Biological degradation of high concentrations of 2,4- and 2,6-DNT on laboratory and field scale

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Battelle June 2024

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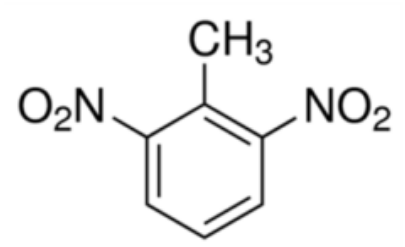
- Laboratory tests
- From lab to field
- Field test results

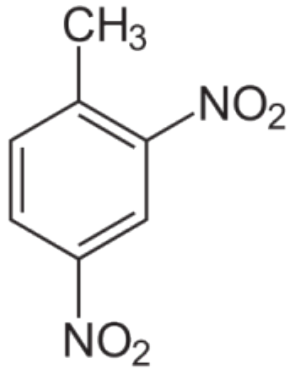
DNT bioremediation

Background

- Site located in Camaçari, Brazil
- Dinitrotoluene (DNT): precursor for toluene di-isocyanate (TDI) -> PU foams
- DNT dissolved in 1,2-DCB
- Concentrations up to ± 1 g/l (max. sol. ± 200 mg/l)



2,6-DNT



2,4-DNT

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Biodegradation – Anaerobic -> aerobic (AN-A)

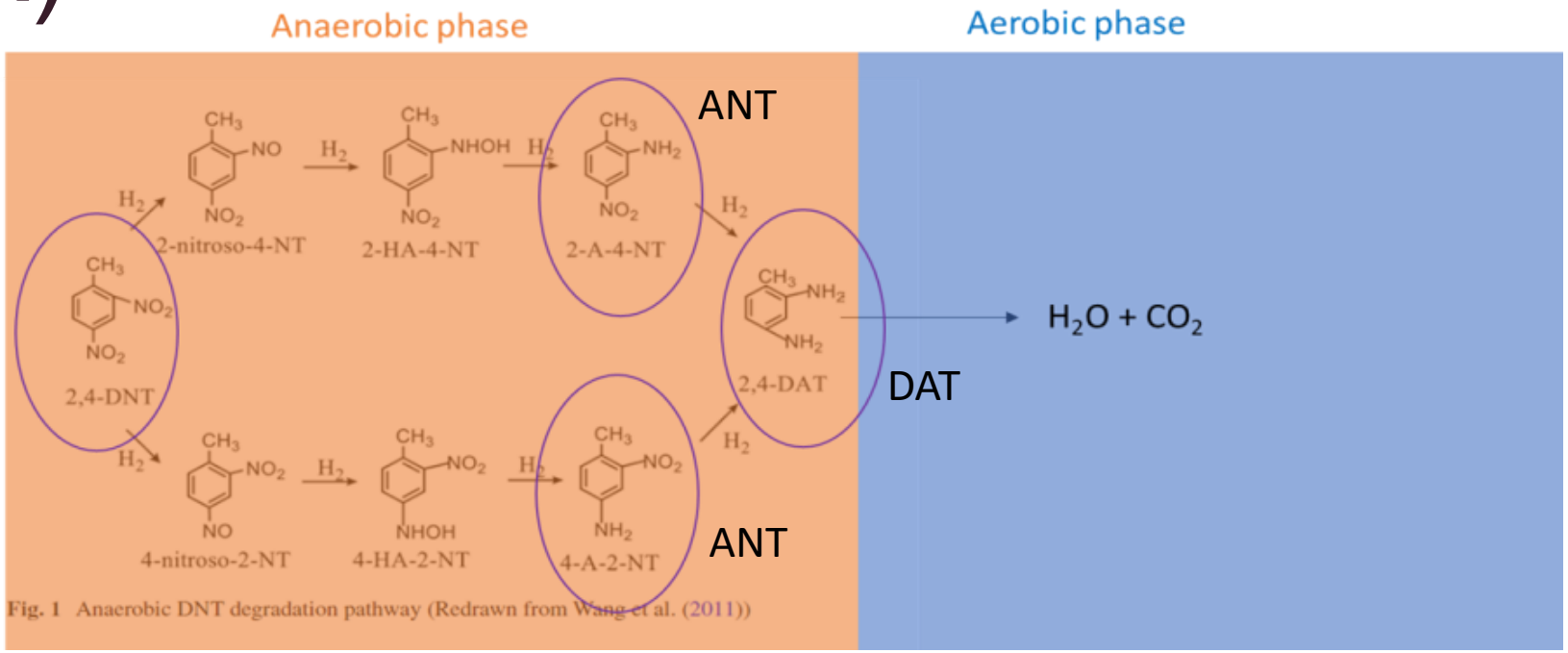
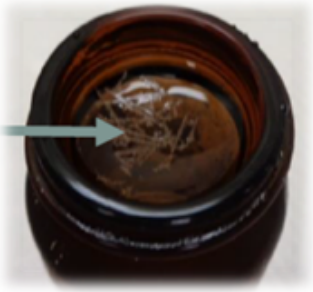


Fig. 1 Anaerobic DNT degradation pathway (Redrawn from Wang et al. (2011))

Aburto-Medina, A. et al. (2017) Degradation of Dinitrotoluene Isomers 2,4- and 2,6-DNT: Appraising the Role of Microorganisms. In: Anjum, N.A. et al. (eds) Enhancing Cleanup of Environmental Pollutants, DOI 10.1007/978-3-319-55426-6_2. Springer International Publishing AG 2017

