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Acidification of headwater streams: structural and functional assessment of microbial communities associated with decaying leaves.

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Introduction

- Acid depositions → forested headwater streams in the Vosges Mountains (North-eastern France)
- Heterotrophic ecosystem ← leaf-litter
- Leaf-litter breakdown = key ecosystem process
→ assess functional alterations
- Acidification → impairs leaf breakdown
- Micro-organisms = pivotal role in organic matter processing

Objectives

Acidification of headwater streams

- Microbial communities associated with decaying leaves
- Microbial activities (organic C and nutrients acquisition)
- Explain reduced leaf-litter breakdown

Methods

Maple leaf disks (18 mm)
(*Acer platanoides*)



Fine mesh bags

6 headwater streams (3 neutral / 3 acidified)



Nov 2009



Jan 2010

7 13 21 28 49 70d

Water
sample



Water chemistry

4
replicate
bags



Mass loss



Microbial community structure (DGGE 16S and 18S)

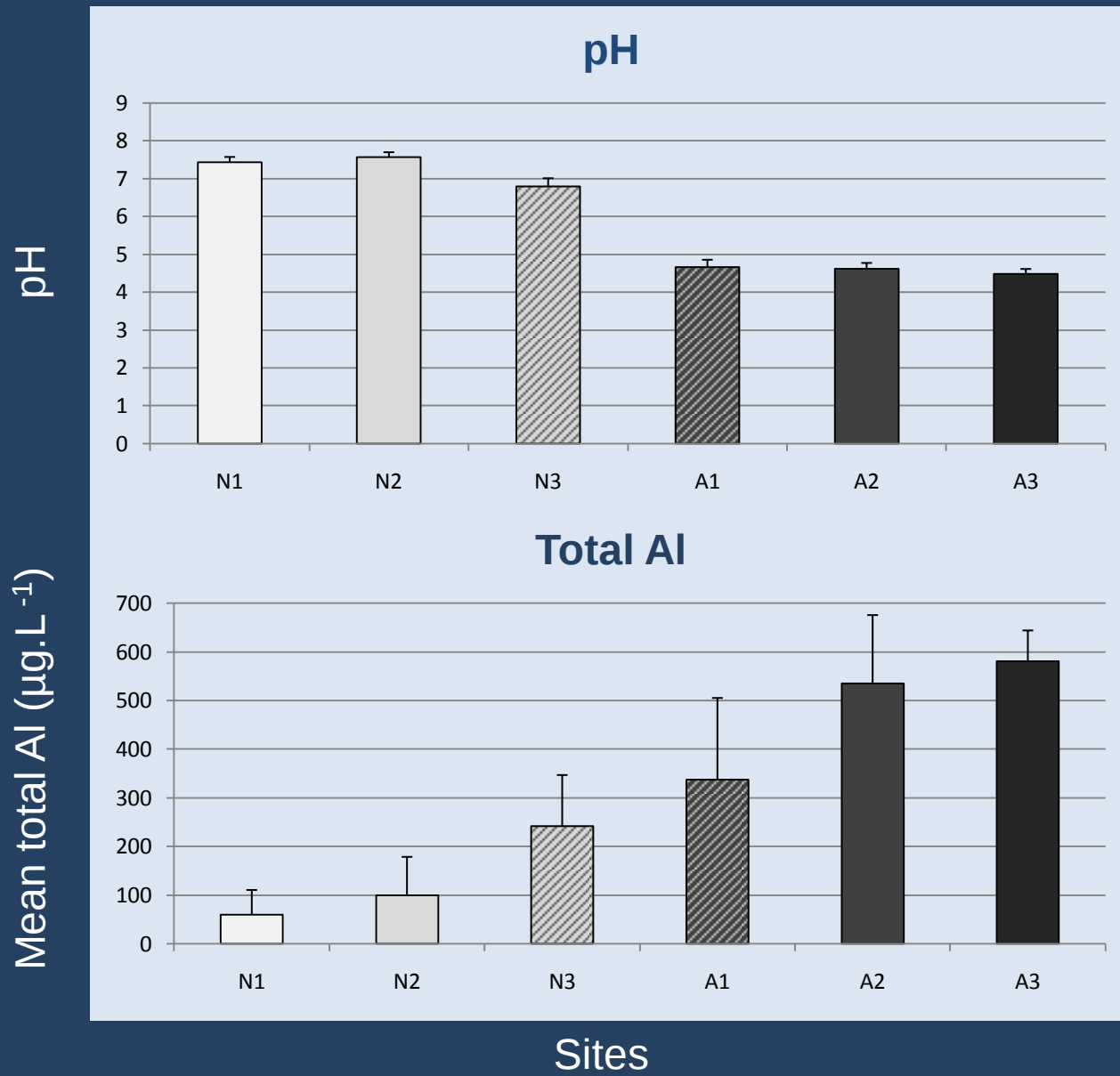


