Soil, plant and red mud: Case study of two deposits in Provence

– DORIS Project –

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Annual Labex DRIIHM Symposium
Interdisciplinary Research Design on Human-Environments Interactions
October 8th-10th, 2018 – Marseille-La Couronne (France)

Research objectives

How these bauxite residues interact with terrestrial ecosystems through the soil-plant continuum?

<u>The researches undertaken were aimed</u>:

- To study the effects of bauxite residues on the biogeochemical characteristics of soils
- To explore how and to what extent these tailings modulated the structuring and functional responses of pedobiological components
- To determine the impacts on the functioning of these pedosystems
- To consider valuation solutions and to recommend management actions of past, current, and forthcoming deposits

Study sites

Terrestrial deposits

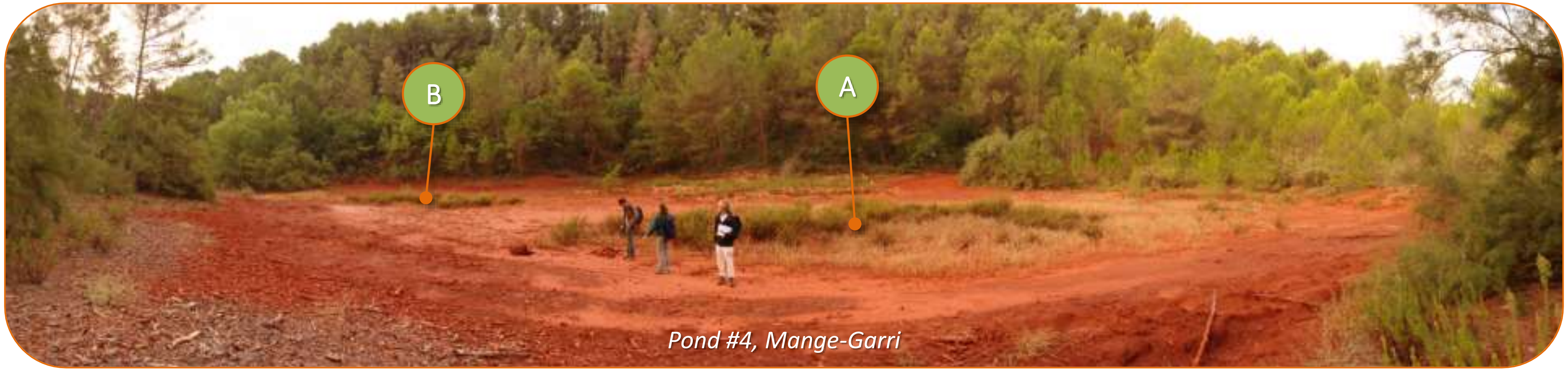
Mange-Garri, Bouc-Bel-Air

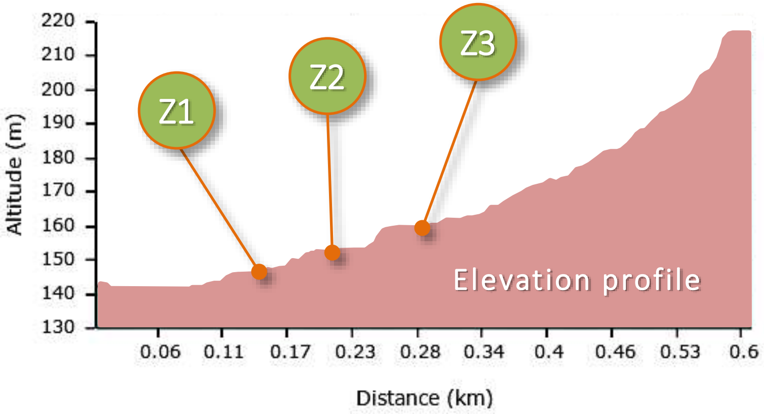
Pond #4

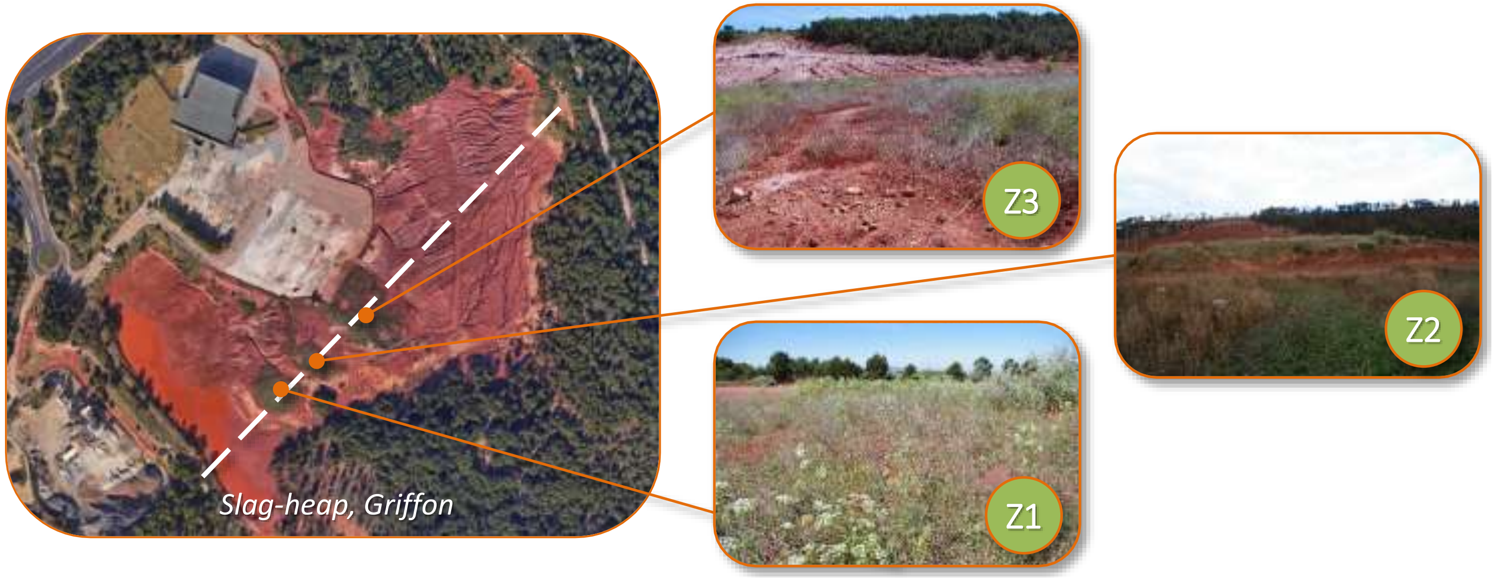
Griffon, Vitrolles

Slag-heap

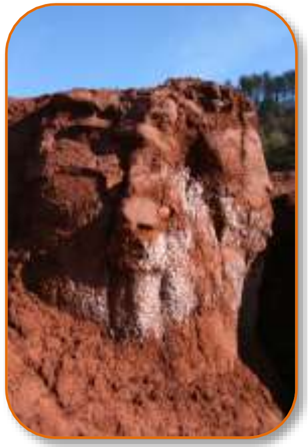
Study stations







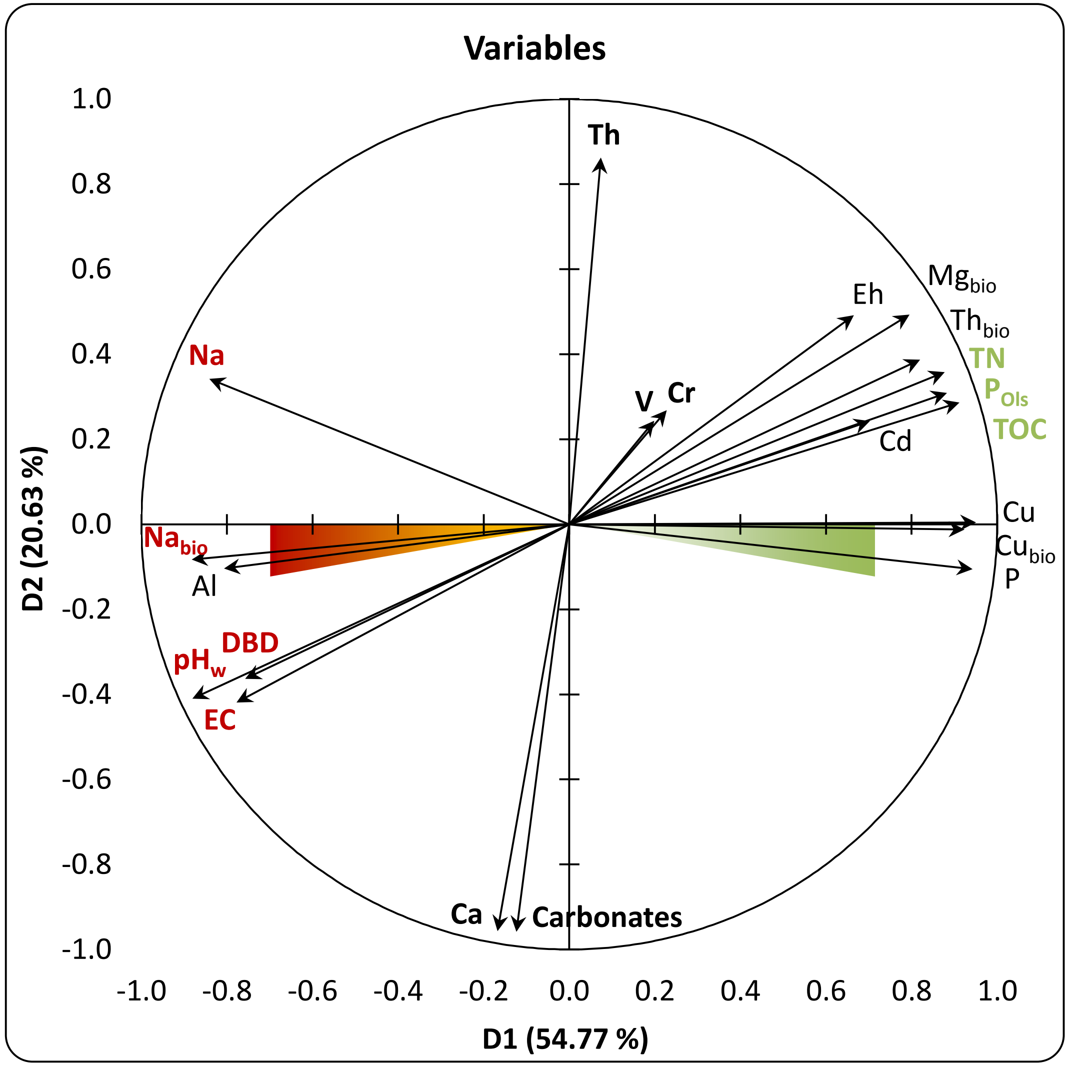
Biogeochemistry

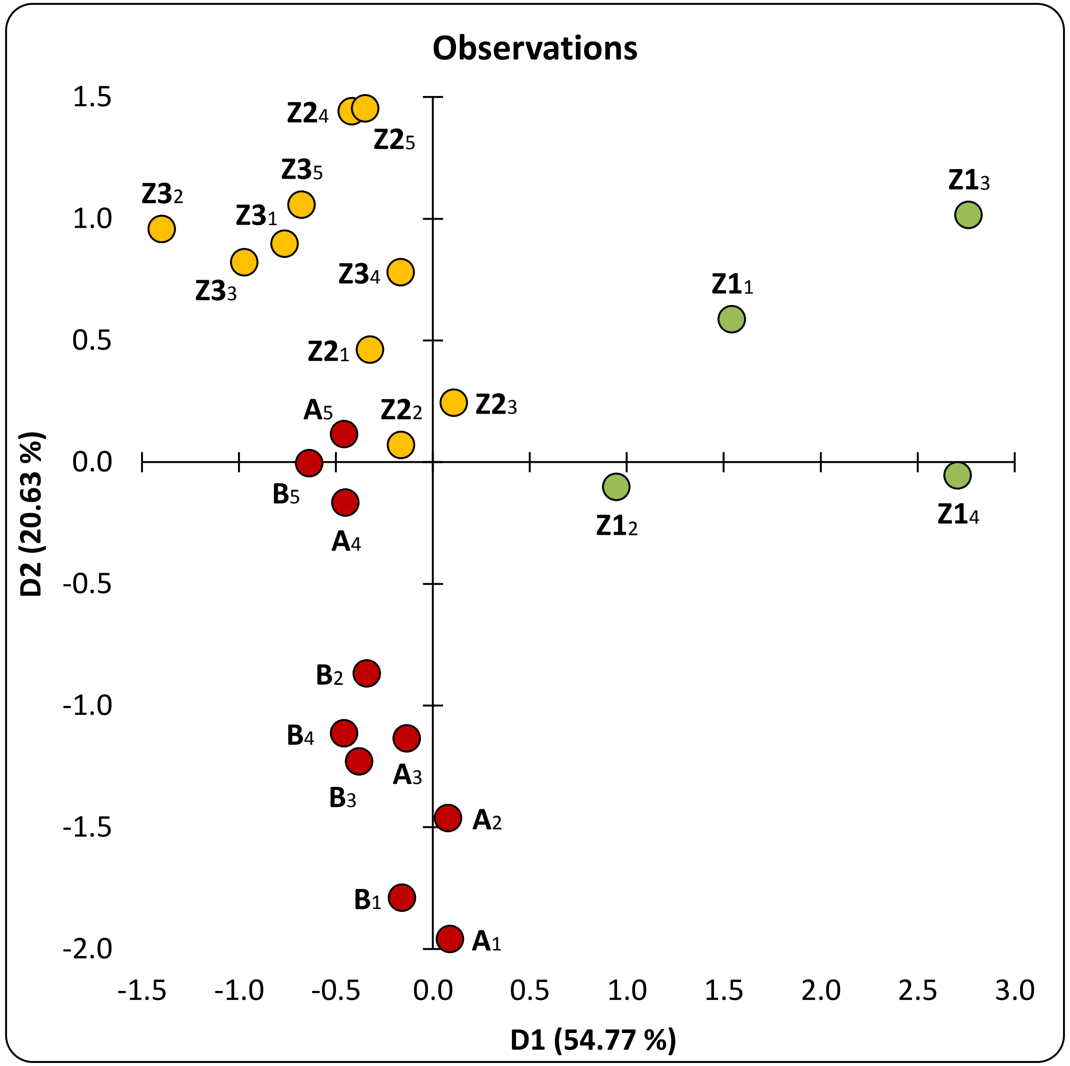


Variable	Unit	Mean ± SD	(min - max)	Variable	Unit	Mean ± SD	(min - max)
Na		31904 ± 8036	(15369 - 42555)	NH_4^+		4 ± 4	(0 - 14)
Mg		3921 ± 1222	(676 - 5709)	P_{Olsen}		44 ± 50	(10 - 174)
Al		52945 ± 3395	(43739 - 57458)	$Na_{bioavailable}$	ppm MS	1494 ± 538	(368 - 2568)
Si		47410 ± 15450	(7711 - 63677)	$Mg_{bioavailable}$		54 ± 39	(16 - 138)
P		892 ± 483	(311 - 2136)	$Cu_{bioavailable}$		1.1 ± 0.8	(0.4 - 3.7)
S		150 ± 185	(0 - 475)	$Th_{bioavailable}$		0.1 ± 0.0	(0.0 - 0.2)
K		2984 ± 873	(262 - 4594)	Clay		253 ± 53	(115 - 336)