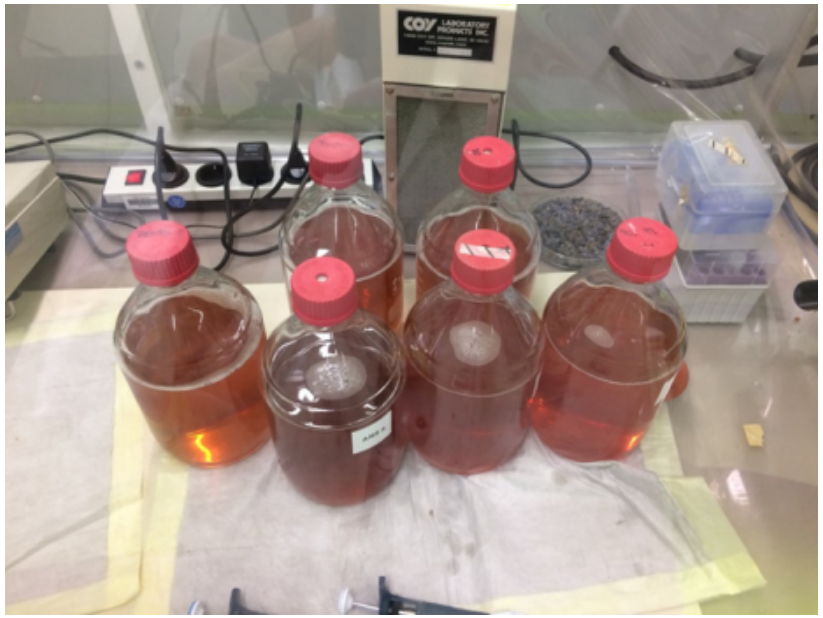
DNT bioremediation

Laboratory degradation test



Marcelle van de Waals and Bas van der Zaan

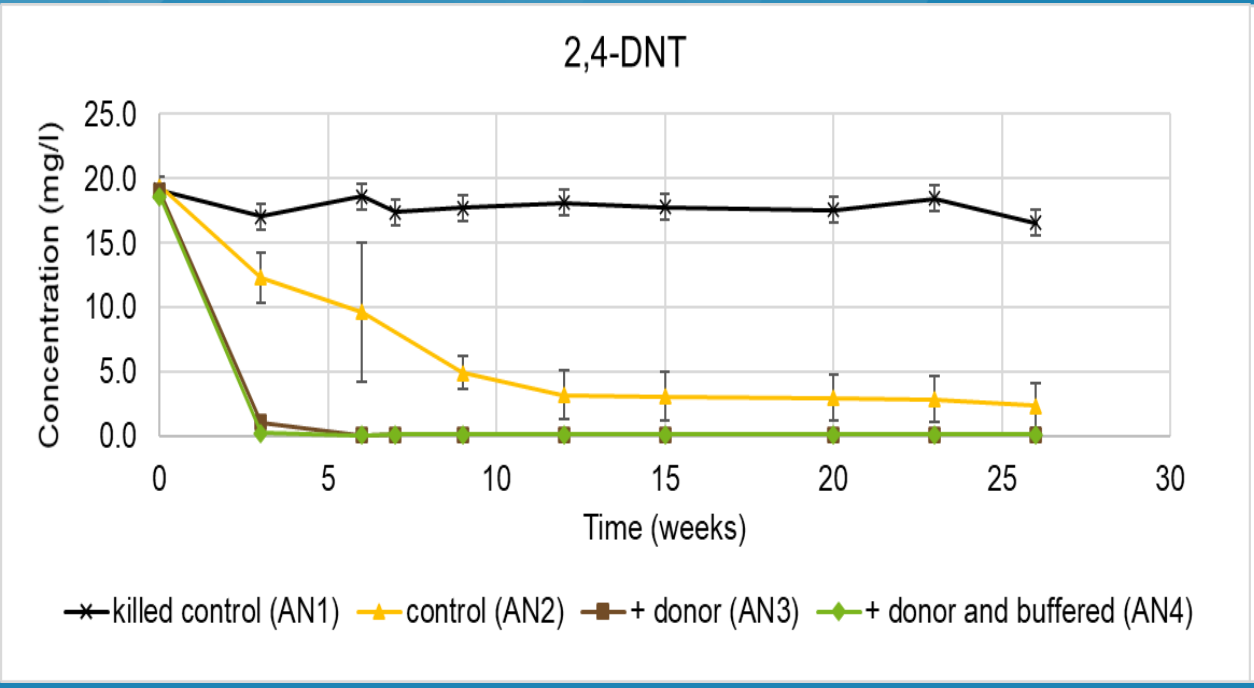
- First test done in Brazil. Concentrations ± 200,000 µg/l (crystallization, analytical variance)
- Second test: concentrations ± 50,000 µg/l
- Investigate both aerobic degradation and the combination anaerobic (reduction to DAT) + aerobic (AN-A)
- Investigate influence of pH (natural versus neutral: on site: 4.27-8.24 (Some indication anaerobic degradation might be faster at higher pH (7-9)[1]

