



Aalborg Universitet

AALBORG UNIVERSITY
DENMARK

Selection and Testing of Surfactants for Enhanced In Situ Alkaline Hydrolysis (S-ISAH) of Pesticide DNAPL

Muff, Jens; Søgaard, Erik Gydesen; Bennedsen, Lars R.; Rügge, Kirsten; MacKinnon, Leah ; Durant, Neal; Pennell, Kurt ; Bondgaard, Morten

Publication date:
2014

Document Version
Early version, also known as pre-print

[Link to publication from Aalborg University](#)

Citation for published version (APA):

Muff, J., Søgaard, E. G., Bennedsen, L. R., Rügge, K., MacKinnon, L., Durant, N., ... Bondgaard, M. (2014). Selection and Testing of Surfactants for Enhanced In Situ Alkaline Hydrolysis (S-ISAH) of Pesticide DNAPL. Poster session presented at Ninth international conference on remediation of chlorinated and recalcitrant compounds, Monterey, CA, United States.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- ? Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- ? You may not further distribute the material or use it for any profit-making activity or commercial gain
- ? You may freely distribute the URL identifying the publication in the public portal ?

Take down policy

If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Jens Muff*¹ & Erik G. Søgaard¹, Lars R. Bennedsen², Kirsten Rügge³, Leah MacKinnon and Neal D. Durant⁴, Kurt Pennell⁵, Morten Bondgaard⁶

¹Aalborg University, Denmark, ²Rambøll, Denmark, ³COWI, Denmark, ⁴Geosyntec Consultants, Maryland, USA, ⁵Tufts University, Massachusetts, USA, ⁶Region Midtjylland, Denmark

Background

Groyne 42 is a 20,000 m² former chemical dump site in Denmark contaminated with 200-300 tons of organophosphorous pesticides (OPPs). The majority of contaminant mass is present as sorbed phase and residual DNAPL. The NorthPestClean project was established to determine the effectiveness of using *in situ* alkaline hydrolysis to treat the DNAPL (Fig. 1).

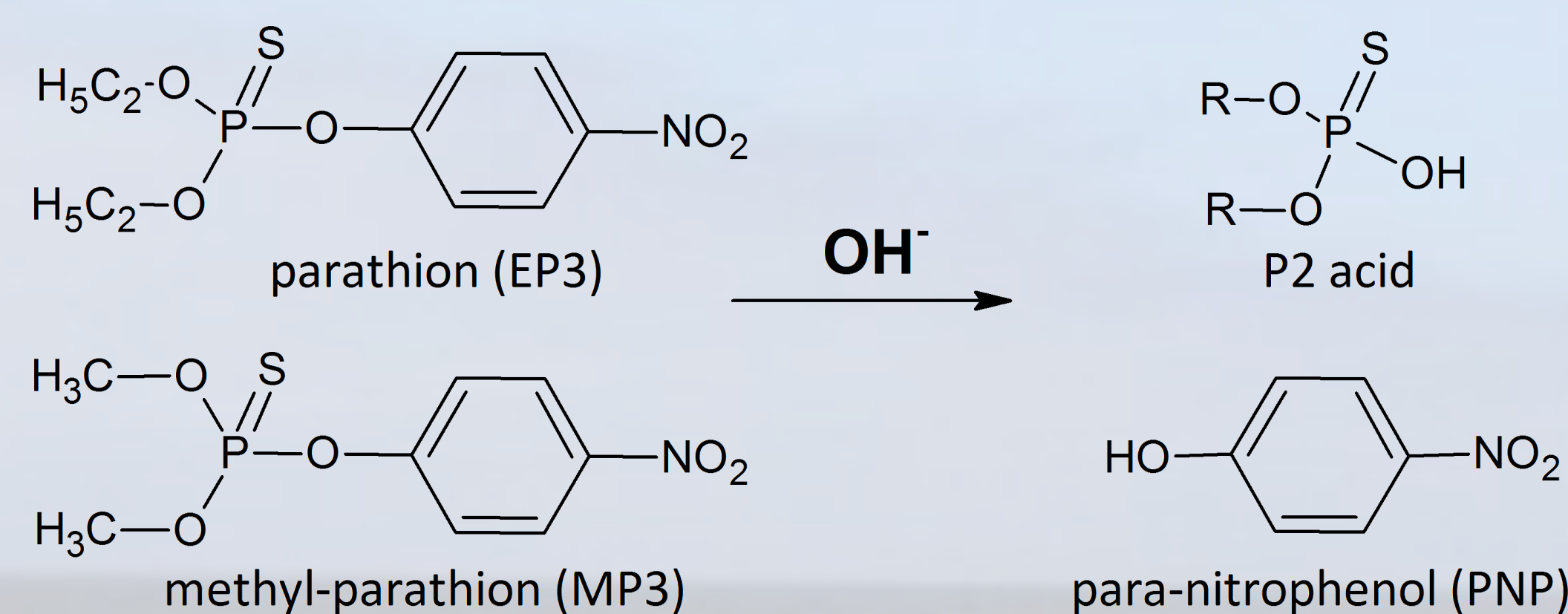


Fig. 1: The alkaline hydrolysis of OPPs.