Ca		44957 ± 22609	(3726 - 93054)	Fine silt		296 ± 84	(174 - 450)
Ti		17273 ± 5801	(4681 - 37352)	Coarse silt	g/kg MS	131 ± 35	(68 - 199)
V		691 ± 289	(497 - 1989)	Fine sand		166 ± 50	(104 - 292)
Cr	ppm MS	723 ± 358	(418 - 2321)	Coarse sand		154 ± 98	(31 - 382)
Mn		621 ± 100	(431 - 860)	Carbonates		165 ± 59	(97 - 273)
Fe		151948 ± 22988	(128744 - 239480)	DBD	g MS/mL	2.4 ± 0.2	(1.9 - 2.8)
Ni		205 ± 53	(18 - 258)	WHC_{pF3}	%	28 ± 2	(21 - 32)
Cu		29 ± 15	(18 - 76)	CEC_{Metson}	cmol+/kg MS	15.0 ± 2.2	(10.5 - 20.8)
Zn		124 ± 93	(36 - 291)	pH_{water}	$Unit_{(1/20)}$	10.1 ± 0.3	(9.3 - 10.4)
As		40 ± 15	(21 - 80)	Eh	$mV_{(1/20)}$	333 ± 11	(316 - 367)
Cd		0.1 ± 0.0	(0.0 - 0.2)	EC	$\mu S/cm_{(1/20)}$	239 ± 75	(99 - 347)
Pb		113 ± 35	(56 - 181)	TOC	g/kg MS	15.5 ± 11.4	(5.5 - 45.4)
Th		77 ± 14	(48 - 101)	TN		1.3 ± 1.1	(0.4 - 3.9)
U		13 ± 2	(10 - 16)	C:N	Molar	15.8 ± 3.1	(11.5 - 21.2)