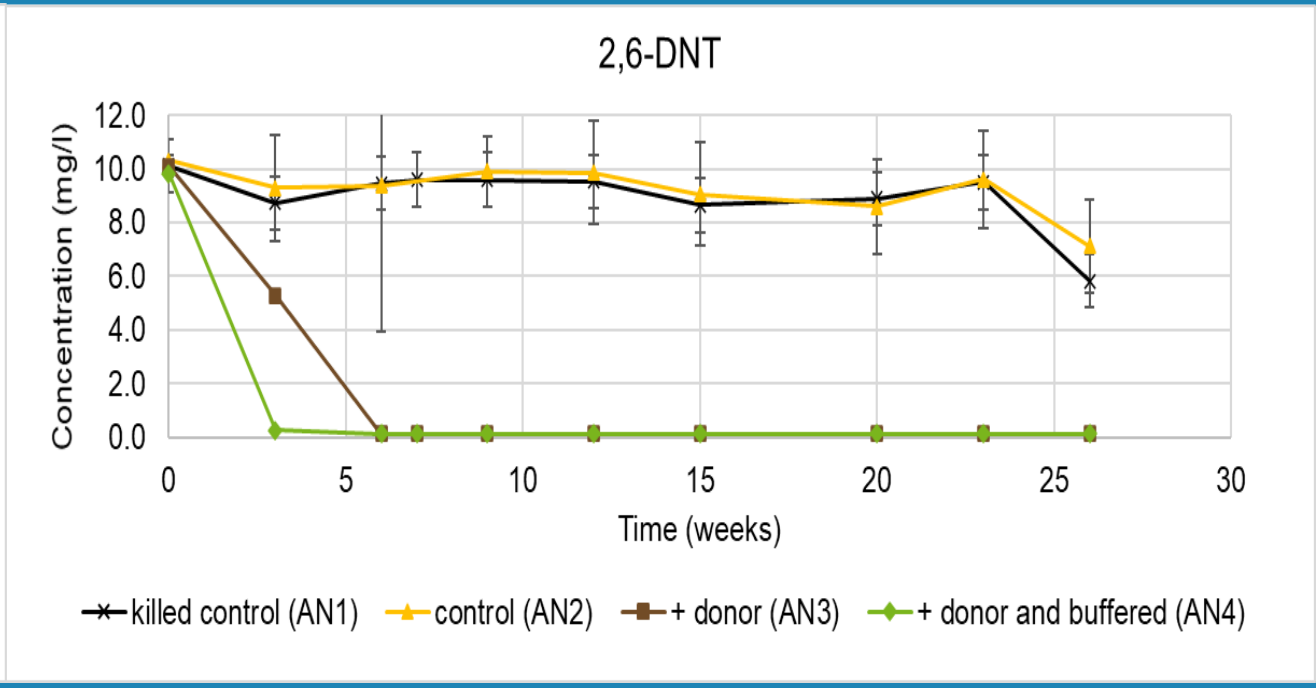


(1) Huang, J. et al. (2015) Biotransformation of 2,4-dinitrotoluene by obligate marine *Shewanella marisflavi* EP1 under anaerobic conditions. Bioresour. Technol. 180; p. 200-206

AN-A test: DNT

- Fast reduction of both 2,4-DNT and 2,6-DNT
- Fastest reduction with electron donor (Dehalo-GS) and neutral pH

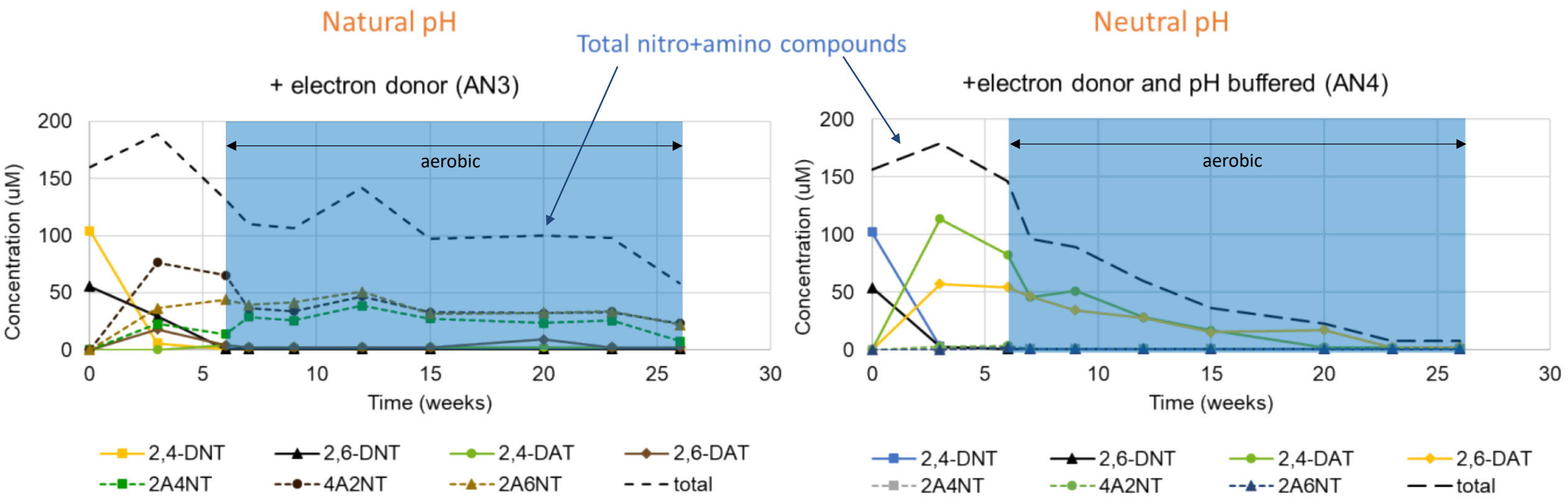




DNT biodegradation

AN-A: degradation products (biostimulation)

