PHORWater

Integral Management Model
for Phosphorus recovery
and reuse from Urban Wastewater

LIFE12 ENV/ES/000441

After-LIFE dissemination plan

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INDEX

1. Overview

On 2014 European Commission added phosphate rock to the list of 20 critical raw materials by combining high economic importance and supply risk.

1.1. Why is phosphorus important?

Phosphorus is essential for food security; it is an irreplaceable fertiliser and it is used as a feed additive but it is also present in pesticides and medicines. Phosphorus is present in every living organism, it is part of the genetic code, it is part of the living structures and it is part of the ATP that stores and releases energy to allow cells functions.

"*Life can multiply until all the phosphorus is gone, and then there is an inexorable halt which nothing can prevent*" (Asimov, I., 1974)

1.2. Why is Europe worried about phosphorus supply?

Phosphorus is obtained by mining phosphate ores but major global reserves of phosphorus are located outside Europe. 80-90% of the World's remaining reserves are found in Morocco, China, Algeria, Syria and Jordan thus the EU is highly dependent on regions under geo-political risk, thus phosphorus scarcity should not only be considered under physical dependency but also under economic volatility.

"*We may be able to substitute nuclear power for coal, and plastics for wood, and yeast for meat, and friendliness for isolation—but for phosphorus there is neither substitute nor replacement*." (Asimov, I., 1974).

1.3. Environmental concerns about phosphorus

While increases awareness on P-supply large amounts of phosphorus arrive to surface waters where lead to algae bloom, tainted drinking water supplies and degradation of recreational opportunities. The last consequence: dead zones where aquatic animals die.

1.4. What can be done?

WWTPs represent a key point thinking about phosphorus flows. Industrial and human wastes end up at the sewer and the recovery of phosphorus at WWTP facilities represent a viable way to reduce eutrophication events at the time that provides an innovative source of phosphorus for agriculture.

The main objective of PHORWater project is to demonstrate the viability and sustainability of the global management of phosphorus recovery in wastewater treatment plants in order to maximise its recovery as struvite by crystallisation and aware about the benefits of this recovery for both WWTPs and agriculture.

1.5. PHORWater

PHORWater – Integral Management Model for Phosphorus Recovery and Reuse from Urban Wastewater is one of the 249 projects supported by LIFE 2012, the European financial instrument for the environment.

The project was implemented at Calahorra WWTP, where the biological process was modified to maximise phosphorus release by the elutriation of the sludge at the gravity thickener, appearing the overflow from the thickener as the optimal flux to feed the crystallisation reactor. As a result, "*Good practice manual to maximise phosphorus recovery*" was developed and the conclusion were disseminated at different congresses.

Next step was the design and construction of the crystallisation reactor which was finally implemented at Calahorra WWTP on May 2.015, allowing phosphorus recovery as high quality struvite. It is a CSTR with a settling zone on top to keep struvite inside to allow crystals growth. When the crystals are big enough they are drown from the bottom.

The reactor has been recovering struvite continuously since July 2.015 achieving a maximum rate of 10 kg of struvite per day. The struvite agricultural assays on potato and wheat crops support the use of struvite as fertiliser, with similar quality results and yield than standard fertilisation programs when applied either alone or combined with other standard fertiliser.

Other benefits from the implementation of the phosphorus recovery system are:

- Sludge production has been reduced by 5%
- Polyelectrolyte consumption has been reduced by 10%
- Energy at the biological process has been reduced by 24%
- Operating expenses have been reduced.

The overall feasibility of the project comes through its internal net worth of 316,788€ and its environmental benefit of 857,568€, given as a net present value. Considering a useful lifetime of 15 years for the recovery plant, PHORWater has a net present value of 1,174,356€.

Considering only the internal net worth, a period of 5 years allows the recovery of the

initial investment mainly due to the energy saves.

1.6. Innovation and demonstration value

Up-to-date, several technologies have been implemented at WWPTs for phosphorus recovery. These technologies have been implemented at different flows (effluent, digester supernatant, sewage sludge or dewatering centrate) but none before the anaerobic digestion, without considering the biological processes and the WWTP as a whole, with their actual scaling problems.

When enhanced biological phosphorus removal is coupled to anaerobic stabilization of the sludge, phosphorus is released at the WWTP and it spontaneously precipitates as struvite. This is a frequent loss-making operational problem that WWTPs have to deal with. By controlling this struvite scaling we would increase the phosphorus recovery rate in an environmental friendly manner at the time that we avoid operational problems.

The innovation of PHORWater is that it has addressed the problem from less to more. Moving from the optimisation of the integral management in order to increase phosphorus availability and decrease uncontrolled precipitation of phosphorus, to a new simple-operational reactor which has been designed and implemented. Finally evaluation of the obtained struvite is an indispensable step to include struvite as a valuable fertiliser in the European Fertiliser Regulation.