Potential Extracellular Enzyme Activities



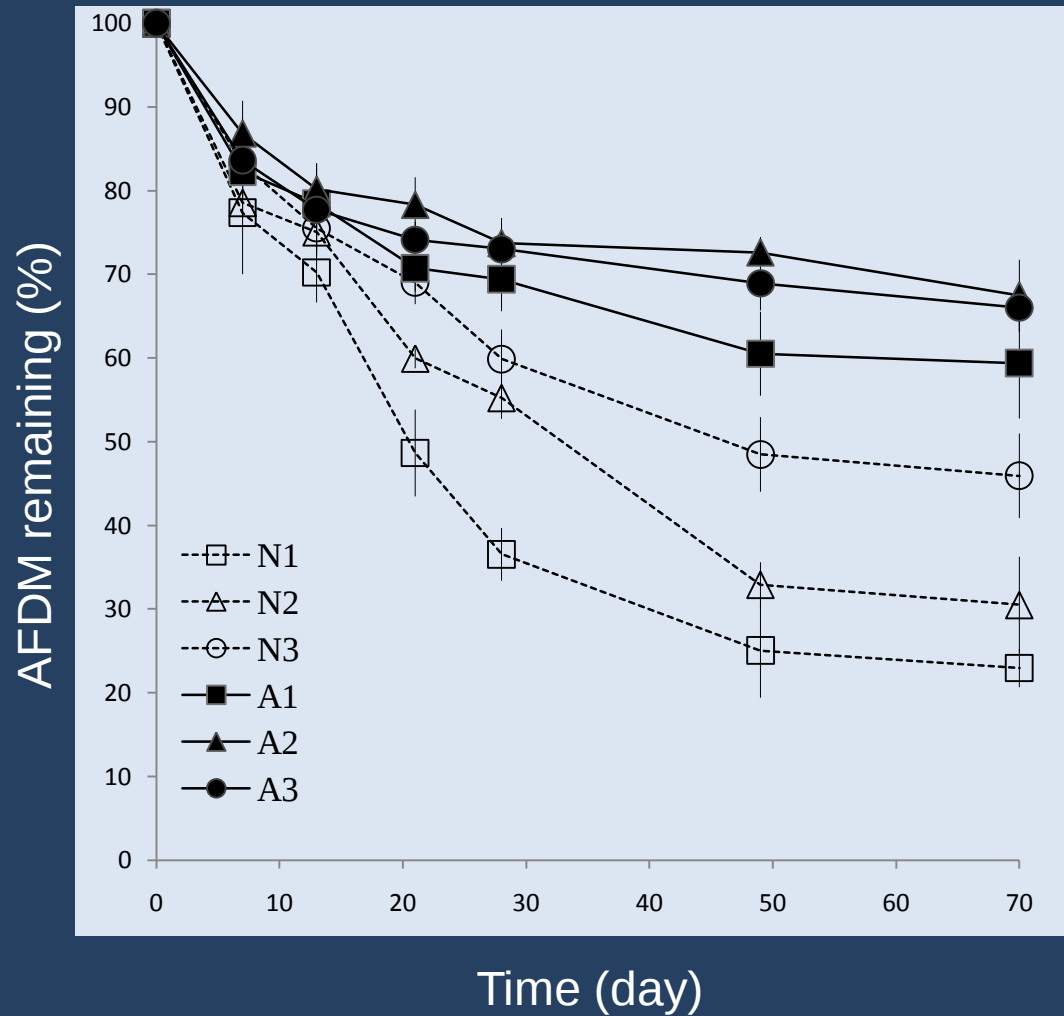
N and P content

Water chemistry

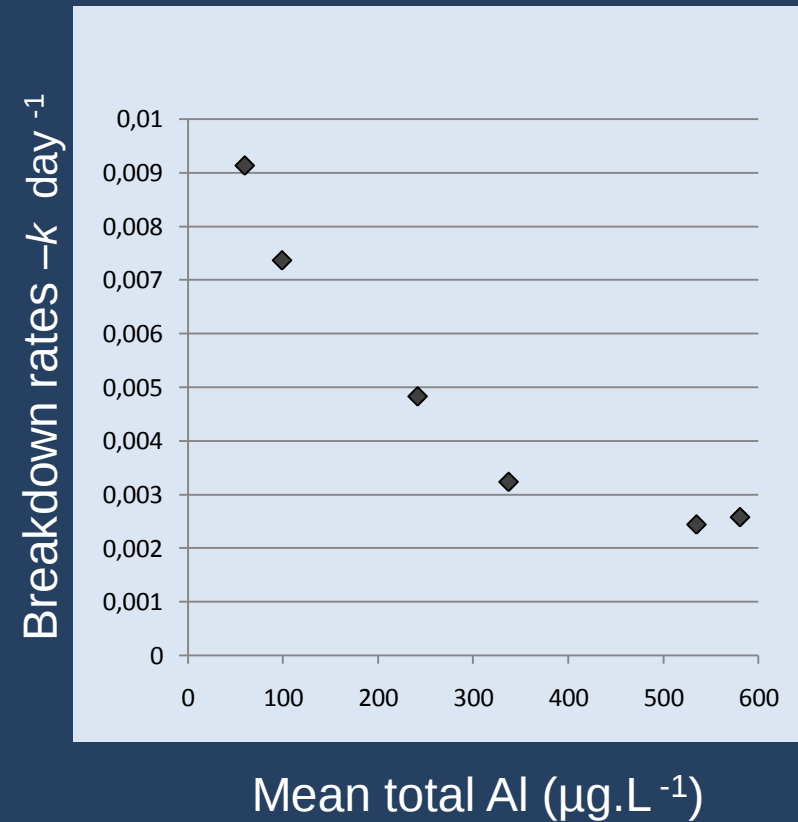


Maple leaf breakdown

Mass loss of leaf disks



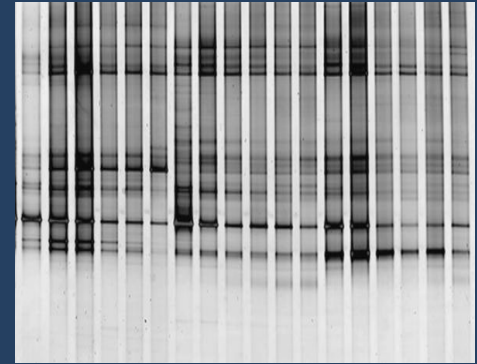
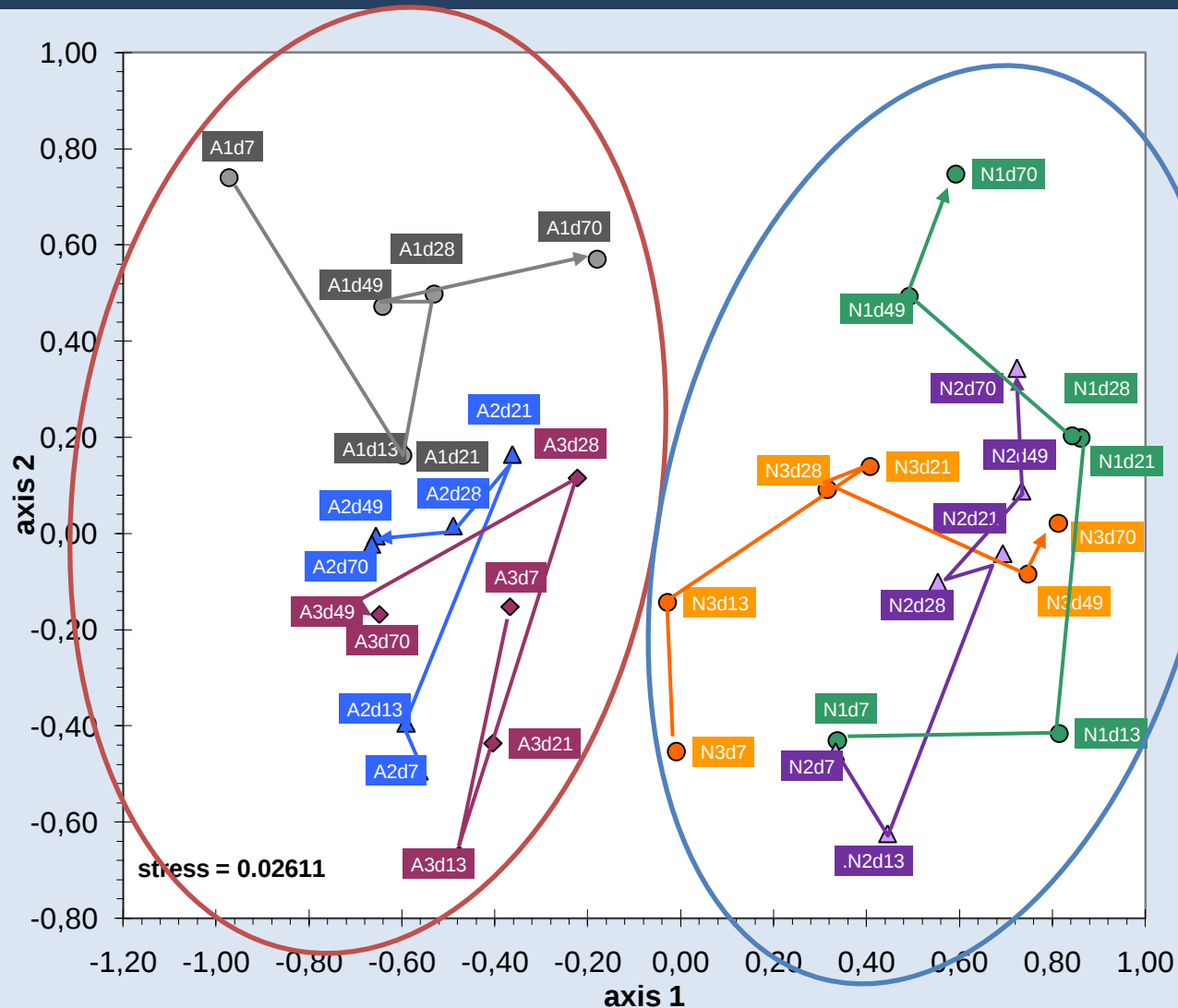
Relationship between breakdown rates (exponential model) and mean total aluminium



Microbial community structure

Bacterial community structure

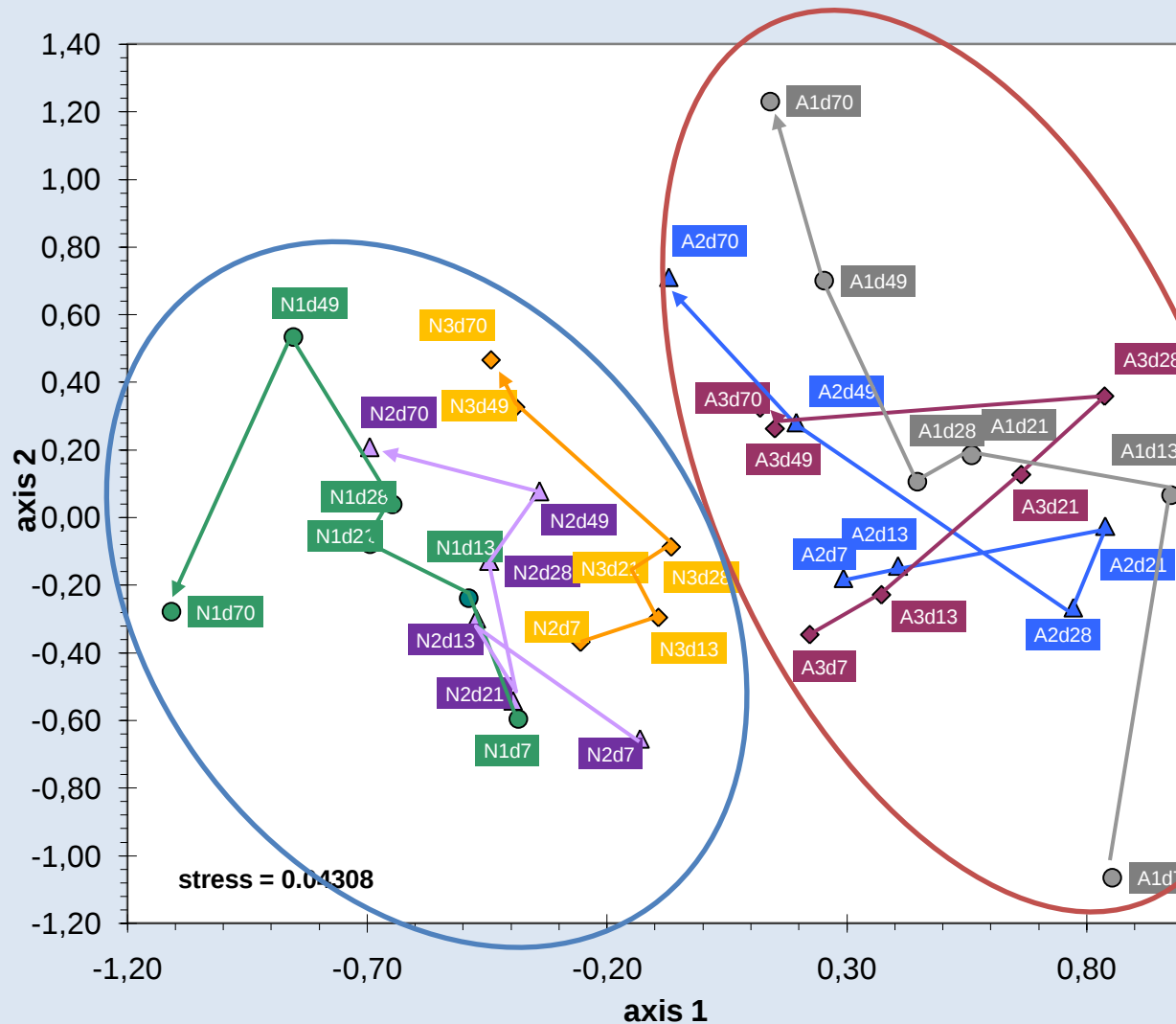
nMDS plot based on 16S rDNA DGGE profiles