- Natural pH: mainly aminonitrotoluene (ANT)
- Neutral pH: mainly diaminotoluene (DAT) : decrease in time



Laboratory test conclusions

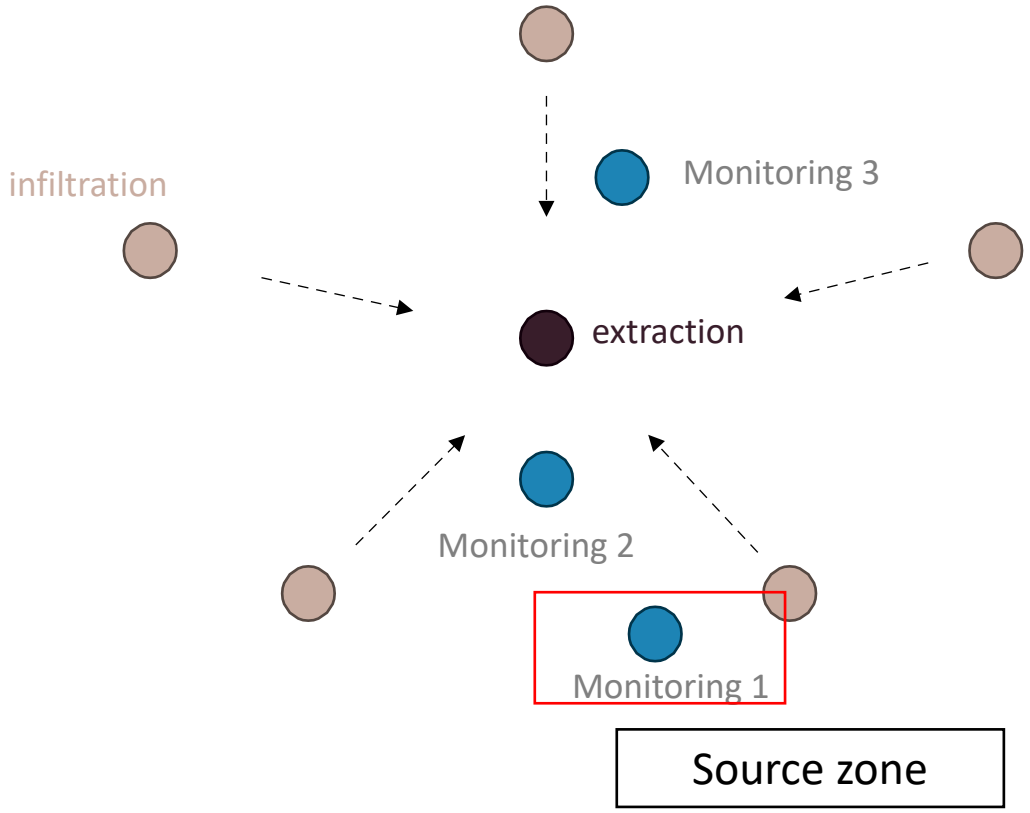
- Only complete removal of both DNT isomers under anaerobic conditions
- Fast reduction of both isomers in the presence of an electron donor
- pH seems to have an effect on reduction rate of especially 2,6-DNT
- At neutral pH major reduction product DAT; at natural pH ANT
- Only complete removal of DAT under subsequent aerobic conditions

DNT bioremediation

Field test Bahia Brazil

- Pilot area just outside source zone (aim for starting concentrations in the order of 50,000 µg/l
- Two depths: potentially investigate and compare pH effect (pH correction optional)
- Anaerobic phase: dose electron donor and circulate ground water
- Aerobic phase when 3 criteria are met

