Diffuse phosphorus input to surface waters
- new concepts in removal, recycling and management -

1st Science School

- Coupling of Fe and P dynamics on global and microscopic scale –

Lead author

Sylvia Walter
Utrecht University

Princetonlaan 8a,
3584CB Utrecht
The Netherlands

Phone: +31 30 253 2428
Email: s.walter@uu.nl

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1. General overview

In total, three science schools are planned within P-TRAP. The schools aim to expose the ESRs to cutting-edge international research related to P-TRAP, where leading scientific experts will teach, typically half day, sessions dedicated to specific subjects. Contributions will be provided by participants from P-TRAP as well as members of the EAB. Also, other experts and stakeholder outside P-TRAP will be invited to contribute to the schools.

The 1st Science School - Coupling of Fe and P dynamics on global and microscopic scale – was initially planned to be hosted by the UU in project month 13. However, due to the timing of the recruitment, the first training (TSTC1) and 1st Annual Meeting, the consortium decided during the first P-TRAP teleconference (17 July 2019) to postpone the school to project month 17 (July 2020). By this the school could have been combined with the second training (TSTC2) and the Progress Review Meeting, reducing the amount of traveling significantly.

Also, in November 2019 the UU agreed to host a workshop of the European Sustainable Phosphorus Platform (ESPP) in Utrecht, which fit perfectly in the agenda of the 1st Science School, offering lots of opportunities for P-TRAP to present the project and interact with international communications of this topic. Therefore, this workshop was planned to be integrated into the 1st Science School.

However, as in March 2020 the Corona pandemic caused severe travel restrictions, the UU as host decided end of April to organize all training and meeting events remotely. ESPP agreed on organizing the workshop online. The used platform was Zoom.

To ensure all training and meeting events happening, the organization and agendas were adjusted to the actual situation. The 1st Science School, initially scheduled as a kind of conference for 2.5 days, has been reduced to 1.5 days of the ESPP workshop.

Aim of the school was to provide an overview about the broad field of research activities, approaches, and methodologies, and enabling the ESRs to fit their research into the larger scientific context. This was perfectly given by participating in the ESPP workshop. 8 in P-TRAP involved beneficiaries (US, UU, KULeuven, UNIMAN) and partner organisations (Wetsus, Fertiberia) and additionally 5 ESRs (Karel As, Lordina Eshun, Rouven Metz, Tolulope Ayeyemi, and Victoria Barcala) presented their projects:

- Vicotoria Barcala (DELTARES) – Capturing phosphorus in drained agricultural area
- Lordina Eshun (UNIMAN) – Formation of vivianite in bioreactors
- Tolulope Ayeyemi (US) – Suitability of P containing Fe phases as fertilizers
- Karel As (UBT) – Lake restoration based on Fe addition
- Rouven Metz (UNIVIE) – Biogeochemical mechanisms influencing the bioavailability of P and Fe from vivianite

The presentations are available online at https://phosphorusplatform.eu/events/59-espp-activities/1975-espp-workshop-on-iron-phosphate-chemistry. Recorded sessions can be found at the ESPP YouTube channel https://www.youtube.com/channel/UCJsIJAsT-6ADikk-4Hje9Qg.

All ESRs were asked to take notes during the workshop for a special newsletter prepared by ESPP afterwards.

2. Participants

The ESPP workshop was initially organised for 30-50 participants, including the P-TRAP ESRs. Due to holding the event online, in total more than 160 international attendances participated in the workshop. All ESRs participated in the workshop and 5 of them presented their projects and first results.

3. Agenda

Workshop on
Iron – phosphorus interactions and opportunities for phosphorus stewardship
13-14 July, 2020 (online)

Day 1 = Monday 13th July

14.00 Welcome. Workshop objectives and organisation – ESPP and co-organisers *(10 mins)*

14.10-16.00 Session 1 – Iron phosphorus interactions in natural and engineered systems

- Thilo Behrends – Challenges for trapping and recycling phosphorus from agricultural run-off: Introduction to the P-TRAP project *(10 mins)*
  Additional input (2 mins / 2 slides maximum):
  - Stefan Jansen, Deltares – Use of iron sand in agricultural drain systems to prevent P run-off
  - Hui Xu, Ghent University – Reducing P losses from drained agricultural fields using iron-coated sand filters
  - Hans Chr. Bruun Hansen, University of Copenhagen – Iron oxide filters for agricultural P
  - Changyong Lu, University of Copenhagen – Magnetic MgFe LDH composites for phosphate removal - is the LDH sufficiently stable?

