

Impact of pesticides on denitrification in groundwaters



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Introduction

Non-target/side effects of pesticides on soil microbial denitrification have been demonstrated. The impact of pesticides on the denitrification activity in groundwater has still to be investigated as it is now well established that groundwater is an ecosystem in itself with specific microbial communities different from soils' ones (Mauffret et al., 2017).

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Objectives

1- Assess the impact (inhibitor/catalyzer ?) of pesticides on denitrification in groundwaters

2- Determine if pesticides impacts vary according to bacterial community diversity, initial denitrification potential, and past history of on site pesticide applications?

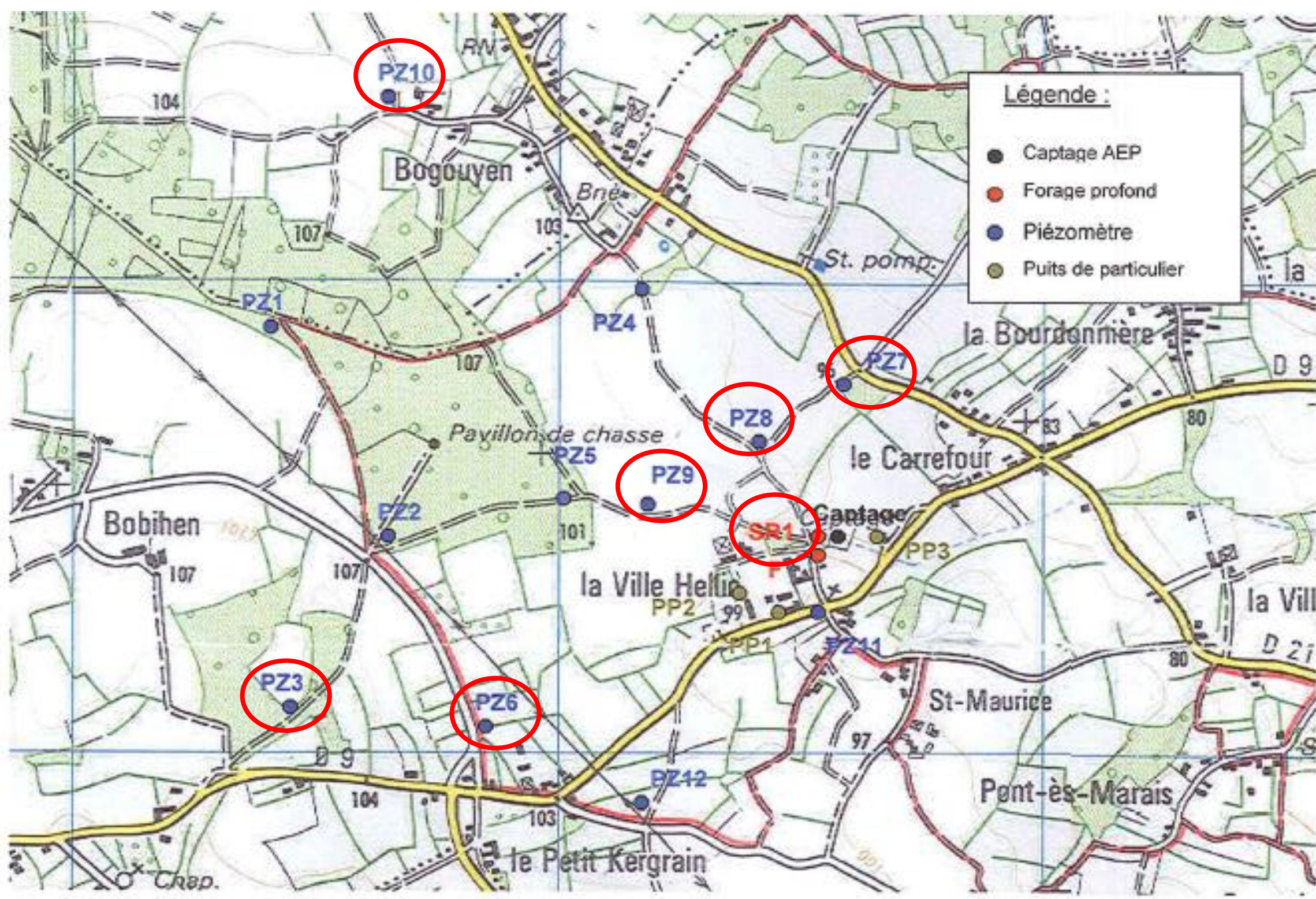
=> Work on a catchment submitted to agricultural practices with fertilizers and pesticides uses, that allows the sampling of groundwater from several wells.