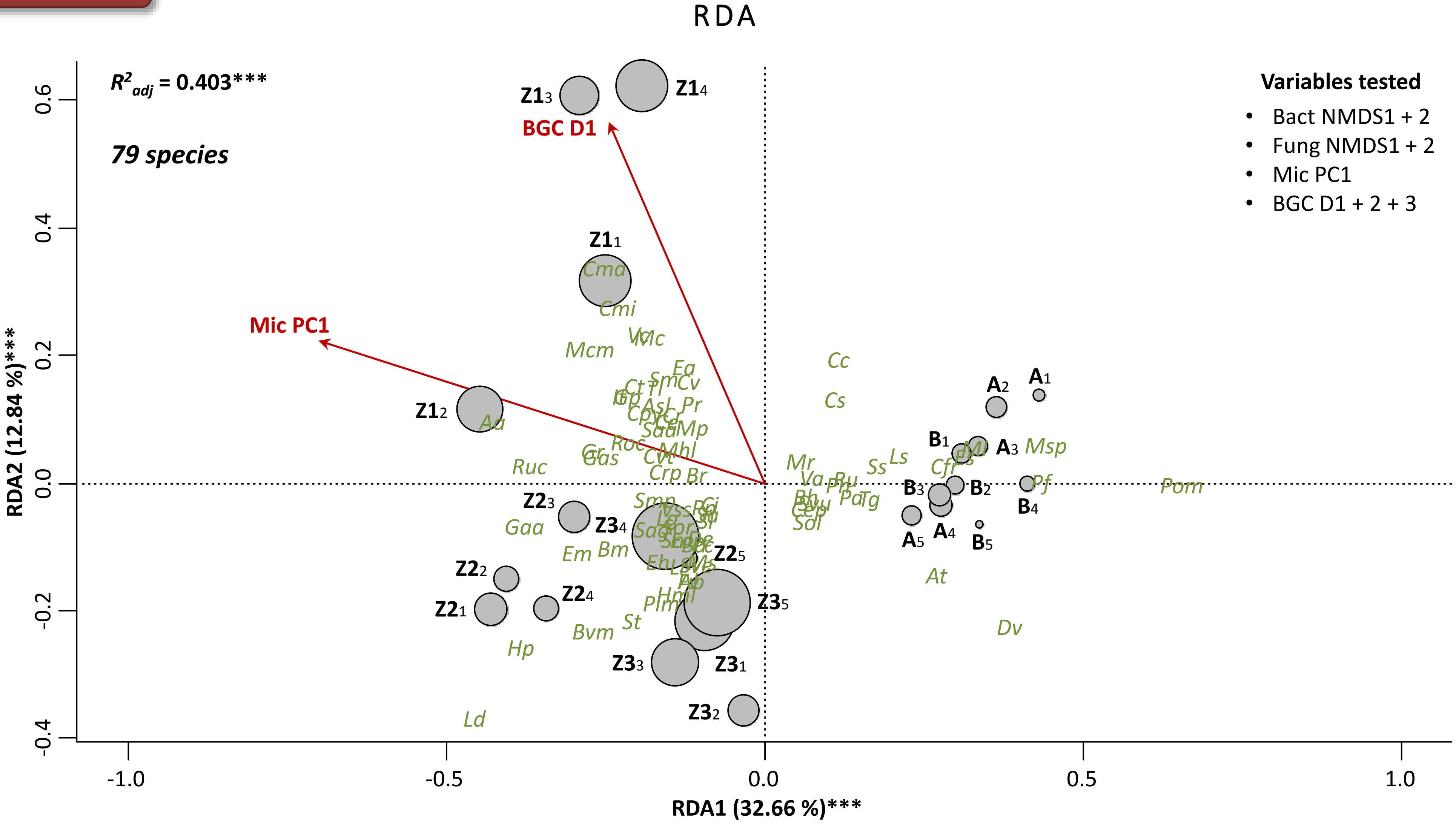
Biogeochemistry

PCA varimax





Vegetation

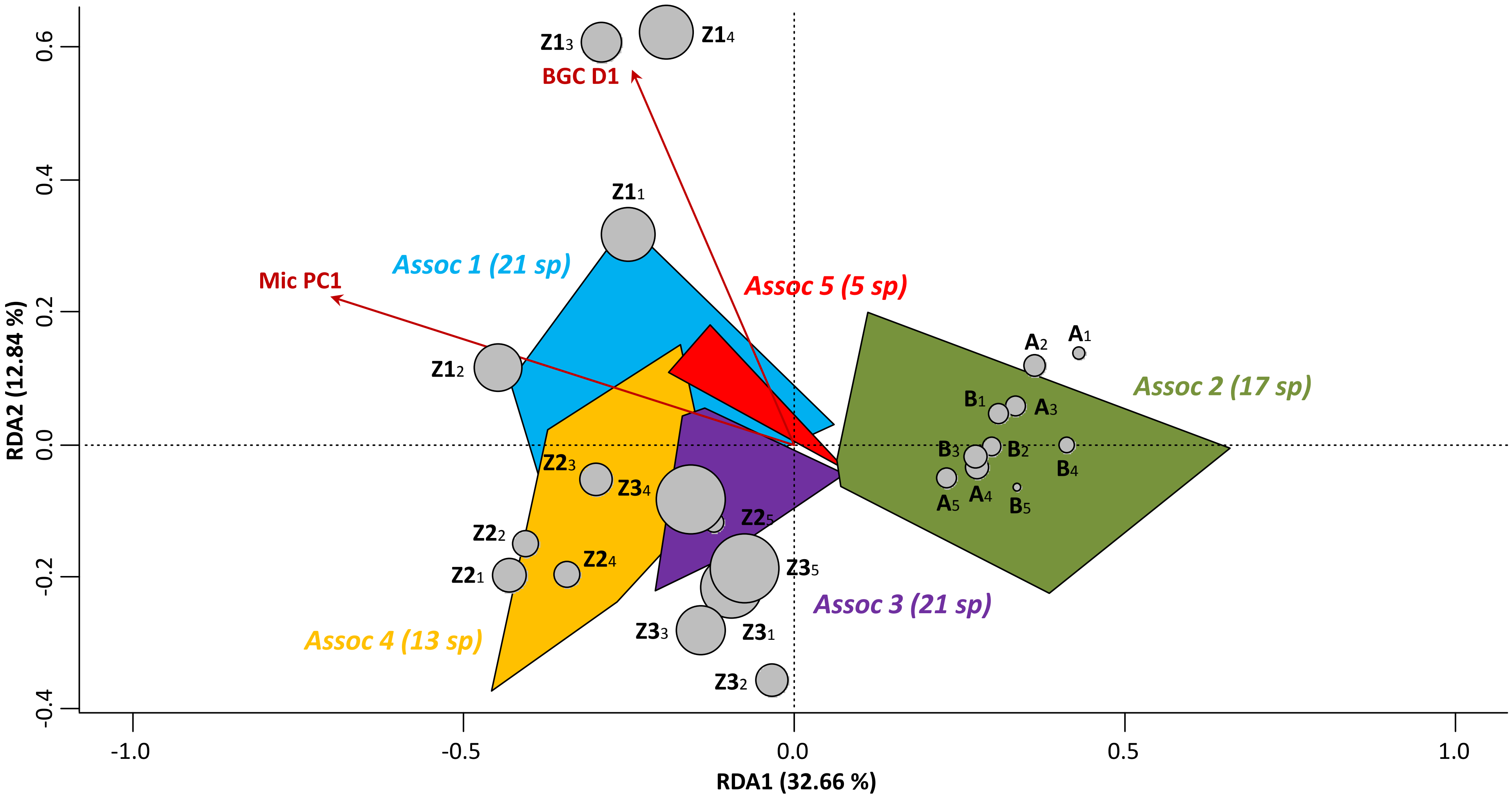