- Lena Heinrich, Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB) – Iron phosphate coupling in wastewater treatment plants and lake sediments *(10 mins)*
- Caroline Slomp, Utrecht University – Fe/P relationship in marine environments *(10 mins)*

- Jean-Christophe Ades, Kemira for INCOPA – Use of iron and aluminium coagulants in wastewater treatment: P- removal and challenges of P- recovery *(10 mins)*
  Additional input (2 mins / 2 slides maximum):
  - Denise Roberts, LKAB Minerals – The source of iron coagulants – magnetite
  - Derrick Emms, Sustainable Water Company – Removal of PO4 from wastewater effluent using ferric from mine water and water treatment stations

- William Schipper – Overview of industrial applications & markets for iron phosphates *(10 mins)*
  Additional input (2 mins / 2 slides maximum):
  - Alexandre Wavreille, Prayon – Industrial applications of iron phosphate
  - *Questions and discussion*

16.00 Wrap-up and close of Day 1

Workshop on
Iron – phosphorus interactions and opportunities for phosphorus stewardship
13-14 July, 2020 (online)

Day 2 = Tuesday 14th July

10.00 Session 2 – Iron phosphate in agriculture

- Bengt Hansen, Kemira – How iron in sewage biosolids and recovered fertiliser products impact crop P availability *(10 min)*
- Cinta Cazador, Fertiberia – The specific case of recovered vivianite as fertilizer *(10 min)*

Additional input (2 mins / 2 slides maximum):

  - Kees Langeveld, ICL for Fertilizers Europe – Impacts of iron on phosphate fertiliser performance and implications for phosphate recycling from sewage (2 min)
  - Antonio Delgado, University of Sevilla – Iron phosphate as fertiliser on Mediterranean soils?

- Erik Smolders, Catholic University of Leuven – Iron in soil and plant phosphorus availability (10 min)
- Guy Kirk, Cranfield – How iron in soil impacts root P uptake and soil nutrient biochemistry *(10 min)*

Additional input (2 mins / 2 slides maximum):

  - Ruben Sakrabani, Cranfield University – Role of P analytical methods and their implications for evaluating P availability in crops

- Jon Lloyd, University of Manchester – Microbial and mineralogical constraints on Fe(III) bioreduction, and links to the phosphorus cycle

12.30 LUNCH BREAK

13.30 Poster session

Virtual poster session with five PhD students from the H2020 P-TRAP project. 5 min presentations followed by 5 min questions, the session is finished with a short general discussion.

- Victoria Barcala, Utrecht Universiy – Capturing phosphorus in drained agricultural area
- Lordina Eshun, University of Manchester – Formation of vivianite in bioreactors
- Tolulope Ayeyemi, University of Sevilla – Suitability of P containing Fe phases as fertilizers
- Karel As, Bayreuth University – Lake restoration based on Fe addition
- Rouven Metz, University of Vienna – Biogeochemical mechanisms influencing the bioavailability of P and Fe from vivianite

14.30 BREAK

Workshop on
Iron – phosphorus interactions and opportunities for phosphorus stewardship
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Day 2 = Tuesday 14th July

15.00 Session 3 – Strategies for phosphorus release and recovery from iron phosphates

- Marie-Line Daumer, INRAE Rennes – Biologic routes for release of phosphorus from iron or aluminium compounds in sewage sludges *(10 min)*
- Leon Korving, Wetsus and Philip Wilfert, IPP Kiel – Vivianite formation and recovery from sewage sludge using magnetic separation or sulphide release *(15 min)*
  Additional input (2 mins / 2 slides maximum):
  - Carlo Belloni, Wetsus – Improved recovery of phosphate through manipulation of iron phosphate chemistry using Mössbauer spectroscopy
  - Sarah Bluteau, McGill University (Canada) – Phosphorus recovery from FeP with sodium sulphide in biosolids (Ottawa municipal WWTP)