=> Batch experiments for denitrification with (i) groundwater characterized by different nitrate and pesticides concentrations and different potential for denitrification, and (ii) various pesticides selected according to their agricultural uses and their presence/absence on the studied site and in French groundwater.

Experimental procedure

Map of the studied site (catchment located in France (Brittany)), and wells location.

This site was submitted to agricultural practices with fertilizers and pesticides uses for a long period. In particular, atrazine was applied. Even if agricultural practices have been stopped for few years, atrazine and DEA are still detected.

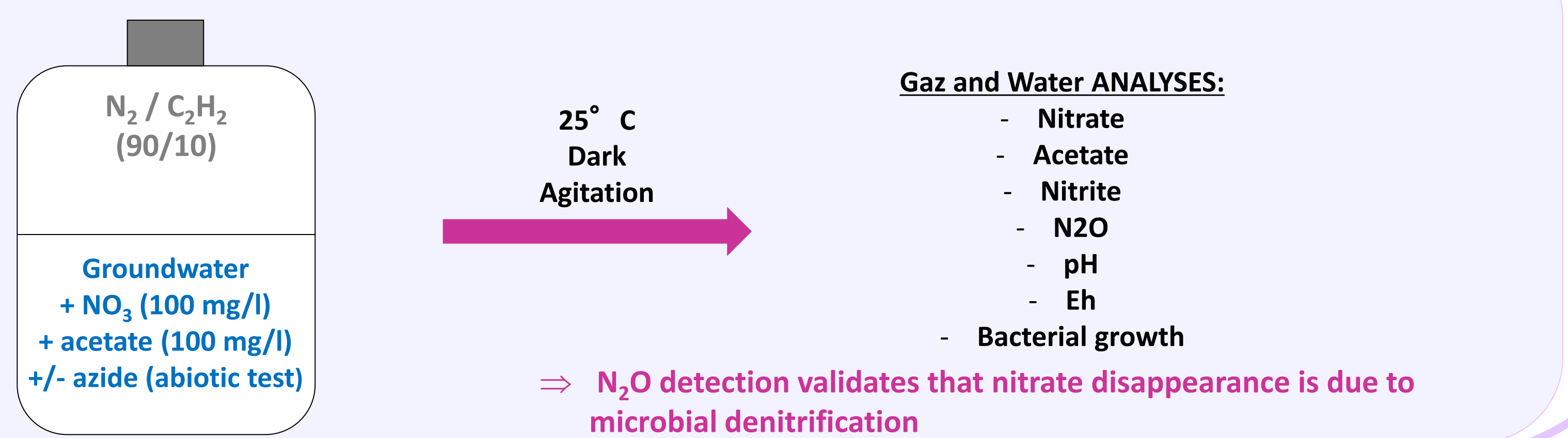


Groundwater analyses

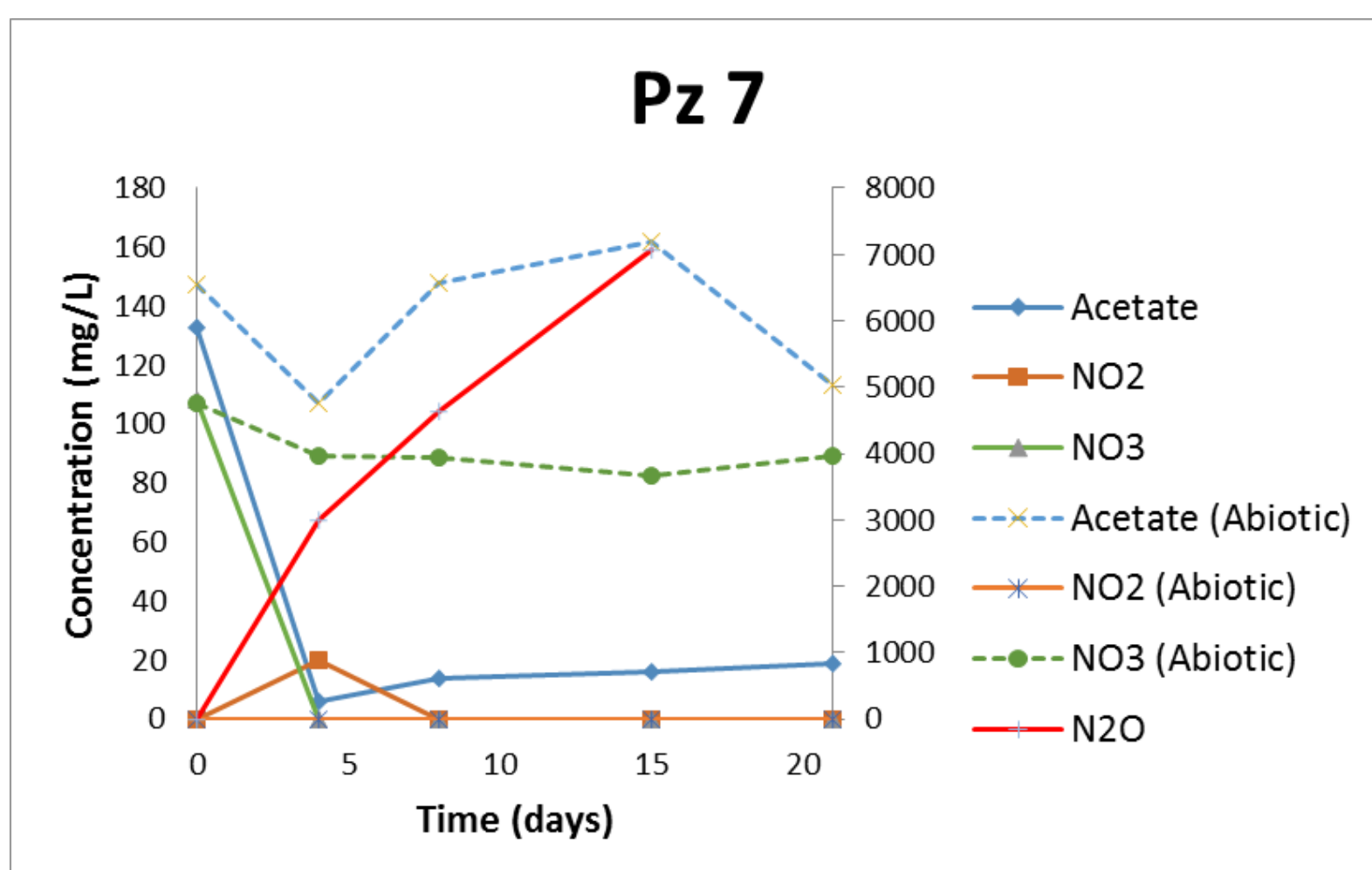
Well	NO ₃ ⁻ (mg/L)	Pesticides	atz genes detection (involved in atrazine biodegradation) (Preliminary tests : to be confirmed)
Pz3	68,2		Detected
Pz6	26,4	DEA	Not detected
Pz7	55	Atrazine, DEA, DIA	Detected
Pz8	< LQ	Atrazine, DEA	Detected
Pz9	< LQ	DEA	Not detected
Pz10	24,2	DEA	Detected
SR1	< LQ		Not detected

=> The wells are quite different when comparing their nitrate concentration and pesticides content.