A primary challenge is *in situ* mixing, establishing sufficient contact between hydroxide and DNAPL.

Scope of study

To test surfactants as a method for enhancing the solubility of OPPs and the rate of *in situ* alkaline hydrolysis and select a commercially available formulation for pilot scale site tests.

Initial selection

Previous work has identified non-ionic surfactants as the best performing type increasing OPP solubility.

Ten candidate surfactants was identified based upon the following criteria:

- stability under alkaline conditions (pH of 12 or higher)
- acceptability for in situ use – not toxic to the environment
- readily biodegradable in the environment
- limited foaming

Screening

Parameter	Compounds
SUM OPP	parathion (EP3), methyl-parathion (MP3), malathion, ethyl-sulfotep
SUM P2 acids	O,O-diethylthiophosphoric acid (EP2), O,O-dimethylthiophosphoric acid (MP2)
PNP	para-nitrophenol

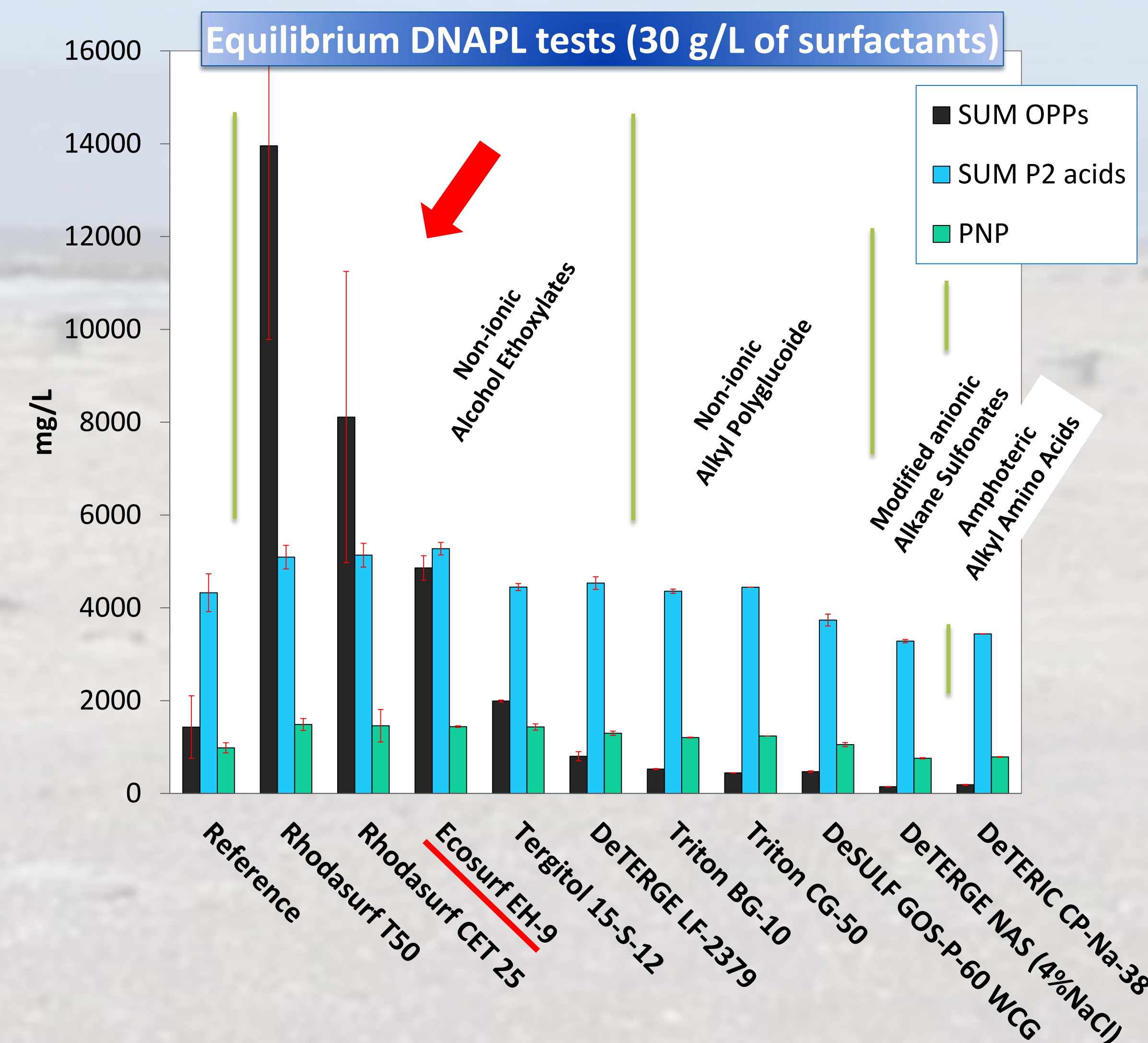


Fig. 2: Screening of ten surfactants at pH 13 after 7 days with a 10:1 surfactant:DNAPL volumetric ratio.