Variables tested

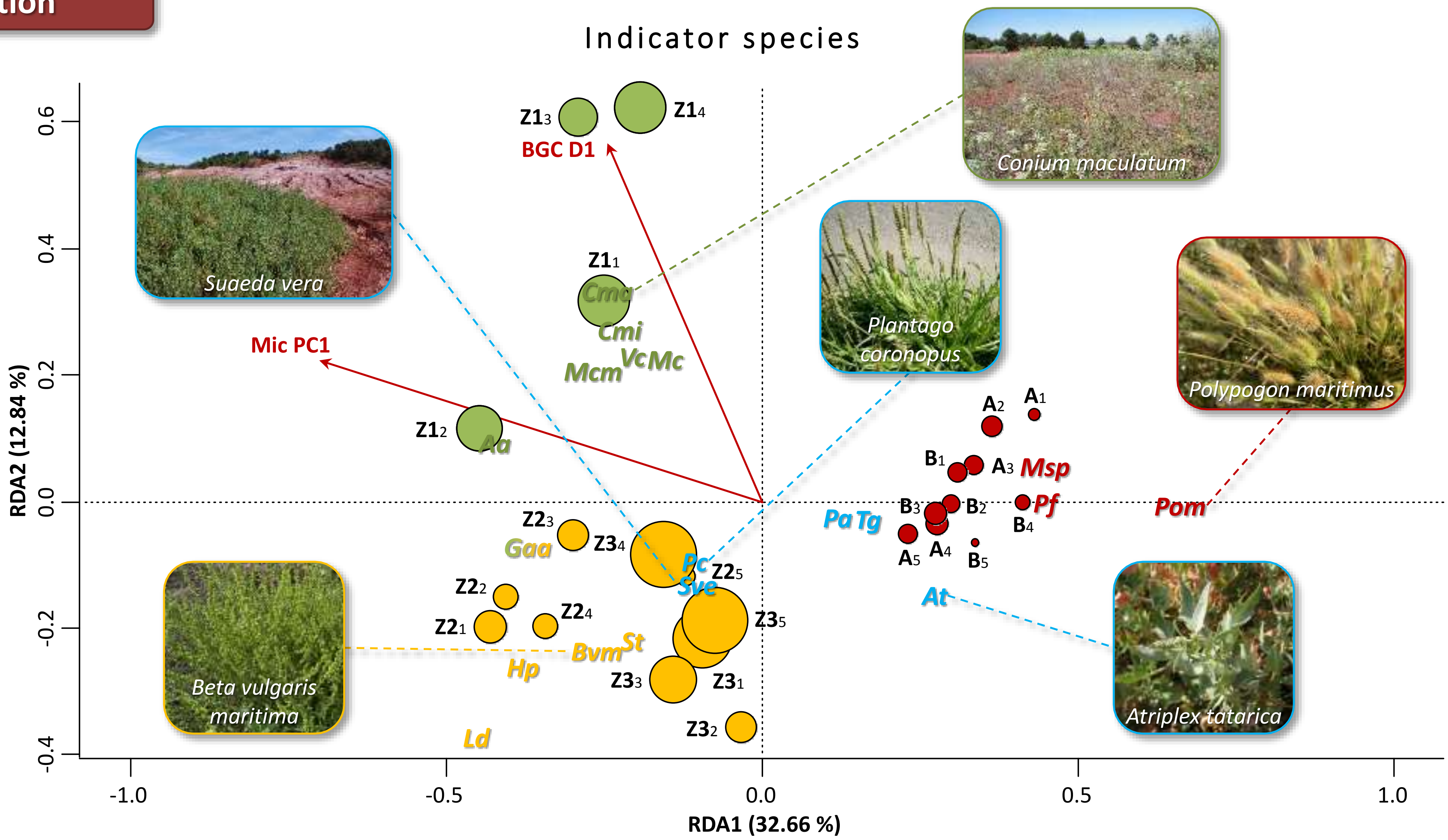
- Bact NMDS1 + 2
- Fung NMDS1 + 2
- Mic PC1
- BGC D1 + 2 + 3