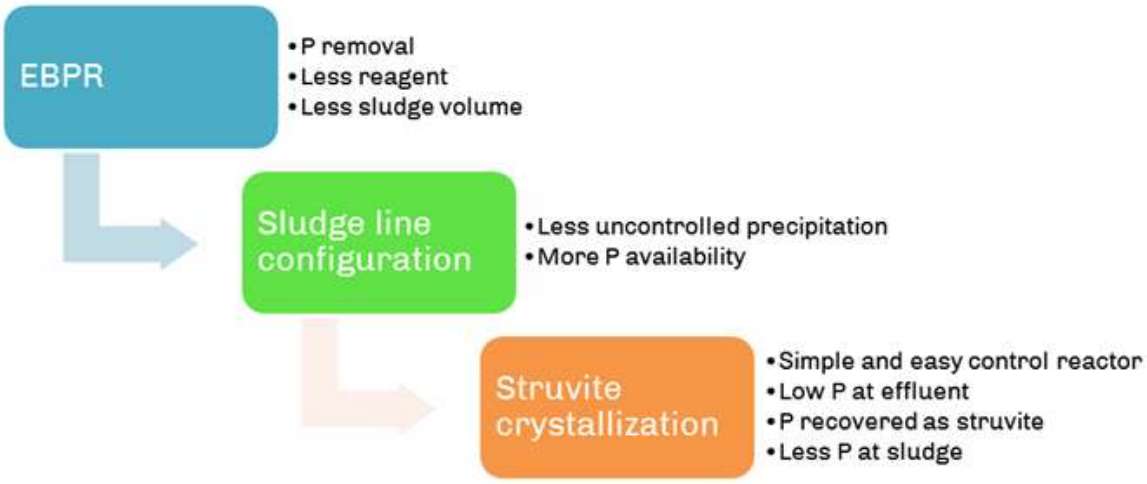

Figure 1. PHORWater process scheme.

Tons of phosphorus arrive every day to WWTPs. According to Article 5 of the Urban Wastewater Treatment Directive, UWWTPs have the obligation to remove this phosphorus to avoid eutrophication but recovery and reuse is not mandatory.

Implementation of the good practice manual to maximise phosphorus recovery, developed by PHORWater and available at http://phorwater.eu/, offers a protocol that could be applied at any WWTP with enhanced biological phosphorus removal coupled to anaerobic digestion. It will produce a P-rich flow to feed the crystallisation reactor.

The crystallisation reactor designed by PHORWater can be fed with any liquid flow with phosphorus concentration higher than 50 mg/l so dewatering centrate can also be used to recover struvite, offering a solution when, due to limiting considerations, the good practise manual cannot be applied.

If all the sewage sludge generated in Spain could go under PHORWater process, it would be possible to recover 5% of the total P used in agriculture.

1.7. Environmental benefits.

Municipal WWTPs are a promising source of phosphorus, but the recovery of this nutrient via PHORWater process at these facilities is not the only environmental benefit obtained.

Enhance biological phosphorus removal has been optimised, reaching values up to 92% of P removal, obtaining low values of P at the effluent and preventing from eutrophication. The damage prevented for every kg of phosphorus that is not dumped into the environment has been quantified at the economic study by a shadow price of 160€.

PHORWater has developed a process that reduces the amount of external energy demand at WWTP by 24%, which represents 81 Tn $CO_{2\text{-eq}}$/yr.

The amount of P at the sludge has been reduce while a slow release fertiliser with constant composition has been obtained, thus the non-point pollution due to the unknown amount of P spread on land by sludge or compost dosage has been reduced.

Struvite has been proved as a quality fertiliser. Its low solubility on water reduces the risk of leachate to water reserves. Cd has not been detected at the recovered struvite while it is an environmental and health concern on commercial fertilisers.

1.8. Relevance to environmental policy and legislation

As mentioned before, WWTPs do not have the obligation to recover P from wastewater, so the first concern should be about the responsible to take this recovery and promote its reuse.

Phosphorus can be recovered as struvite from WWTPs, and struvite has been proved as a good, save and environmental-friendly fertiliser but it has been recovered from a waste (wastewater). This fact makes a difference between European countries. The End-of-waste status is a national decision so struvite can be applied as fertiliser according to national regulation in some European territories while it is considered waste in other parts of the EU. At the same time the application of the Mutual Recognition Regulation to fertilisers and growing media, based on the freedom of movement of goods through mutual confidence between Member States and on the assumption that Member States are applying equivalent criteria for the protection of the environment and human health, should be considered.

PHORWater, through the European Sustainable Phosphorus Platform has provide the results from LIFE PHORWater project to the EC (JRC-IPTS) to consider the revision of the EC fertiliser regulation (2003/2003) in order to include the struvite recovered from WWTPs as a EC fertiliser.

PHORWater also contributes to the implementation of the following policies:

European Parliament Resolution on 24 may 2012 on a resource-efficient Europe (2011/2068(INI))

European Council, 1986. Council directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture.
Directive 2000/60/EC. Water Framework Directive.
Council Directive 91/271/EEC concerning urban waste-water treatment.
COM(2011)571: roadmap to a resource efficient Europe
Communication from the commission: on the review of the list of critical raw materials for the EU and the implementation of the raw materials initiative

2. Dissemination strategy

Access to water and sanitation are basic rights. Eutrophication is an environmental problem that leads to tainted drinking water supplies and degradation of recreational opportunities, thus the dissemination and exploitation of the results will be addressed to a wide audience, including general public to scientist and decision makers.