Batch experiments (anaerobic conditions) for potential denitrification activity measurement



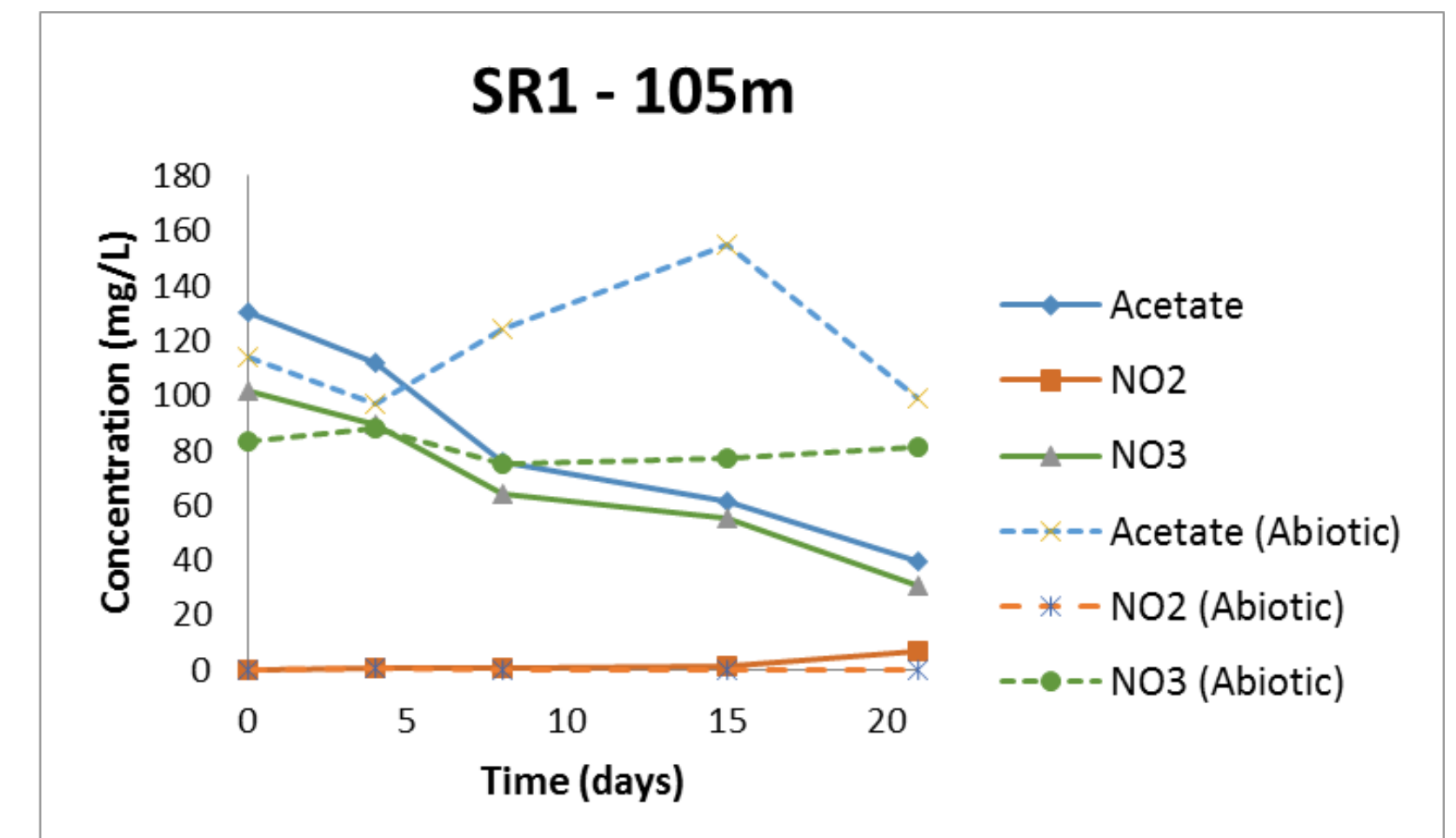