Stream	Phylotype richness
N1	17
N2	15
N3	22
A1	22
A2	28
A3	26

Fungal community structure

nMDS plot based on 18S rDNA DGGE profiles

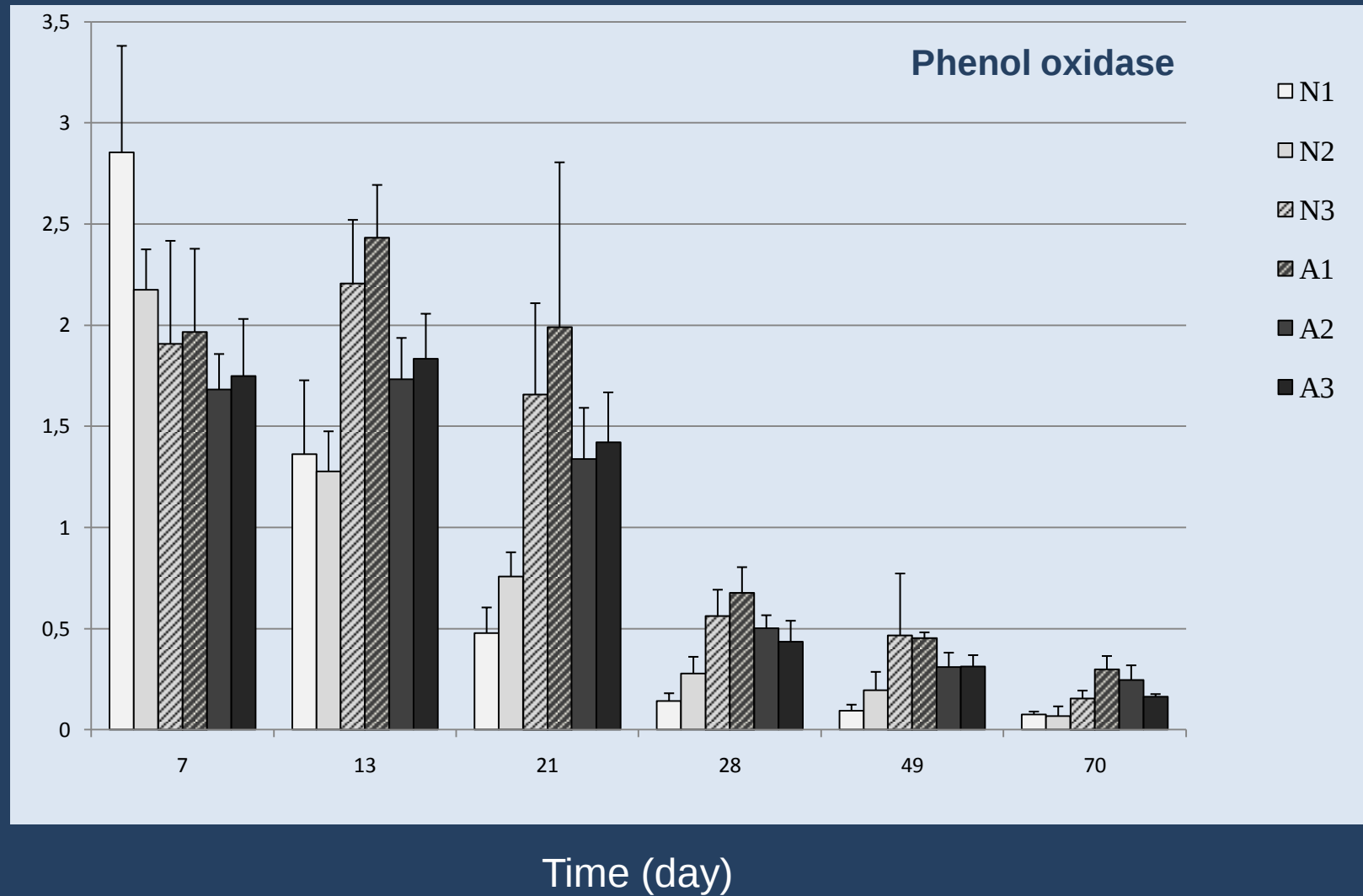


Stream	Phylotype richness
N1	19
N2	20
N3	20
A1	14
A2	16
A3	14

Lignocellulolytic Enzyme Activities

Phenol oxidase

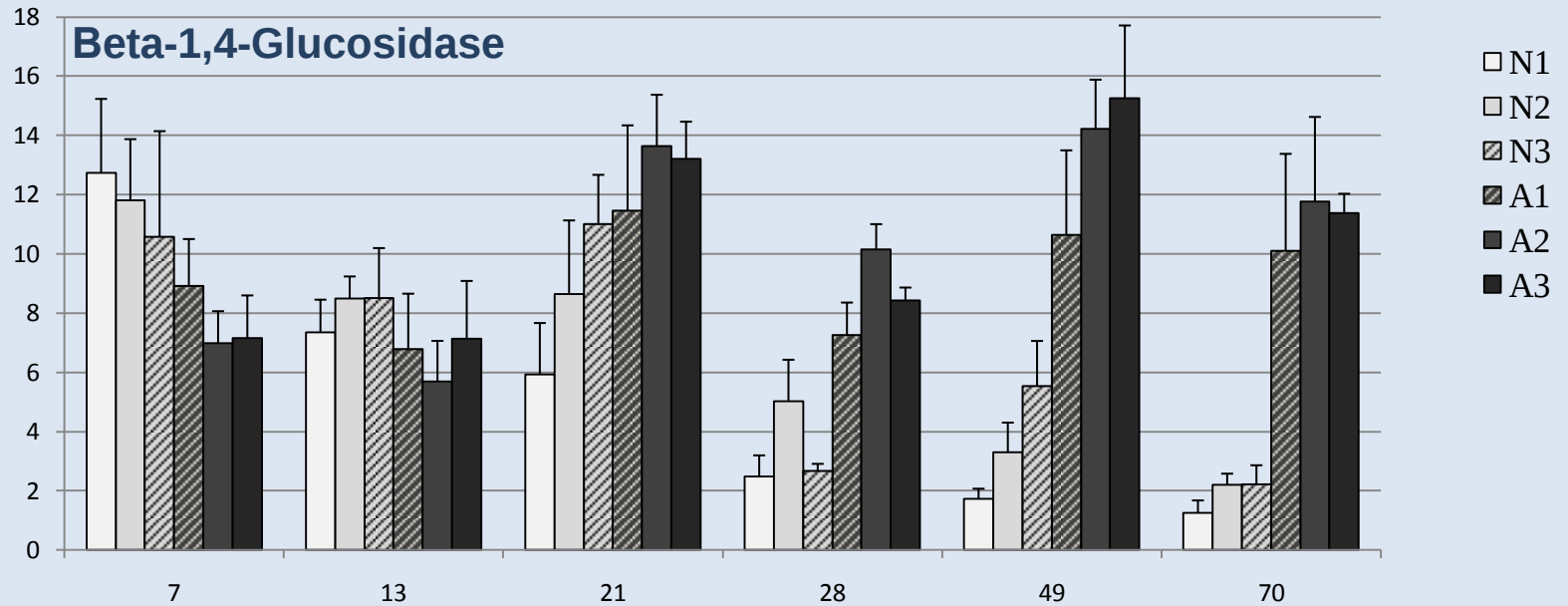
Enzyme activity (ABTS)
 $10^{-2} \mu\text{mol} \cdot \text{min}^{-1} \cdot \text{g}^{-1} \text{AFDM}$



Exocellulase

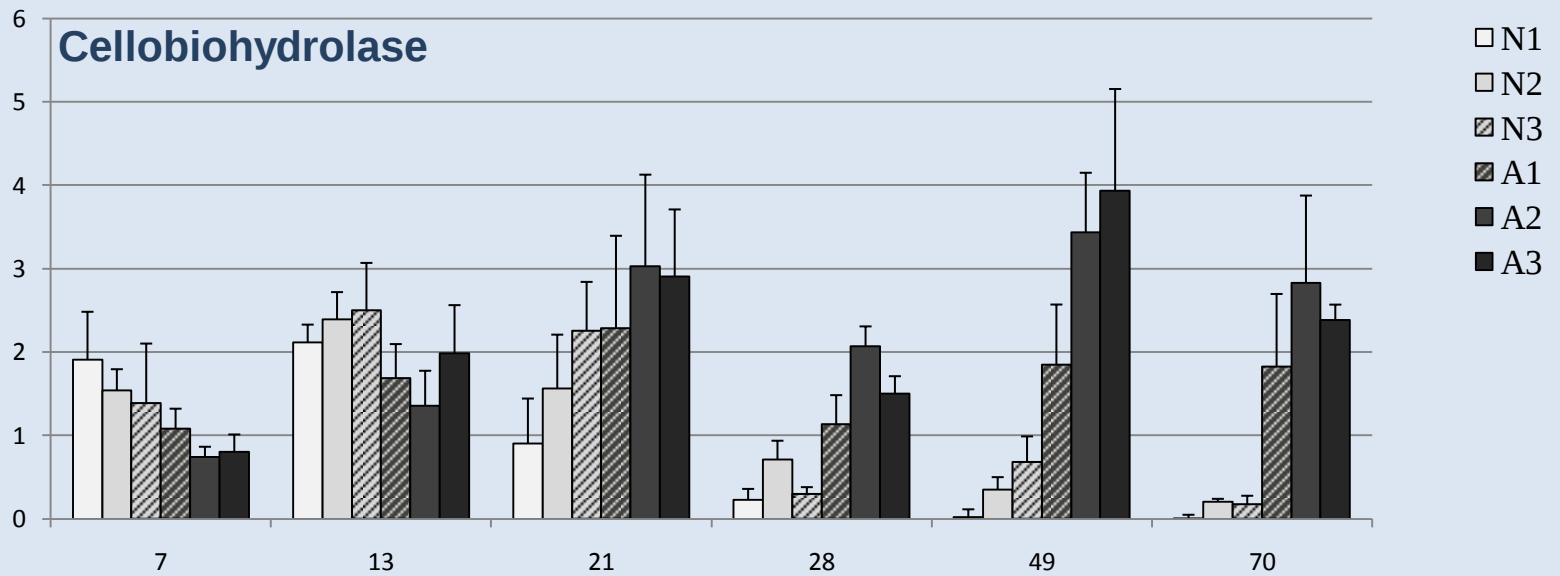
Enzyme activity
 $\mu\text{mol.h}^{-1}.\text{g}^{-1}$ AFDM