Field test Bahia Brazil



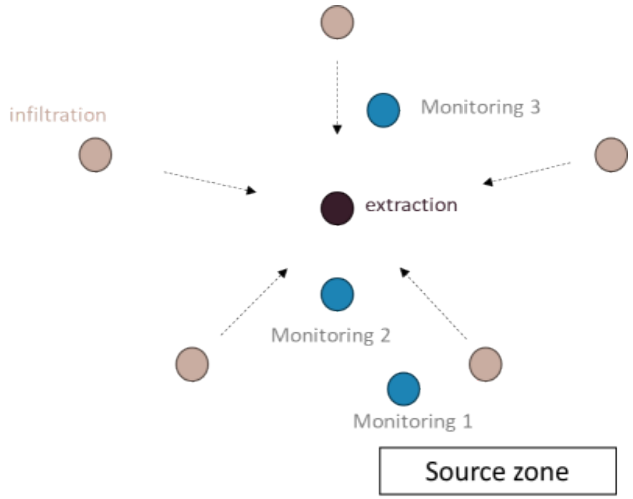
Field test Bahia Brazil

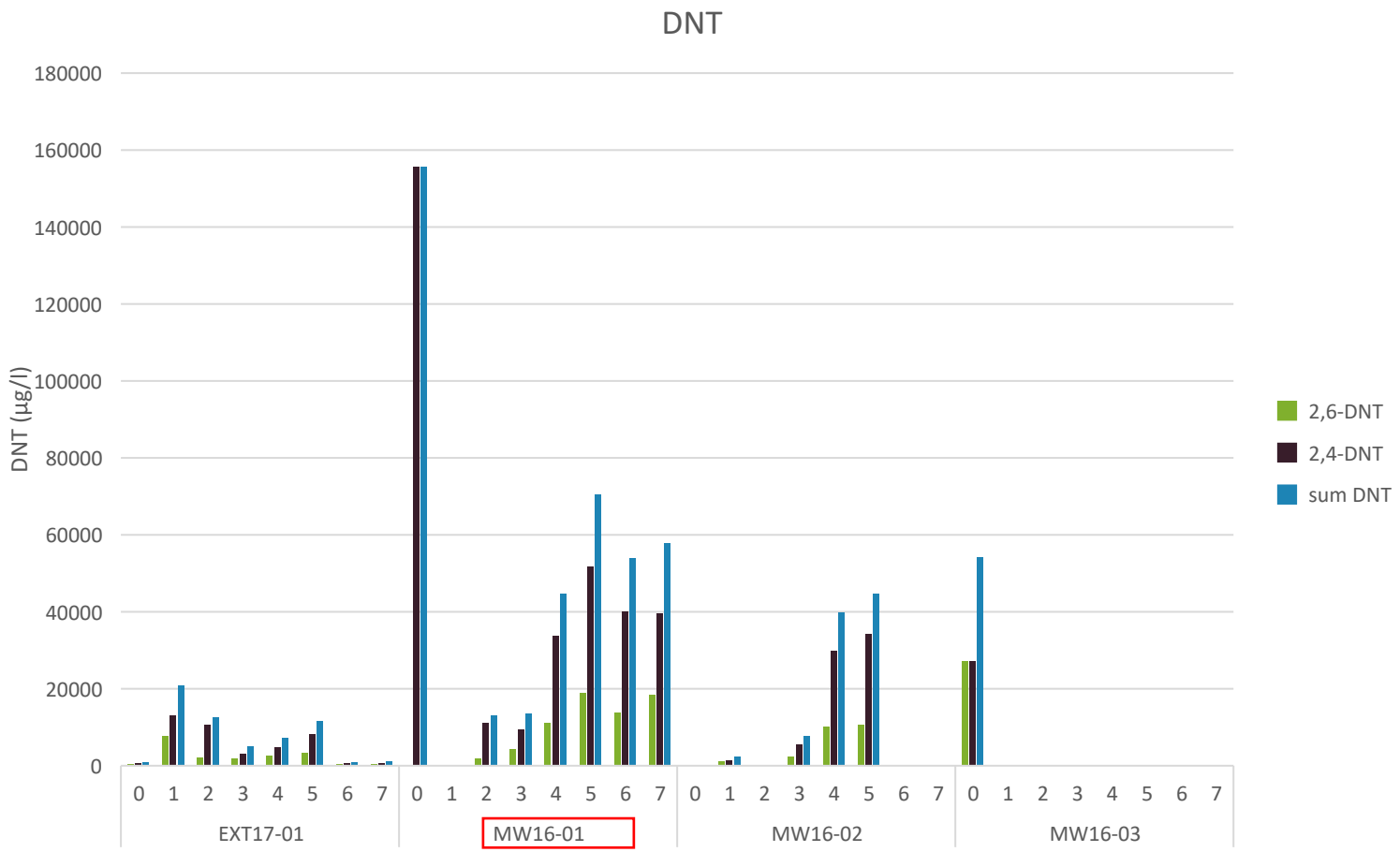
Targets pilot for switching to aerobic phase:

Condition to be met in 3 wells	Criteria
DNT decrease	> 90%
Degradation products/(degradation products +DNT)	> 95%
DAT/(DAT+ANT)	> 60%

DNT bioremediation

Shallow layer (17 m-bgl)