Batch equilibrium solubility tests showed that **alcohol ethoxylate non-ionic surfactants** was superior with respect to increasing OPP solubility compared to the alkaline tap water reference. The concentrations of hydrolysis products were on the same level as the reference and hence no significant enhancement of the hydrolysis rate was observed.

Alcohol Ethoxylates



Fig. 3: The contaminated soil/ surfactant water ratio used in this test was 4 g/mL. No extra DNAPL was added.

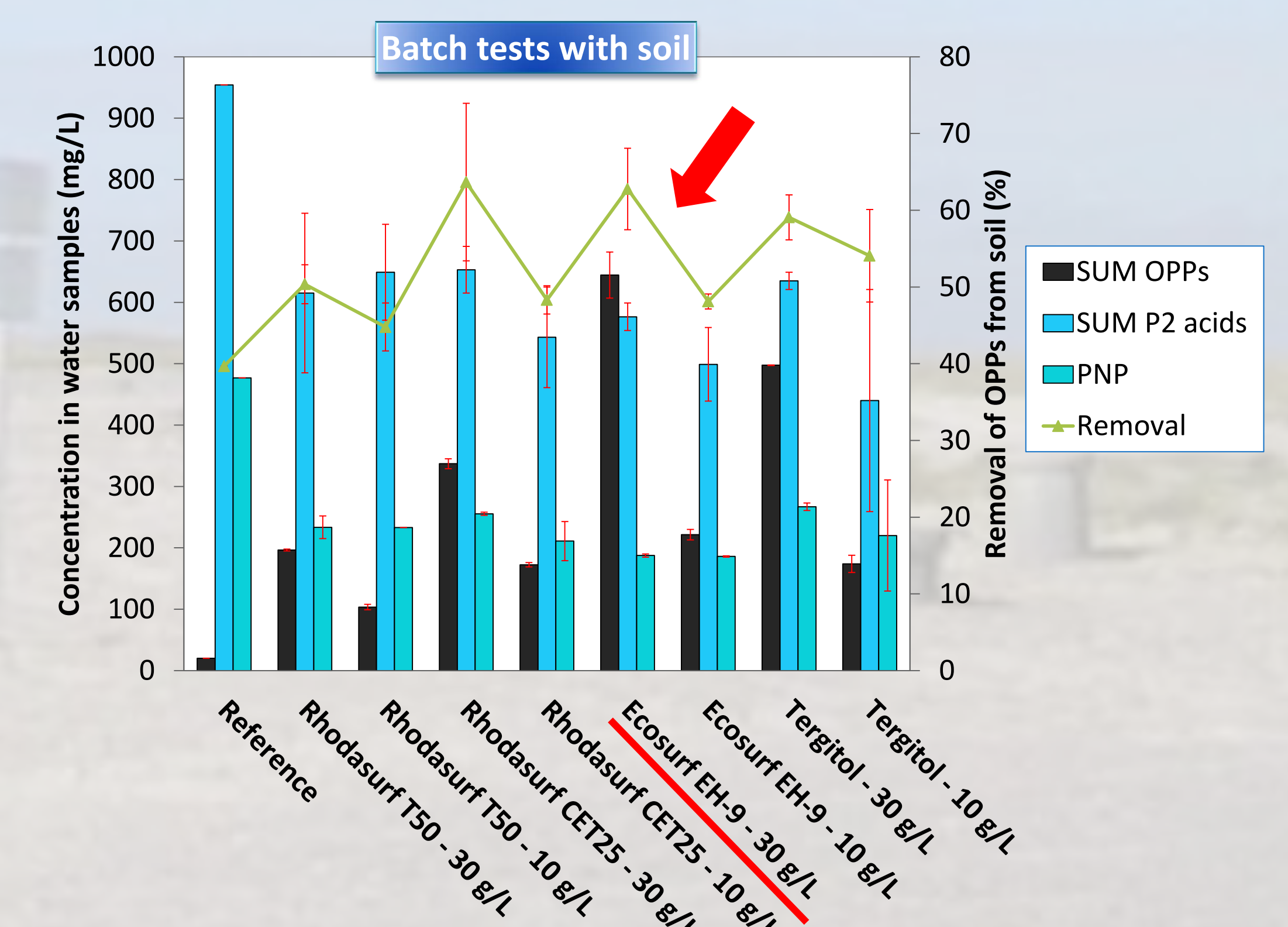


Fig. 4: Results of batch tests with soil of four alcohol ethoxylates after 7 days of reaction at pH 13.

Ecosurf EH-9 was best at increasing OPP solubility in the presence of soil due to higher soil adsorption of the other ethoxylates. Highest OPP removal from the soil was obtained with Rhodasurf CET25 (64%) and Ecosurf EH-9 (63%) compared to 40% of the reference alkaline tap water. Ecosurf EH-9 has higher biodegradability and lower costs.

Conclusion

Ecosurf EH-9 was chosen for pilot scale tests at the Groyne 42 site at a concentration of 4%.
(Results of pilot scale test: Session H5 Tuesday by MacKinnon et al.)