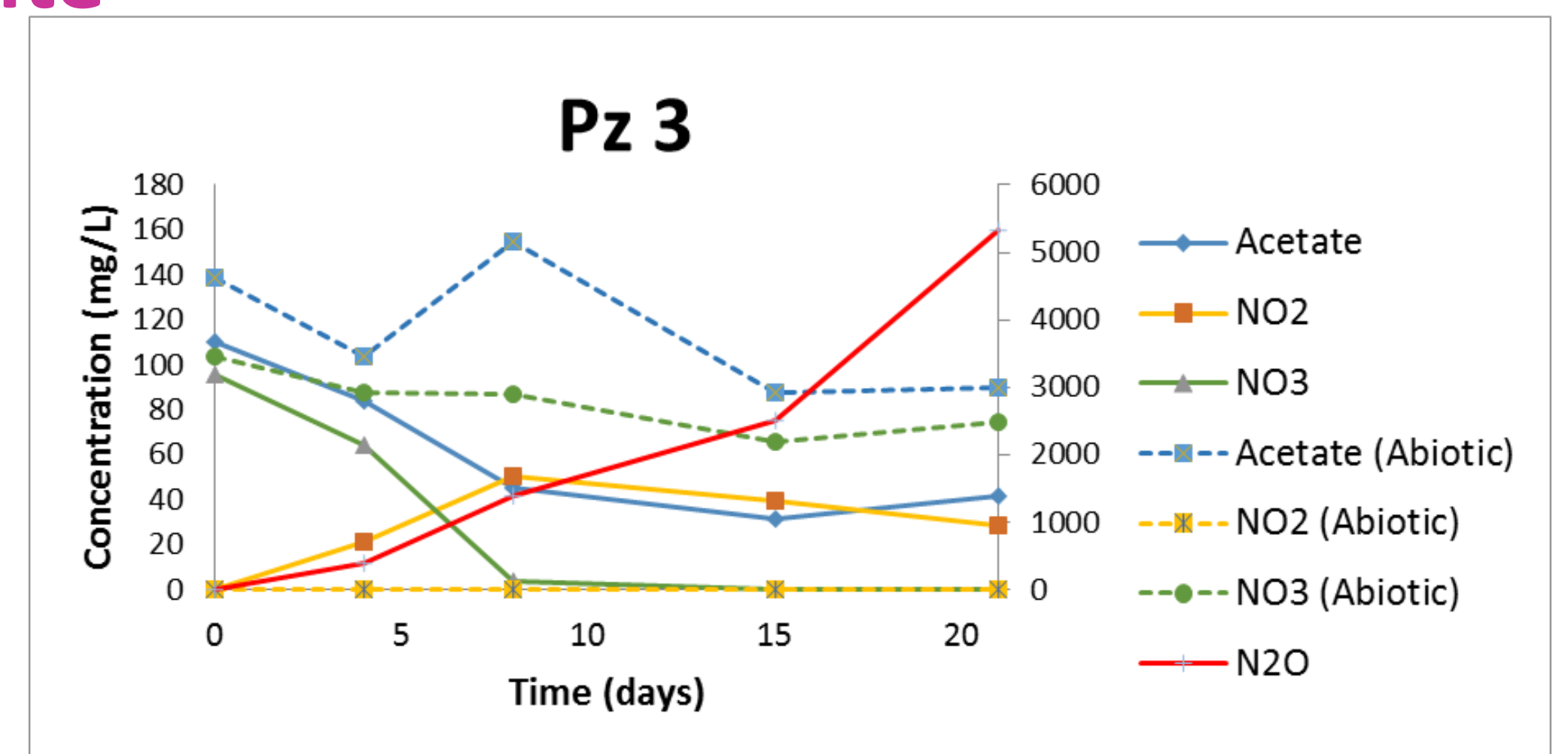
Denitrification activity of microbial communities from the studied site