Vegetation

Concordance analysis

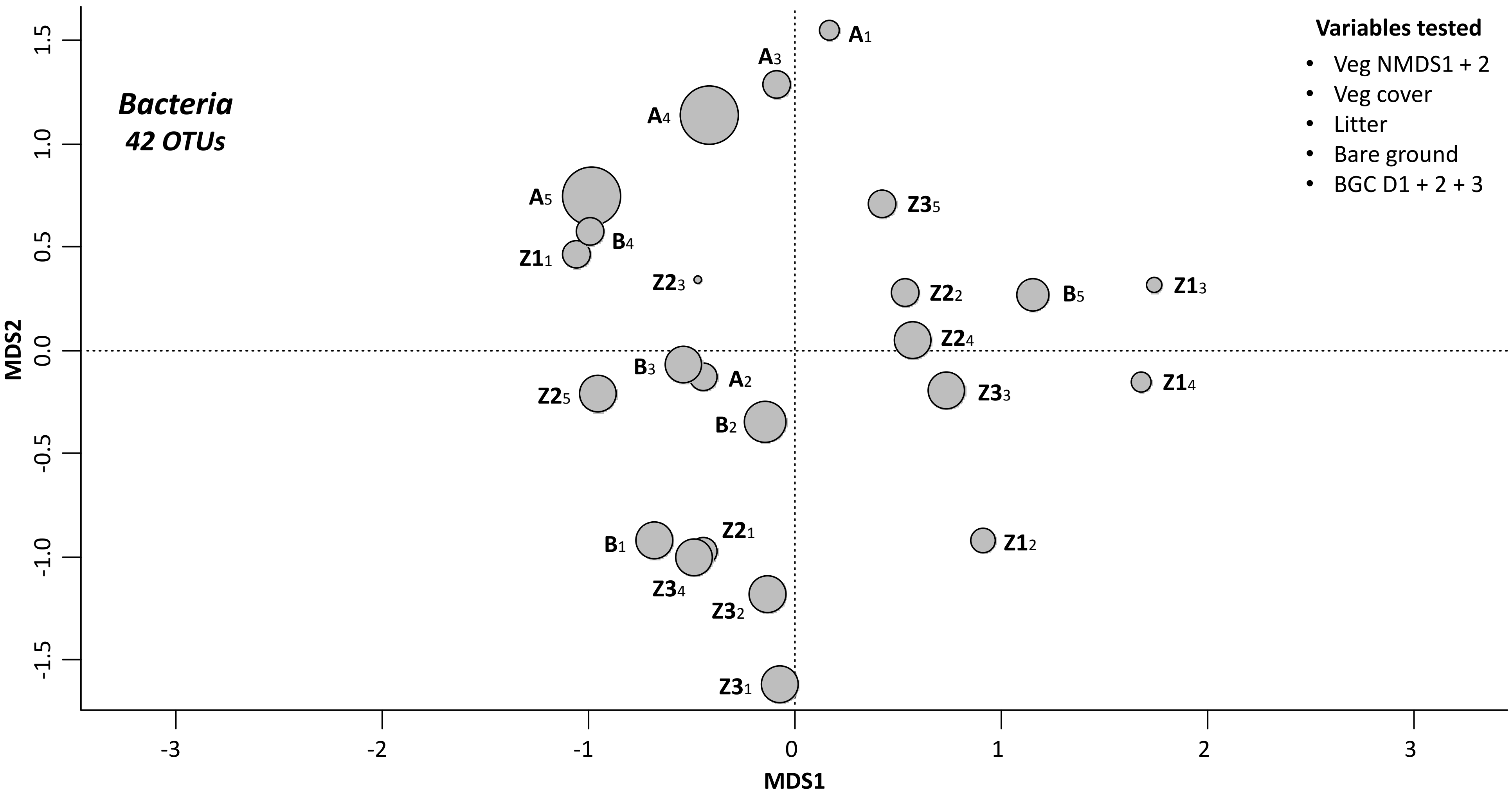


Vegetation


Indicator species
Suaeda vera
Conium maculatum
Plantago coronopus
Polypogon maritimus
Beta vulgaris maritima
Atriplex tatarica
BGC D1
Mic PC1
Z1₃ Z1₄ Z1₁ Z1₂
Z2₁ Z2₂ Z2₃ Z2₄ Z2₅
Z3₁ Z3₂ Z3₃ Z3₄ Z3₅
A1 A2 A3 A4 A5
B1 B2 B3 B4 B5
Cma Cmi Vc Mc Mcm Aa Gaa Pc Sve Bvm St Hp Ld Pa Tg At Msp Pf Pom
RDA2 (12.84 %)
RDA1 (32.66 %)
0.6 0.4 0.2 0.0 -0.2 -0.4
-1.0 -0.5 0.0 0.5 1.0