Beta-1,4-Glucosidase



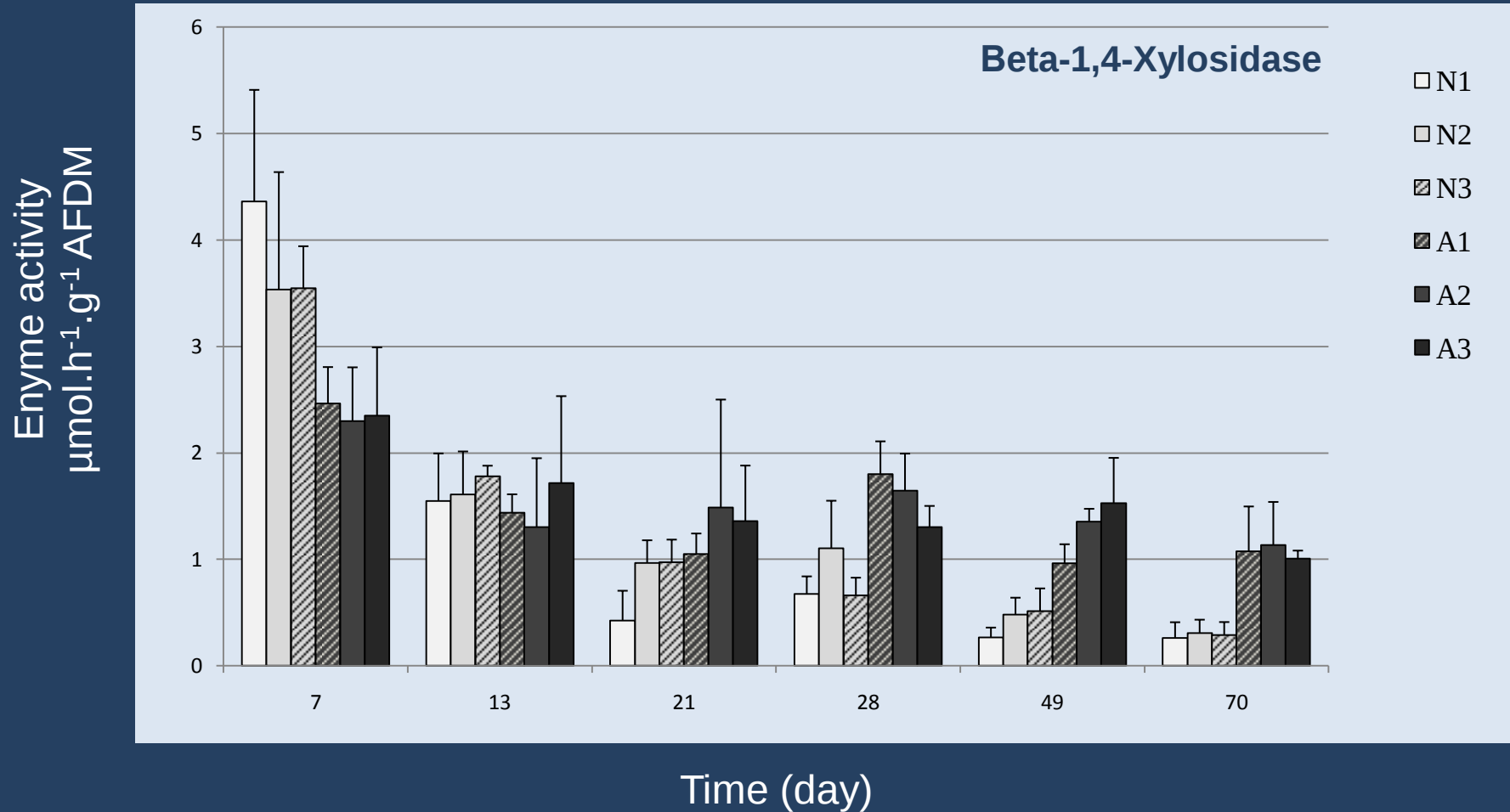
Enzyme activity
 $\mu\text{mol.h}^{-1}.\text{g}^{-1}$ AFDM

Cellobiohydrolase



Time (day)