Batch experiments for the quantification of the potential denitrification activity of groundwater sampled from the wells of the studied site allowed to classify the wells in 3 groups:

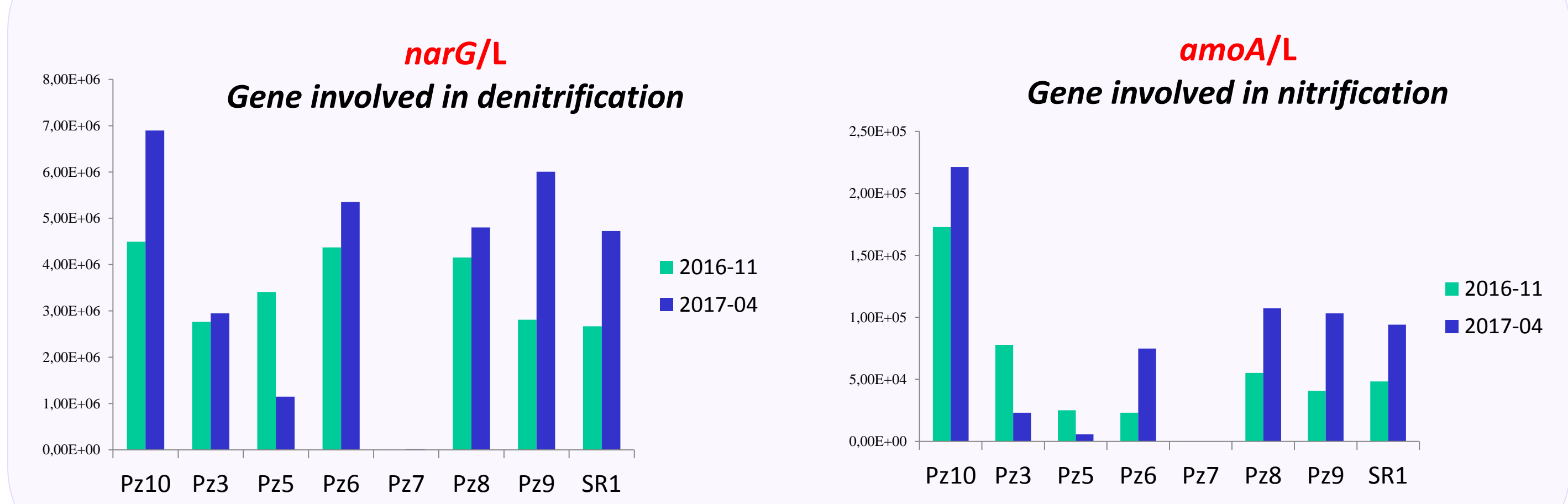
High potential denitrification activity	Pz 7 and Pz 10
Middle potential denitrification activity	Pz 3 and Pz 8 (14 and 18 m)
Weak potential denitrification activity	Pz 6, Pz 9 and SR1 (105 m)

=> There is no relation between the potential denitrification activity and nitrate concentration in well



=> SELECTION of Pz 3 for the first experiments on the impact of pesticides on denitrification as:
 - For this well, a good (but not too high) potential denitrification activity was obtained
 - In this well, no pesticides or metabolites have been detected suggesting no previous contact between the Pz3 microbial community and pesticides

Detection/quantification of genes involved in the N-cycle (qPCR)



=> There is a potential for denitrification AND nitrification in each well.