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DNT bioremediation

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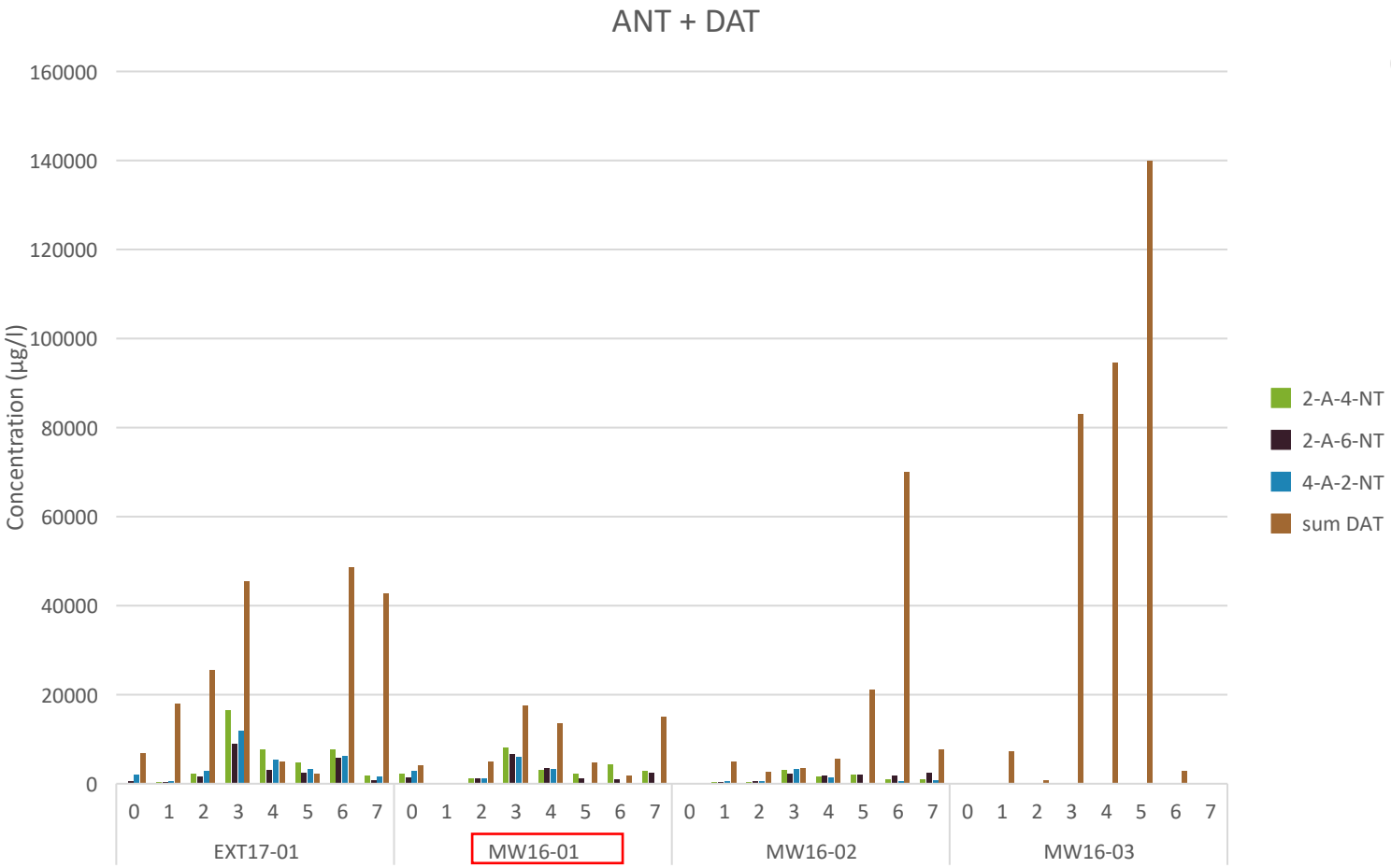