Hemicellulase

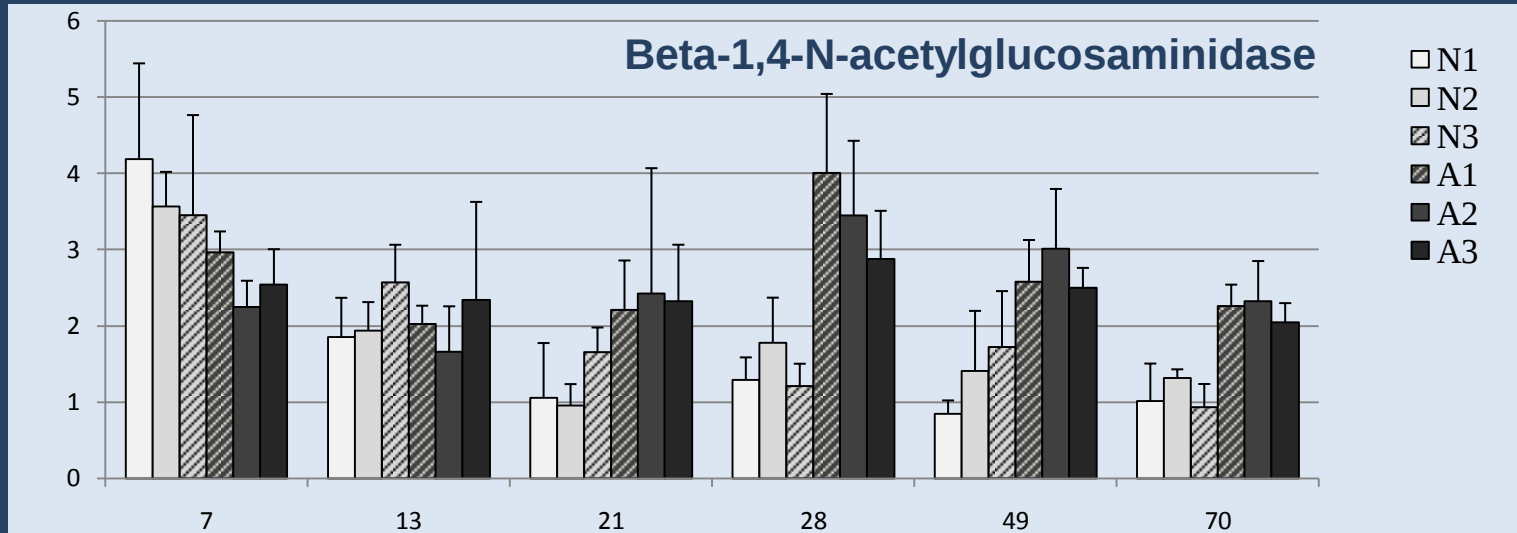


Important potential activities in acidified streams
→ enzyme production not reduced