- Lisbeth Ottosen, DTU, Denmark – Separation of phosphorus from sewage sludge ash by electrolysis *(10 min)*
- Simon Kellmann, GEH Wasserchemie – Regeneration of phosphate-loaded granular ferric hydroxide and P-recovery from regeneration-solutions *(10 min)*

Impact of iron on industrial P-recovery processes

- Ludwig Hermann, Proman and ESPP President – overview of different process routes *(5 min)*
  Flash presentations of different processes, with the emphasis on how iron impacts the process and whether the P-content bound to iron can be recovered (2 mins / 2 slides maximum):
  - Jürgen Eschment, Parforce – Phosphoric acid recovery from phosphorus-containing materials
  - Ángel Galinda Carbajo, ZAR/Technicas Reunidas - Dealing with iron with Phos4life Technology
  - Alfred Edlinger, MITechnology – FerroPhos process
  - Cristoph Ponak, University of Leoben – Desorption of P from Fe-containing liquid metal during reduction of sewage sludge ashes
  - Siegfried Klose, EuPhoRe – Recovery of phosphorus bound to iron in sludge

17.00 Wrap-up and closure

4. Impressions of the Meeting

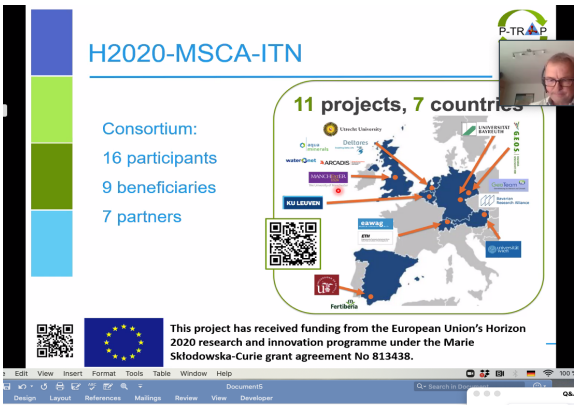

Fig. 1: Starting the workshop with a keynote presentation given by Thilo Behrends (UU) in his function as coordinator

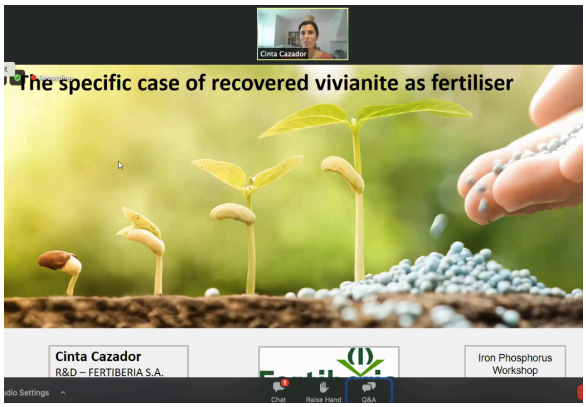

Fig. 2: Cinta Cazador (FERTIBERIA) going into detail about recovered vivinanite as fertilizer. FERTIBERIA is hosting 2 ESRs for related secondments.

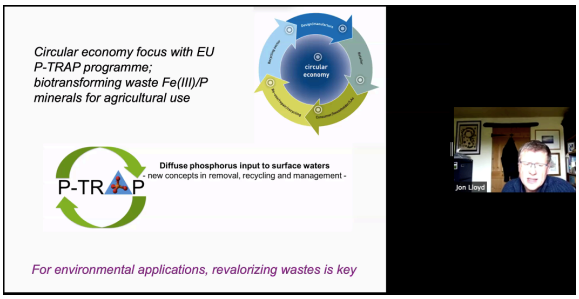

Fig. 3: Jon Lloyd (UNIMAN) emphasising the contribution of P-TRAP to the EU objectives of supporting circular economies