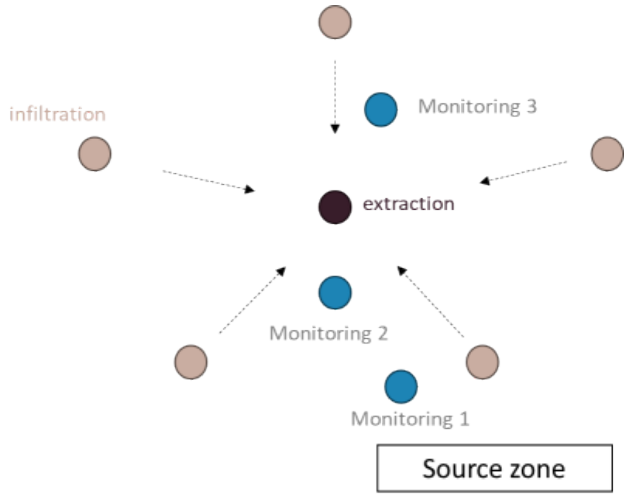

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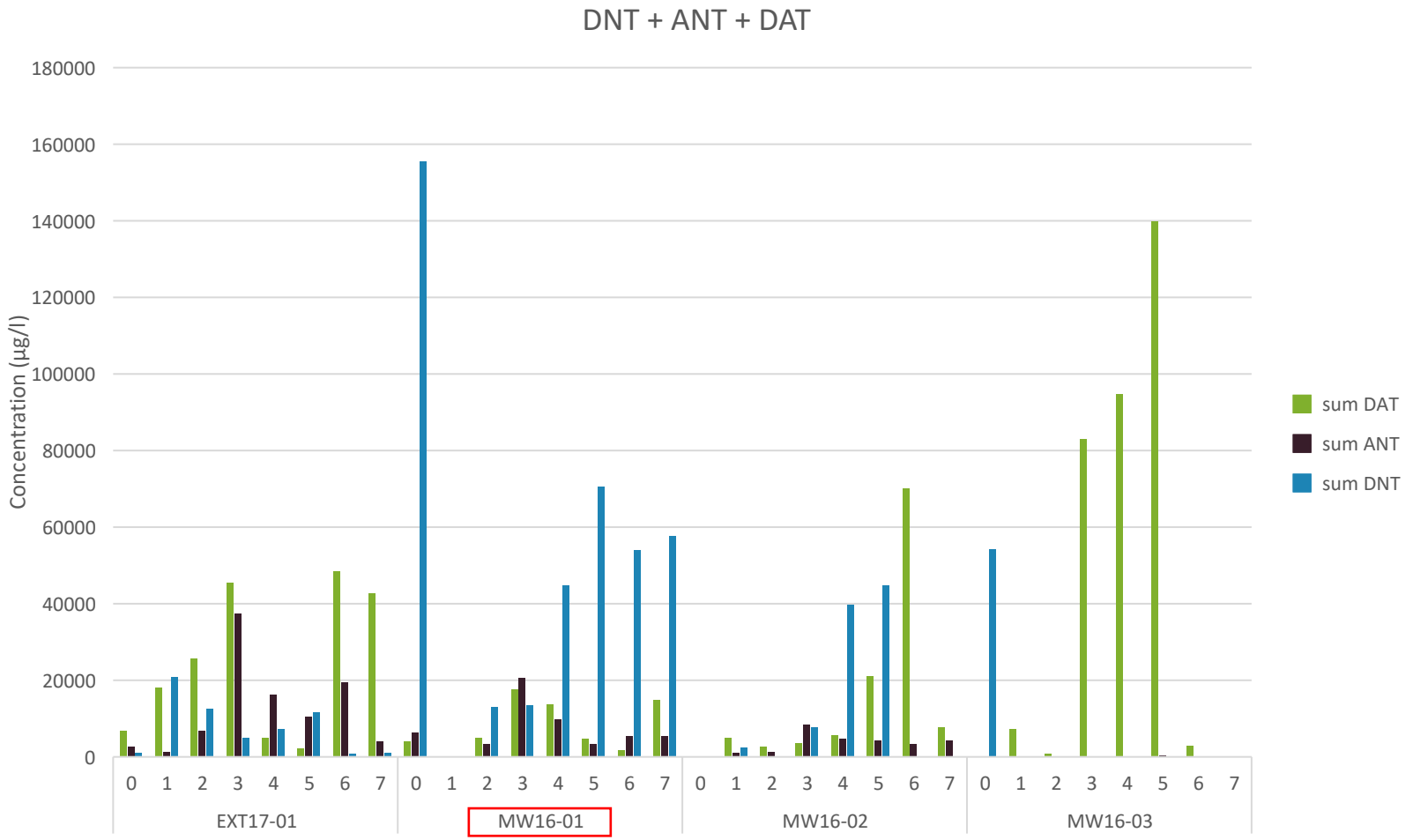
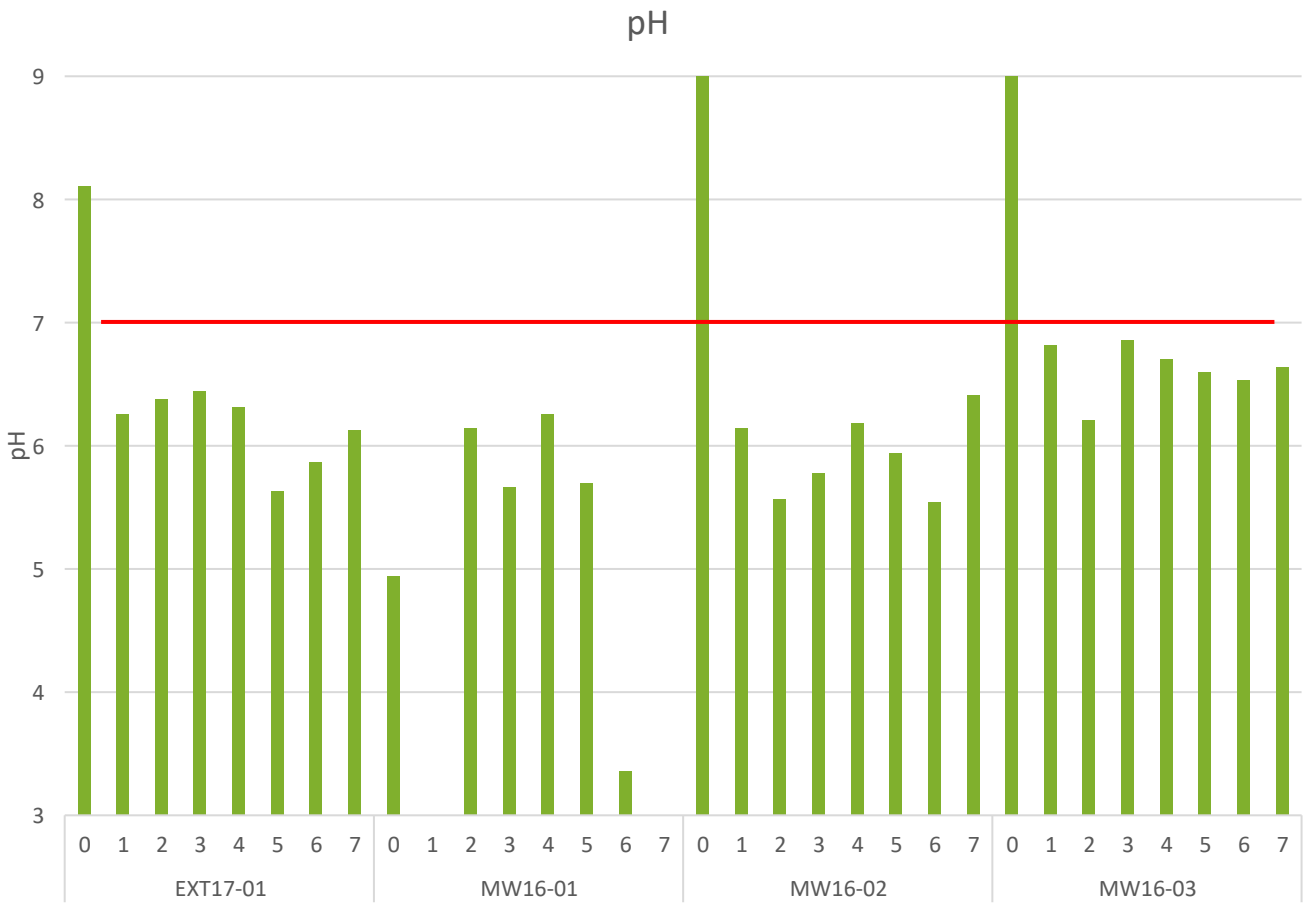
Shallow layer (17 m-bgl)