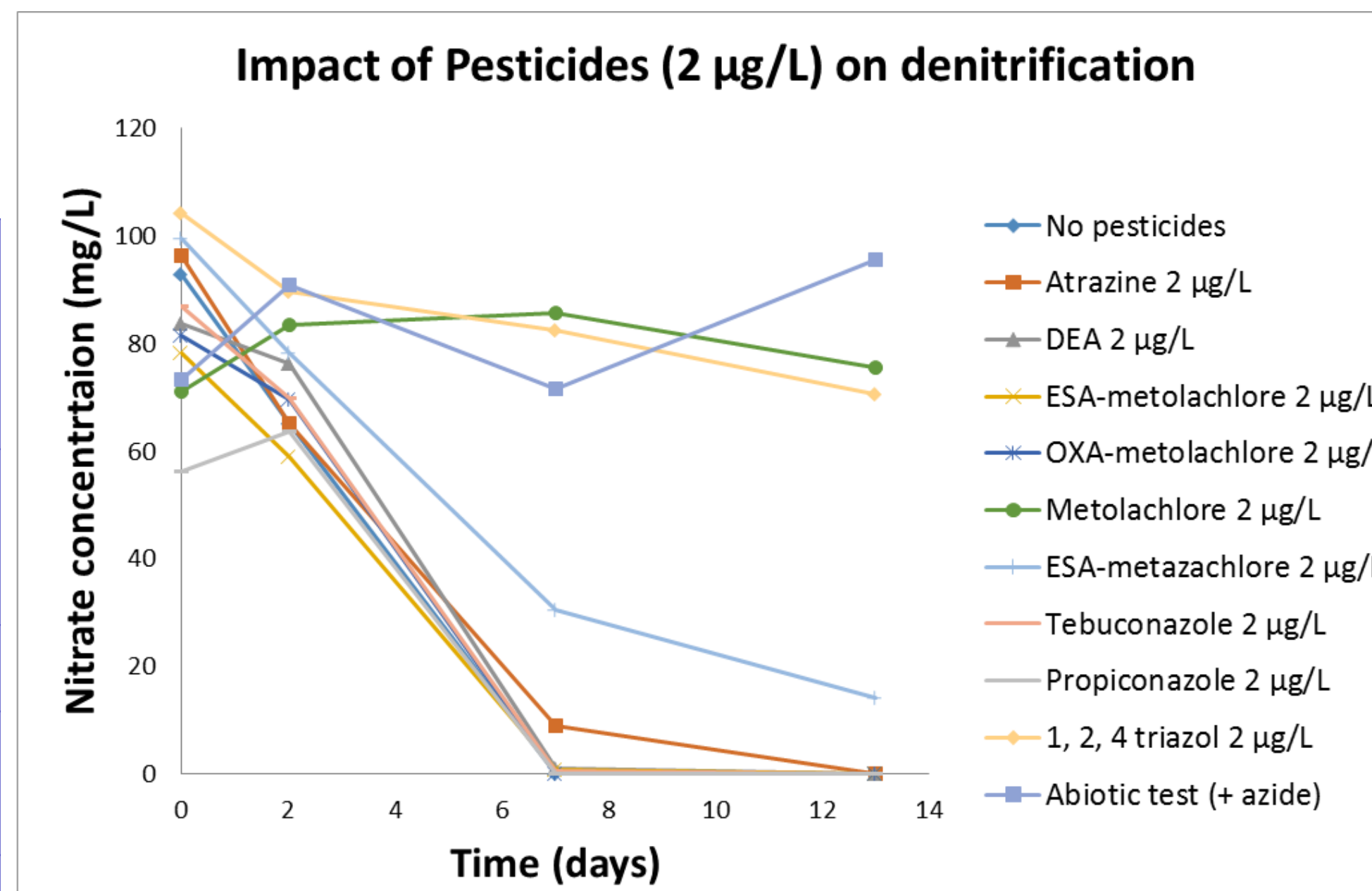
Pesticides impact

List of pesticides used in batch experiments with Pz3 groundwater to study the impact of pesticides on denitrification.

