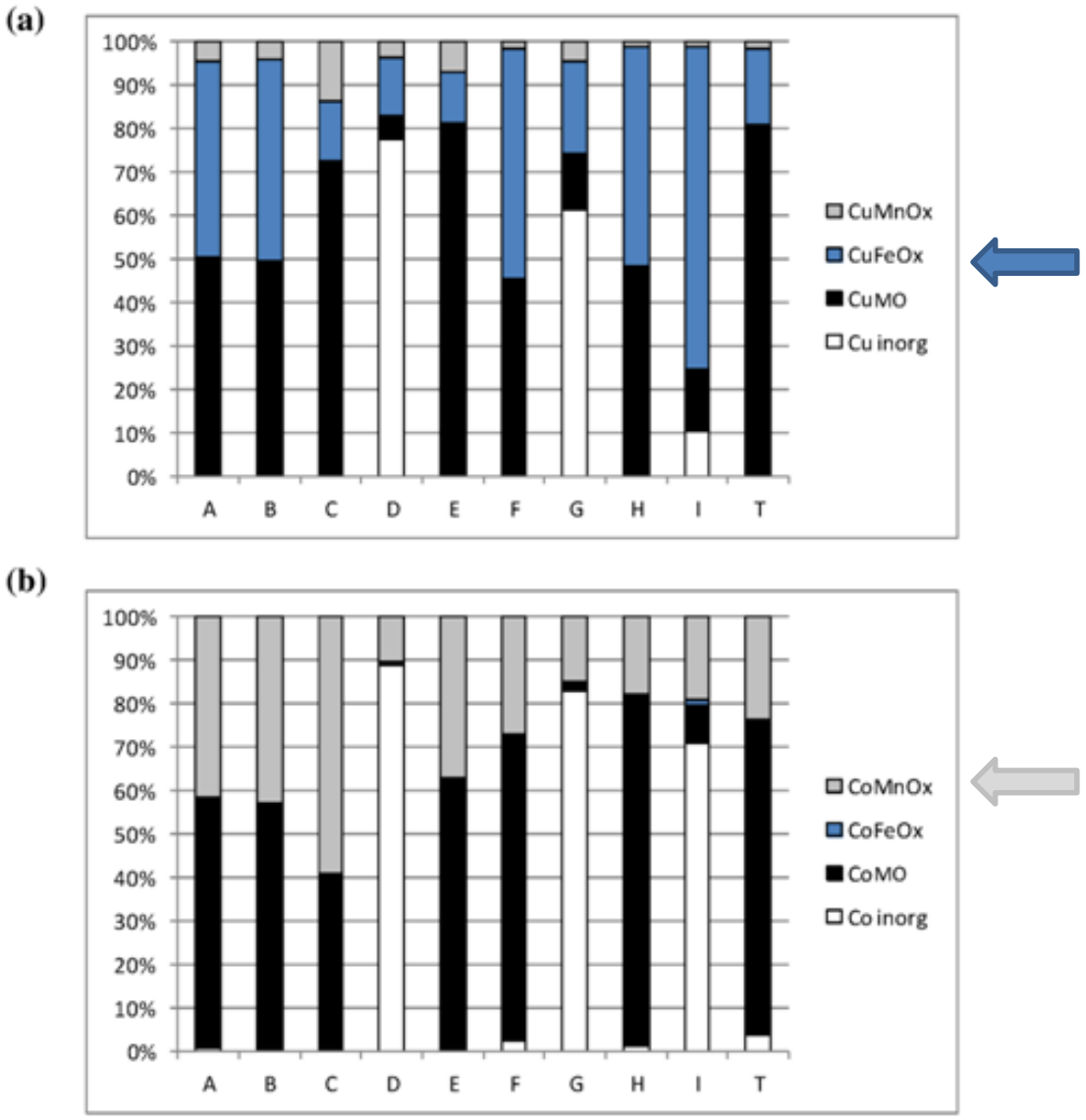
→ Partial discrimination of vegetation units

Results


1000 ppm Cu
50 ppm Cu
1000
100
10
1
Mobilizable Co (mg.kg-1)
10
100
1000
10000
100000
Mobilizable Cu (mg.kg-1)
D
E
C
G
I
A
F
B
H
T

Results

Geochemical modelling predicts differences between young and old swards :
→ ageing effect?



Results

	Shoot Cu	Root Cu	Shoot Co	Root Co
Total Cu / Co	0,773 NS	0,943 *0,016*	0,857 NS	0,883 *0,047*
Mobilizable Cu/Co	0,732 NS	**0,973** *0,005*	0,756 NS	**0,892** *0,042*
Mobile Cu/Co	0,731 NS	0,931 *0,021*	0,840 NS	0,878 *0,050*
Free Cu/Co	0,143 NS	0,173 NS	-0,162 NS	0,043 *0,040*
MnOx Cu/Co	0,650 NS	0,794 NS	**0,888** *0,044*	**0,885** *0,046*
FeOx Cu/Co	**0,774** NS	**0,948** *0,014*	0,843 NS	0,865 NS
OM Cu/Co	0,774 NS	0,941 *0,017*	0,824 NS	0,872 NS
pH	0,746 NS	0,664 NS	0,477 NS	0,645 NS
TOC	-0,222 NS	0,273 NS	-0,077 NS	-0,129 NS
Total Fe	-0,236 NS	0,071 NS	-0,009 NS	-0,173 NS
Total Mn	0,415 NS	0,512 NS	0,786 NS	**0,900** *0,037*

Conclusion

1.

Soil characterization confirmed the importance of the link with the vegetation units :

- Swards and rocky steppe are clearly different from steppic savanas and forest according to parent material and geochemical background in Cu and Co, but also to acidic and trophic status, or granulometry.
- There is also a clear distinction between swards according to the ancientness of rock outcrop : D and G develop on material recently brought to the soil surface compared to C and E. (see geochemical modelling)

Conclusion

2.

The behaviour of *A. davyi* (survival and growth) on diverse soil conditions included :

- Death of the plant for high levels of Cu and Co. The range of bioavialble content above which a drastic reduction of survival has been observed was 1,000 $mg.kg^{-1}$ for Cu and 50 $mg.kg^{-1}$ for Co.
  If these results are confirmed, bioavailability tests could be set up with A. davyi.
  Mortality thresholds, ecological ranges and conditions for linearity accumulation should therefore be defined.
- Comparisons with previous observations on the field (GAM)

Conclusion

3.

- The comparison of plant content to chemical extractants and geochemical modelling showed that the Lakanen et al. (1971) method was adapted to the prediction of the plant content : → largely used by authors in Katanga
- Total and $CaCl_2$ methods are significantly correlated to Lakanen et al. and hence give similar information.
- The geochemical modelling is potentially useful to predict the distribution of contaminants among solid phases and assess their mobility in the soil-plant systems.

Thank you for your attention