DNT bioremediation

Shallow layer (17 m-bgl)



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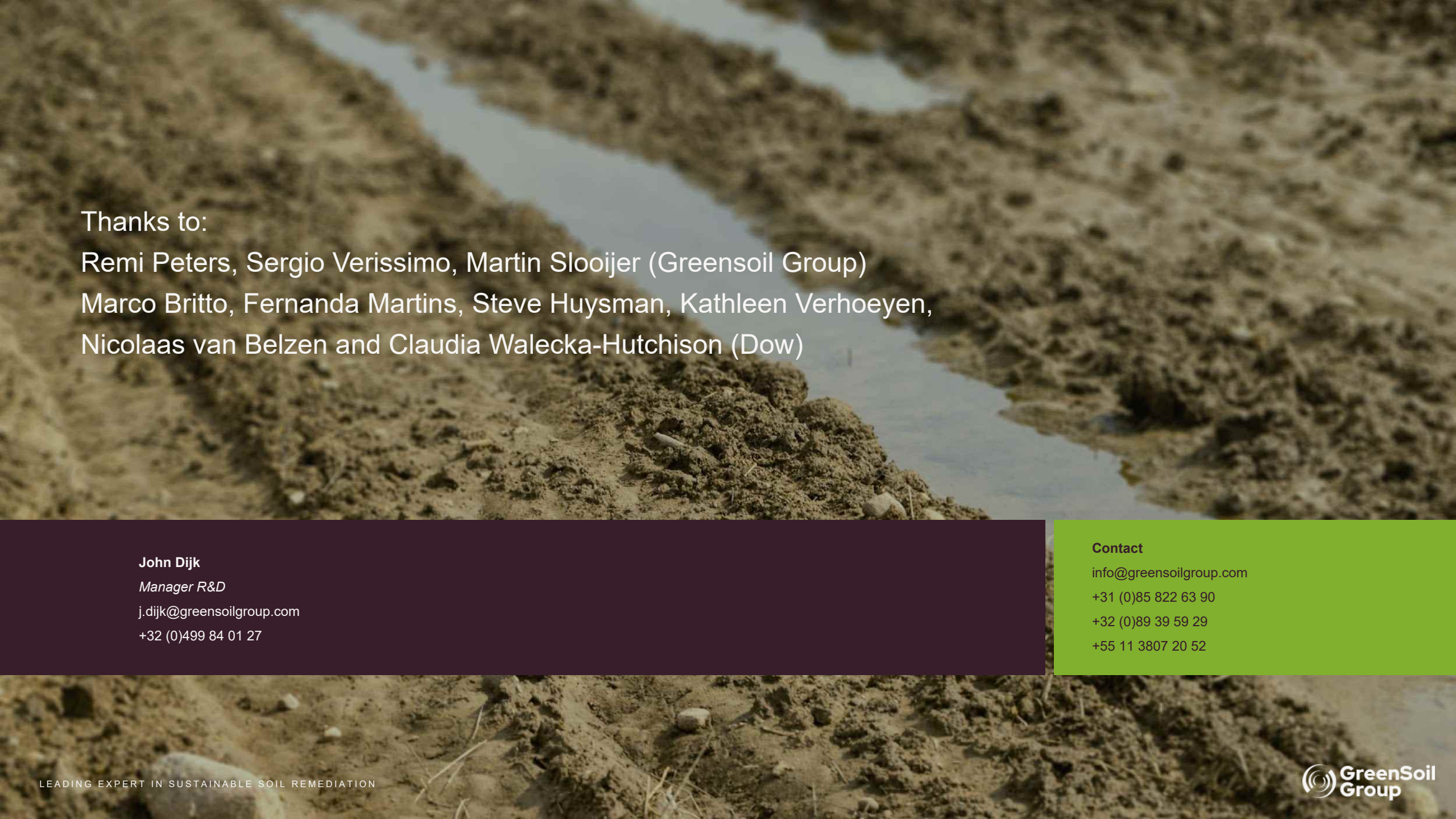
Conclusions layer 17 m-bgl

- Lower DNT starting concentrations (about 10 times lower compared to deeper layer)
- Despite low pH complete reduction to DAT and DAT dominant degradation product in contrast to laboratory test (heterogeneity?)
- Criteria for switching to aerobic phase met

Condition to be met in 3 wells	Criteria	Value (AVG)
DNT decrease	> 90%	95.6%
Degradation products/(degradation products +DNT)	> 95%	96.5%
DAT/(DAT+ANT)	> 60%	86.8%

Field test conclusions

- Starting DNT concentration important
- Good anaerobic results from laboratory test could be replicated in shallow layer
- Currently aerobic conditions in shallow layer and pH correction in deeper layer (more variation due to high concentrations/lower pH?)
- pH less critical than laboratory test suggested likely due to heterogeneity/soil matrix (same experiences with for example ERD)



Thanks to:
Remi Peters, Sergio Verissimo, Martin Slooijer (Greensoil Group)
Marco Britto, Fernanda Martins, Steve Huysman, Kathleen Verhoeyen,
Nicolaas van Belzen and Claudia Walecka-Hutchison (Dow)

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