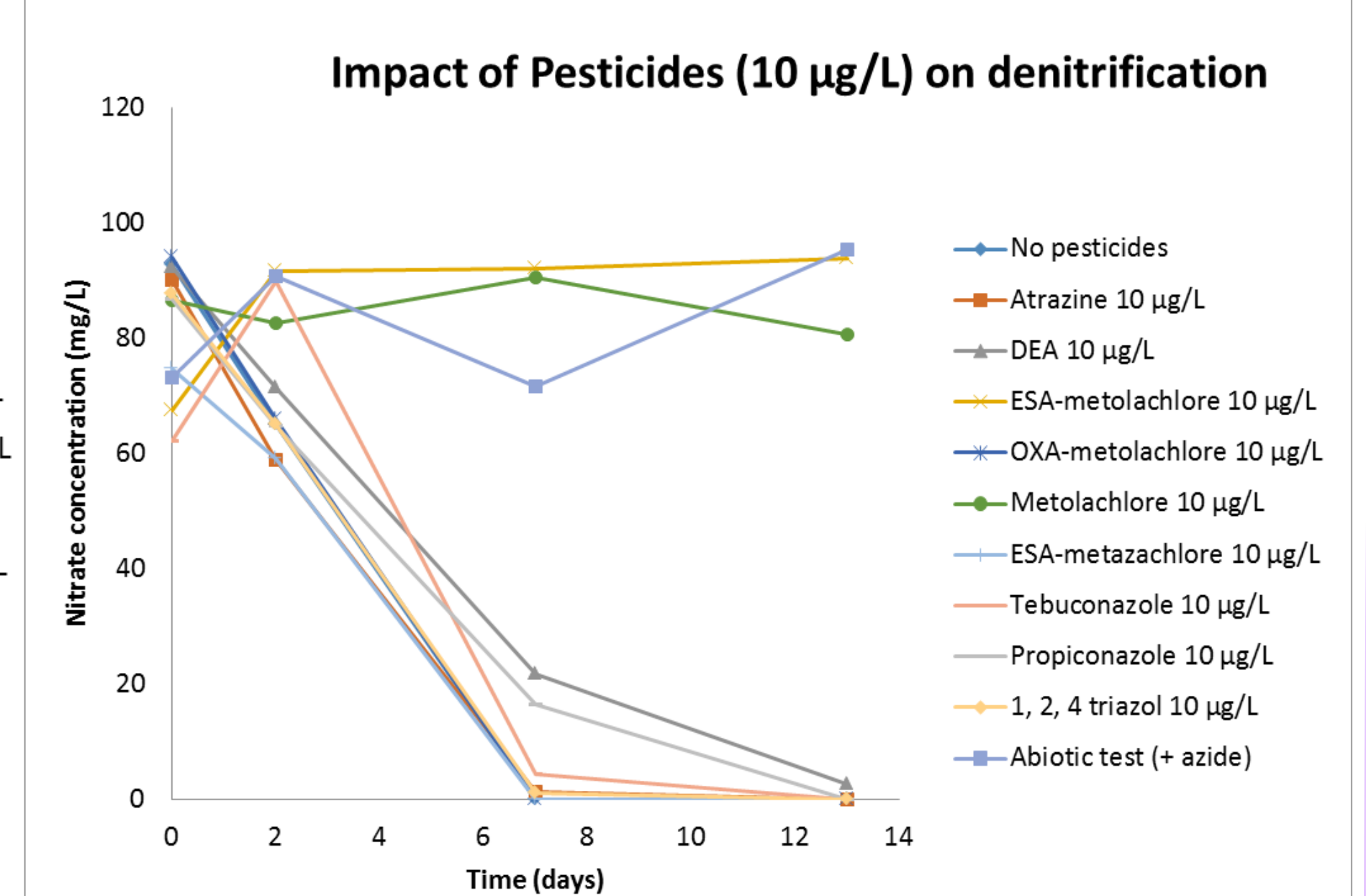
=> Pesticides chosen according to their presence/absence on the studied site and in French groundwater, and their frequency of use in agriculture.

Atrazine	Used in the past on the studied site. Molecule forbidden in France for several years but still detected in French soils (including soils of the studied site). Also detected in groundwater of the studied site.
DEA (Deethylatrazine)	Metabolite from atrazine biodegradation. Toxic and stable in the environment. Found in some of the wells of the studied site.
Metolachlor	One of the most found pesticides in French groundwater.
OXA-metolachlor	Metabolite from metolachlore biodegradation. One of the most found pesticide metabolites in French groundwater.
ESA-metolachlor	Metabolite from metolachlore biodegradation. One of the most found pesticide metabolites in French groundwater.
ESA-metazachlor	Found in French groundwater and in some wells of the studied site
Tebuconazole	Fungicide having a potential impact on soil mineralization
Propiconazol	Main fungicide found in French groundwater.
1,2,4 triazol	Metabolite common to all fungicides. Can stop nitrification.

Impact of pesticides (2 µg/L) on groundwater denitrification



Impact of pesticides (10 µg/L) on groundwater denitrification



=> Pesticides that do not have any impact: Atrazine, DEA, OXA-metolachlore, ESA-metazachlore, Tebuconazole, propiconazole
 => Pesticides that have an impact at both concentrations: Metolachlore
 => Pesticides that have an impact only at "high" concentration: ESA-metolachlore

Conclusions

- On a same catchment, microbial communities of different wells display different potential for denitrification. Moreover, pesticides exposure of these communities on site varies, and first results suggest different potential for atrazine biodegradation (atz gene detection) according to the wells
- Preliminary tests suggest that some pesticides can induce a total inhibition of denitrification at 2 µg/L pesticides whereas other do not have any effect even at higher concentrations.

Next steps

- Impact of pesticides as cocktail (compared to single pesticides)
- Is the impact the same with groundwater having (i) high or low potential denitrification activity, (ii) previously been in contact with pesticide(s), (iii) different microbial community diversity...?

Bibliography: Mauffret, Baran, Joulian (2017) Effect on pesticides and metabolites on groundwater bacterial community. Sci Tot Environ 576: 879-887.