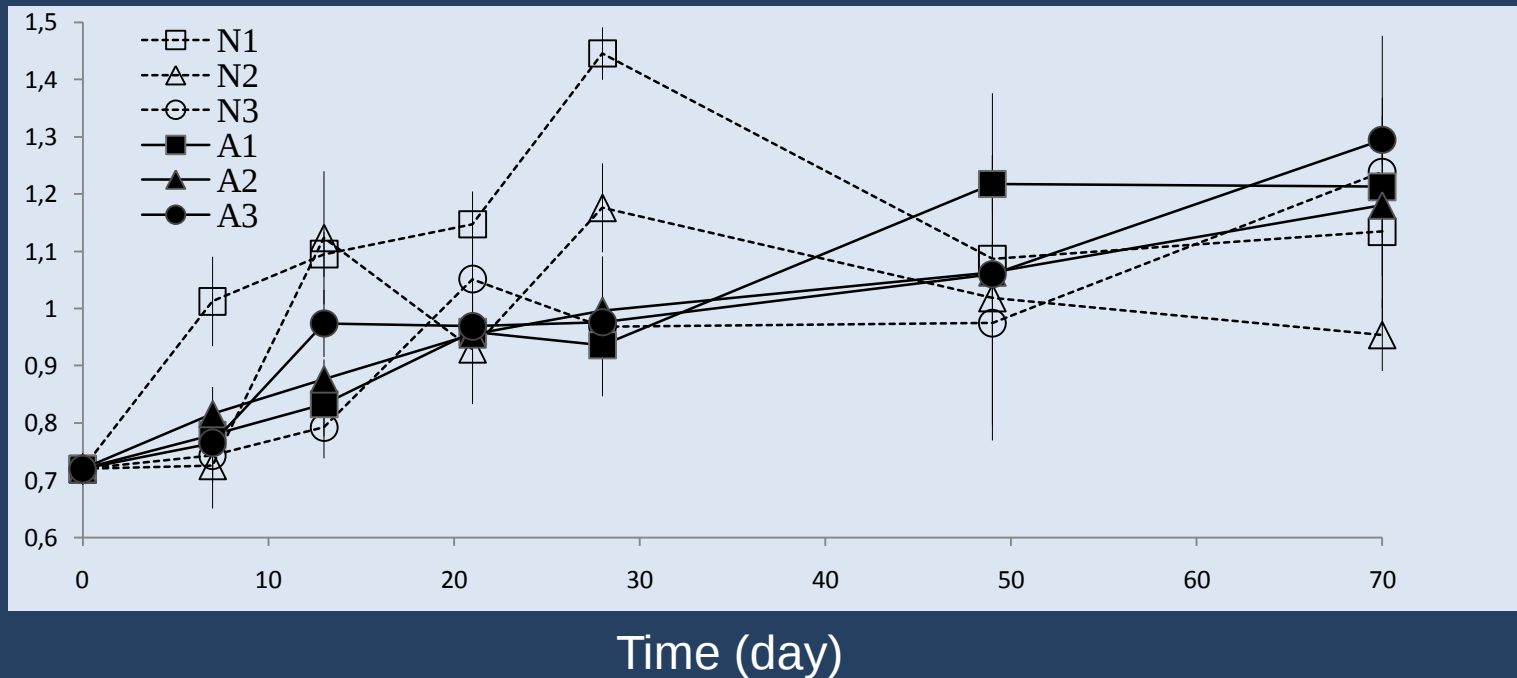
Microbial nutrient acquisition

Nitrogen uptake

Enzyme activity
 $\mu\text{mol.h}^{-1}.\text{g}^{-1}$ AFDM

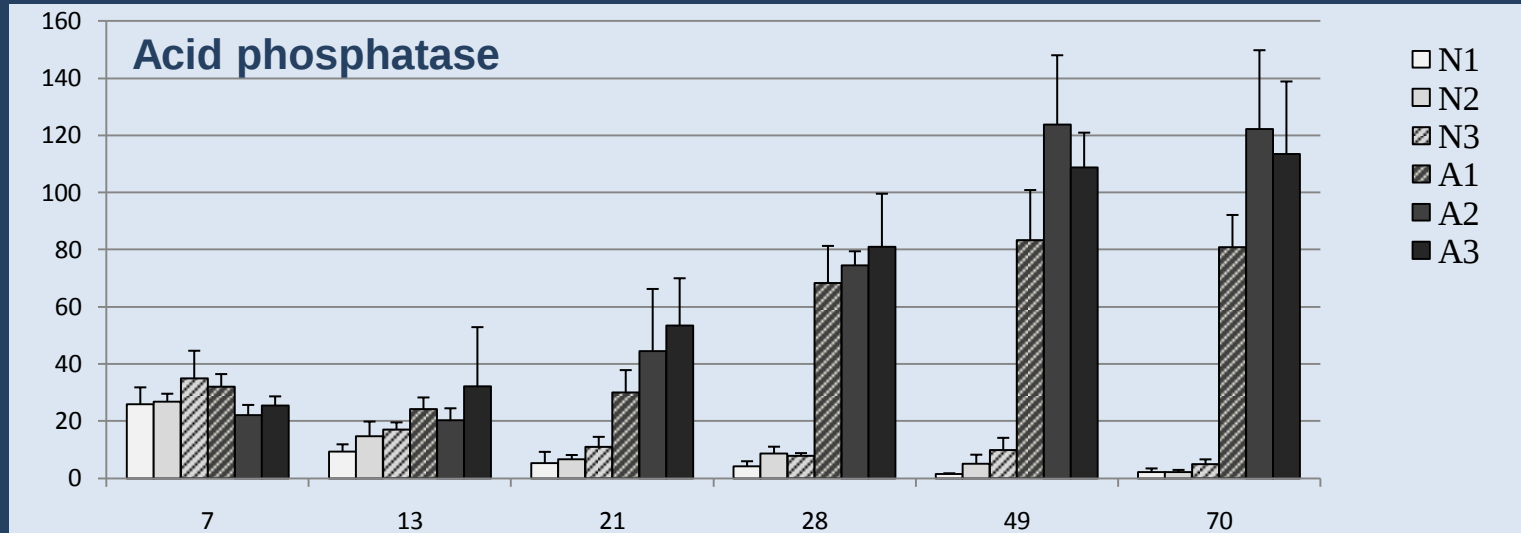


Nitrogen content
% DM

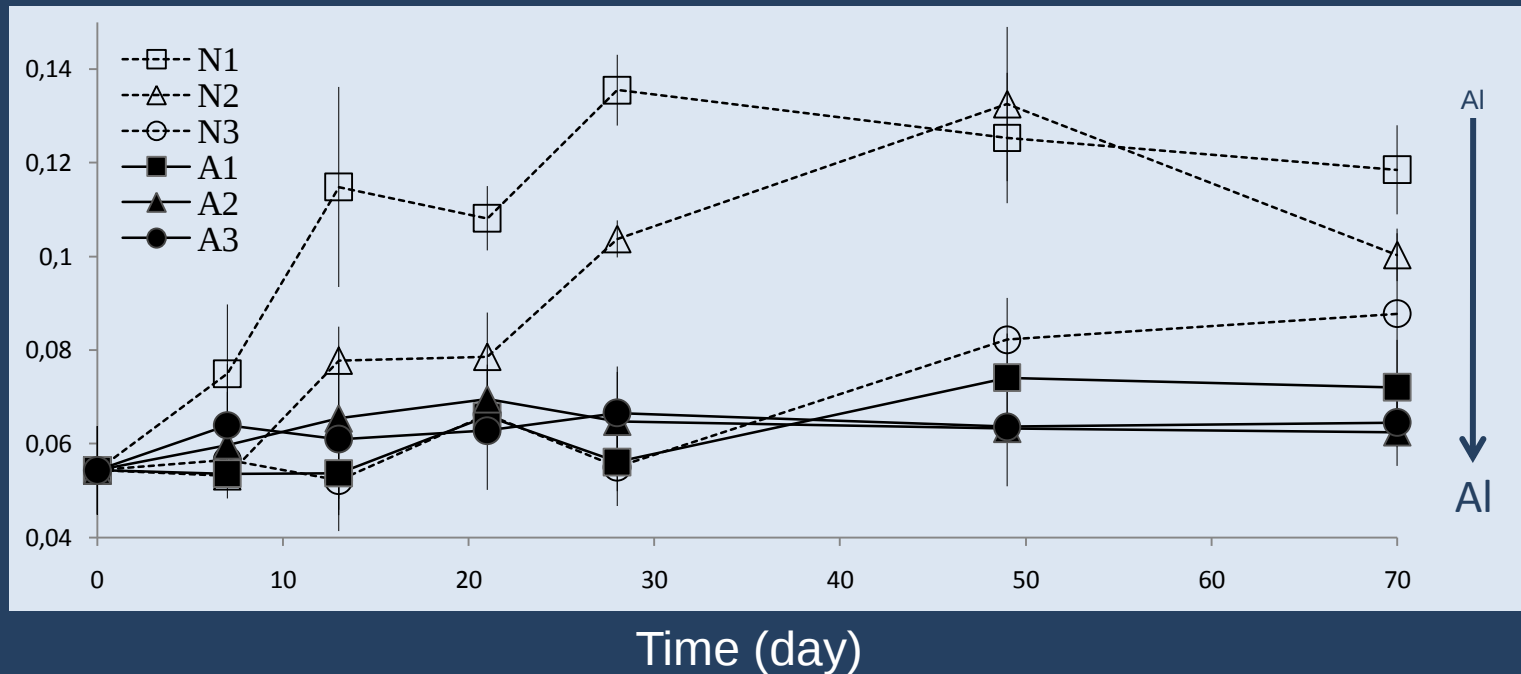


Phosphorus uptake

Enzyme activity
 $\mu\text{mol.h}^{-1}.\text{g}^{-1}$ AFDM



Phosphorus content
% DM



Conclusion

- Relationship Al concentration / Leaf processing
- Environmental factors controlling :
 - Microbial succession and diversity
 - Patterns of potential Extracellular Enzyme Activity
- Nutrients acquisition:
 - N uptake non limiting
 - Acidic streams : Increasing enzymatic effort for P acquisition + uptake reduced with increasing Al concentration

Discussion

- Microbial diversity → Enzyme Activities
- Leaf breakdown not related to Enzymatic effort in acidic streams
 - Enzyme production controlled by abiotic and biotic factors
 - Microbial activity constrained by nutrients availability
- P limitation (Sequestration of P with high Al concentration)
- Direct and indirect microbial interactions with Al
- Repercussions in the stream food webs

Perspectives

- Ergosterol contents
 - confirm fungal growth in acidic streams
- Identify differences in microbial community composition



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