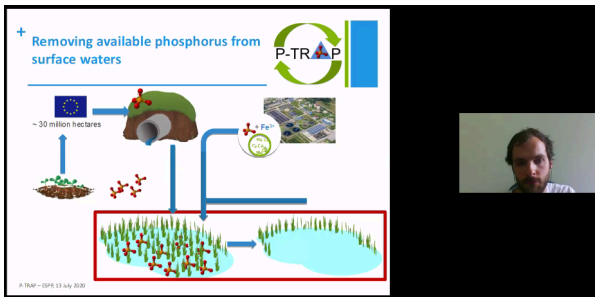

Fig. 4: Karel As (UBT) introducing his project on iron addition to immobilize phosphorus in lakes in relation to P-TRAP as a whole

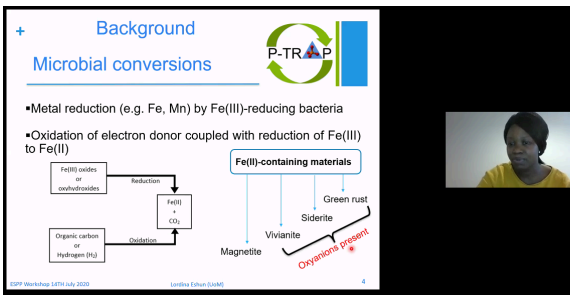

Fig. 5: Lordina Eshun (UNIMAN) introducing the theoretical background of microbial conversions by iron reducing bacteria to receive vivianite

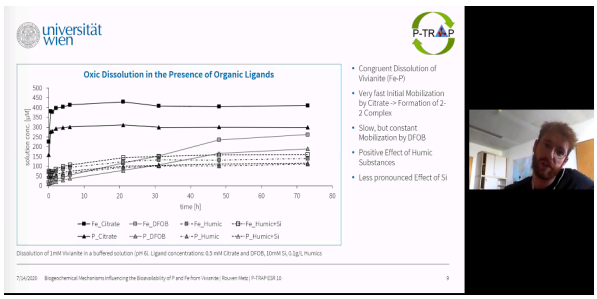

Fig. 6: Rouven Metz (UNIVIE) who started as the first P-TRAP ESR showing his prelimary results investigating the dissolution of vivianite depending on time

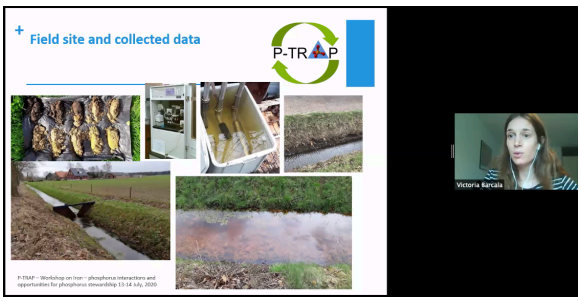

Fig. 7: Victoria Barcala (DELTARES) demonstrating the practical work sampling outside the laboratories

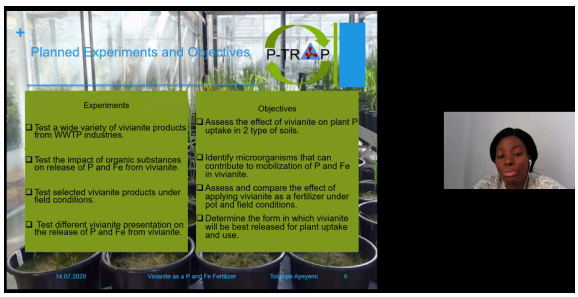

Fig. 8: Tolulope Ayeyemi (US) giving an outlook of plans after restarting the lab work

4. History of the deliverable

Date	Actions / Changes
November 2019	Agreement with ESPP to organise the workshop in Utrecht
February 2020	Date fixed and venue organised
May 2020	Decision taken to hold the workshop remotely
June 2020	Agenda prepared by ESPP, including P-TRAP presentations
July 2020	Workshop held by Zoom