Microorganisms

PCoA

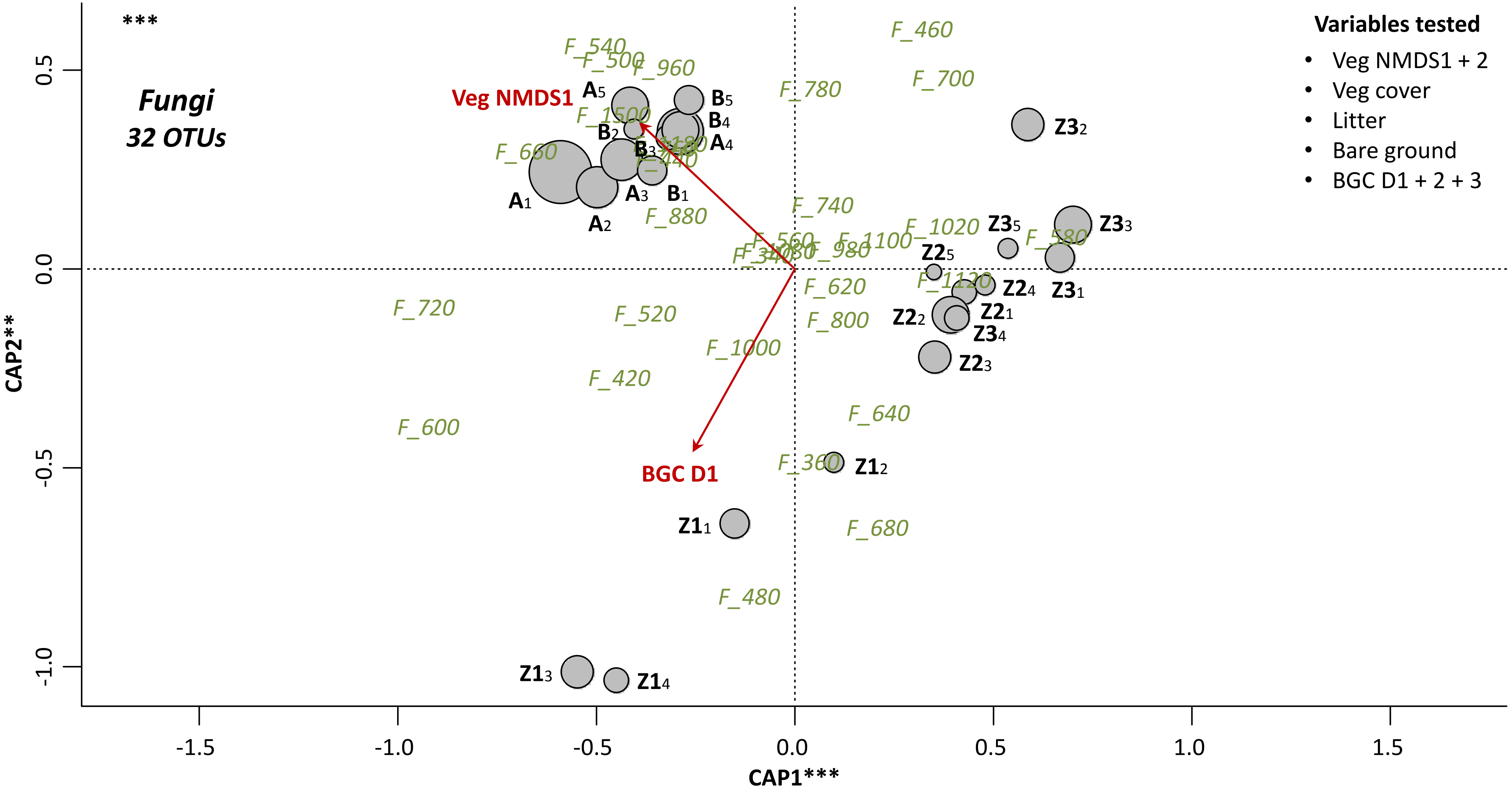


Variables tested

- Veg NMDS1 + 2
- Veg cover
- Litter
- Bare ground
- BGC D1 + 2 + 3

Microorganisms

dbRDA



Variables tested

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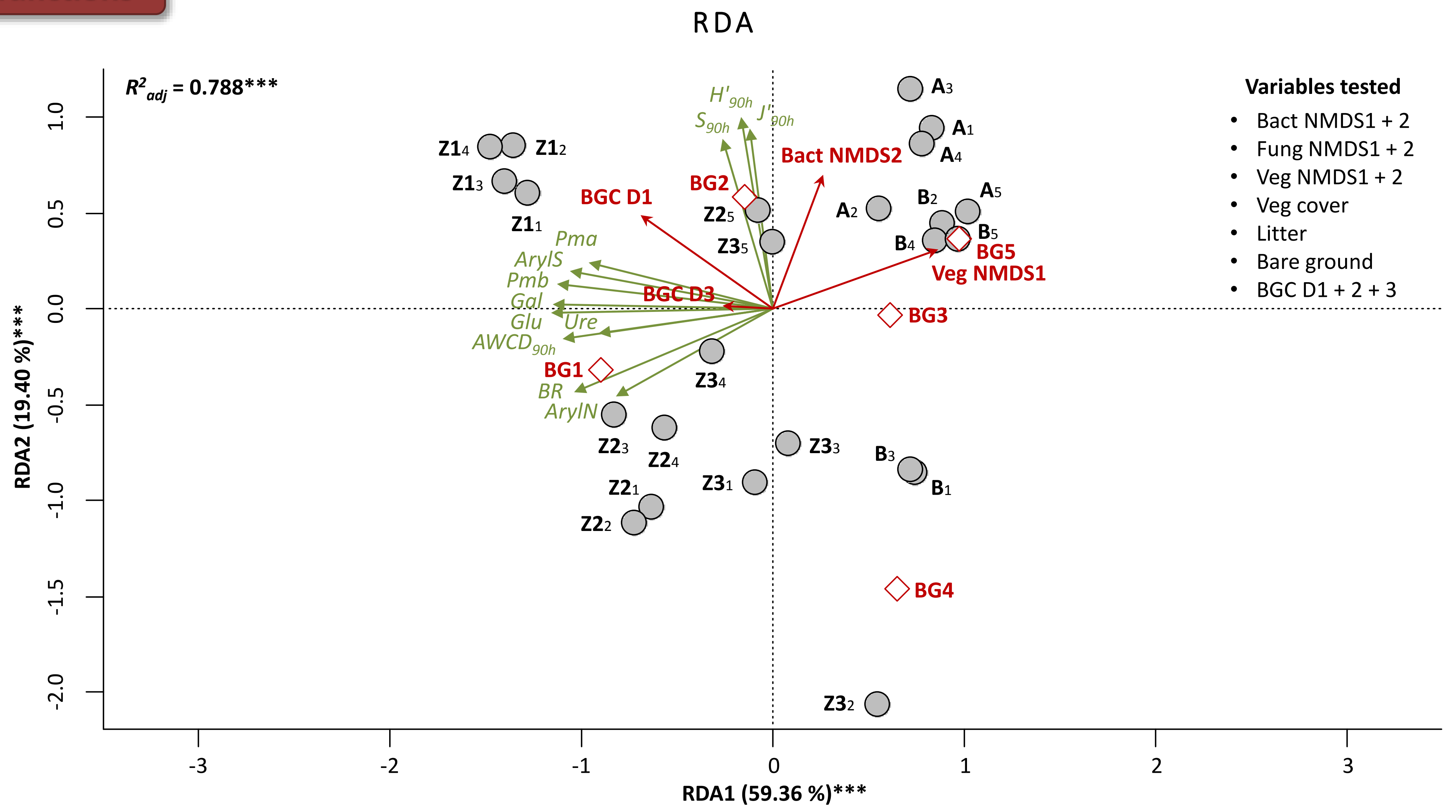
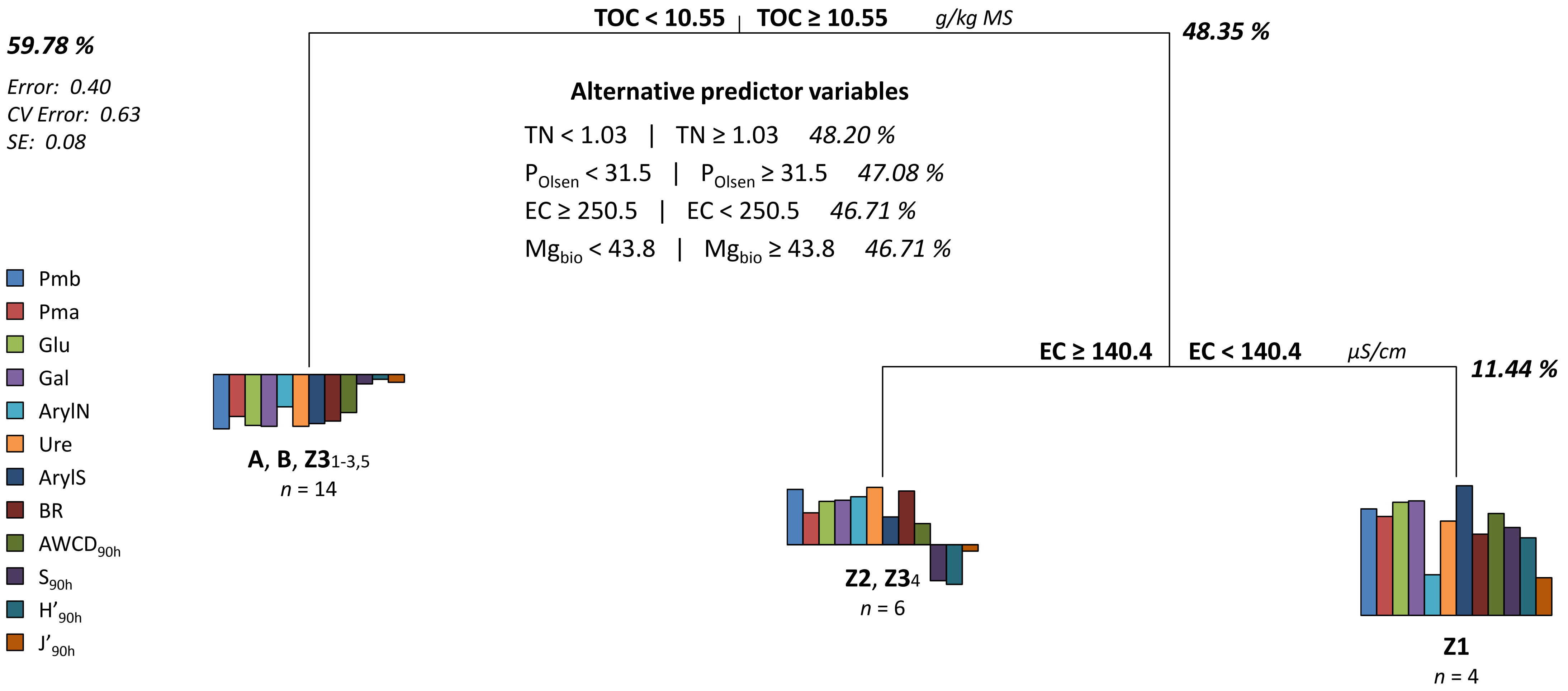
Microbial functions



Microbial functions

Multivariate Regression Tree analysis



Conclusions

How these bauxite residues interact with terrestrial ecosystems through the soil-plant continuum?

What this work showed at the scale of the deposits studied:

- Existence of two inverted gradients: pH, EC, Na *versus* SOM, nutrients
- Structuring of fungal and vegetal communities and microbial functions along these gradients
- Increasing alkalinity and sodicity inhibited the biological processes of pedogenesis and, by feedback, slowed the OM enrichment of soils
- Evidence of strong above-belowground linkages through reciprocal functional relationships
- Identification of indicator plant species of alkaline sodic habitats/soils similar to those of the Mediterranean coastline (*e.g.* sansouïre)

Outlooks

REDMUD Project – *Red mud inputs into soils: responses and structuring of microbial and plant communities*

- To optimize the red mud soil matrix to establish sustainable favorable soil conditions
- To favor the revegetation and progressive Na decrease of red mud soils through the use of halophyte/halophile plant species evidenced

MARS Project – *Microbial diversity Assessment in Redmud Soils*

- To explore the diversity and structure of bacterial and fungal communities of red mud soils (metabarcoding)
- Screening and selection of useful microbial strains

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