2.1. Identification of target groups and message.

General public should know about the problem of uncontrolled discharges of phosphorus and that efficient use of phosphorus includes reduction of the excess P consumed by diet. We also like to get science closer to the population through educational activities and general media to explain how WWTPs can become a resource recovery facility.

Water Agencies are interested on the promotion and support of innovative technologies that can reduce operational expenditures and provide valuable products at their facilities. Collaboration with Consorcio de Aguas de La Rioja, EPSAR, and ESAMUR at different dissemination events has increase the impact of the project in Spain.

Policy-makers and regulatory authorities are critical for the P-recovery technologies success. The non-waste status is crucial for struvite application on agriculture and PHORWater will keep on this goal. Exploitation of the results that show struvite as a secure and good quality fertiliser to policy-makers and regulatory authorities is our major concern. Direct contact with policy officers has been considered the best way to show our message.

End users have shown interest in the obtained product. Networking by exchange of experiences and interests has been stablished. PHORWater will continue on the dissemination of struvite quality as fertiliser as well as the dissemination of the operating benefits of the process implementation. Several articles will be produced at scientific and general magazines.

2.2. Dissemination products.

Communication and dissemination has been a major concern during the project to identify and to get to proper stakeholder that will determine the success of the project.

Since the beginning of the project, **PHORWater logo**, formed by the initials of Phosphorus and Water, links wastewater treatment with clean water and agriculture.

Logo has been used at any dissemination product combined with LIFE programme logo.

On-site panel were placed at every partner's office as well as at Calahorra WWTP in a visible place.

Website (http://phorwater.eu/) in English, Spanish and French has been used to increase the visibility of the results and the dissemination activities. Over 10.000 visitors got around the web during the project development.

Promotional leaflets and **technical posters** have been disseminated during different events to reach to the audience.

Also, **social networking tools** such as google+ site or blogsite have been used to increase the visibility of the project. (https://plus.google.com/u/0/+PhorwaterLife) (http://lifephorwater.blogspot.com.es/)

PW News has been distributed to more than 60 subscribers and it is also available to download at the website.

Layman's report is a mandatory activity that helps on the dissemination and exploitation of the results. It is meant to reach general public and aware about the environmental problem of phosphorus and the solution offered by the project. PHORWater Layman's report is available at the website and it reached over 20 downloads during the first week available. It will also be sent to the policy officers contacted and to the PW news mailing list.

Merchandising products have been distributed during the events organized by PHORWater consortium and they are also available at partners' office. Notebooks, pens, USBs and folders where distributed during the conferences so the attendants could take note at the same time that help on the dissemination of the project. All merchandising products included PHORWater and LIFE programme logos.

Figure 2. Dissemination products.

2.3. Dissemination activities.

Dissemination activities from 2014 to 2015 where focus on awareness about phosphorus availability, discharges and potential to recovery. On 2016, with technical results available, PHORWater focused the dissemination activities not only on the exploitation of the results but also on the value of recovered struvite as fertiliser

Congresses and conferences: PHORWater has presented the results at different events either by poster, conference or both at national and international events.

META 2014. XI Reunión de la Mesa Española de Tratamiento de Aguas. Alicante (Spain), 18th Juny 2014. Poster.

4th Sustainable Phosphorus Summit, Montpellier (France), 1-3rd September 2014. Poster.

2nd European Sustainable Phosphorus Conference. Berlin (Germany), 5-6th March 2015. Poster.

IWA Nutrient Removal and Recovery. Moving innovation into practice. Gdansk (Poland), 18-21st May 2015. Conference.

Innovation in wastewater treatment. Leeds (UK), 22 March 2016. Conference. A poster was also shown at the 11th IWA Specialist Group Conference on Wastewater Pond Technologies that took place in parallel sessions.

Cristal 8. Rouen (France). 26-27th May 2016. Poster.

13th IWA Leading Edge Conference on Water and Wastewater Technologies. Jerez de la Frontera (Spain), 13-16th June 2016. Conference.

META 2016. XII Reunión de la Mesa Española de Tratamiento de Aguas. Madrid (Spain). 20-22nd Juny 2016. Poster.

Trade fair and other events:

ECOFIRA-EFIAQUA 2015. Valencia (Spain). 20-22nd October 2015. Dissemination material and conference. Innovation award.

EXPOCIENCIA 2016. Valencia (Spain). 28th May 2016. Poster and demonstration.

PHORWater Activities: Struvite samples, leaflets and merchandising were distributed at these events.

PHORWater's open day. Struvite, a fertiliser that improves our environment. Calahorra (Spain). 1st March 2016. Conference and visit.

PHORWater workshop: Experiencias sobre la recuperación de fósforo en EDAR. Valencia (Spain). 8th April 2016.

PHORWater workshop: P-recovery as struvite. Regulation constraints for its use as fertiliser. Lyon (France). 12th May 2016.

PHORWater workshop: Cristalización de estruvita en EDAR, una inversion en forma de fertilisante. Logroño (Spain) 30th June 2016. EU Green Week partner event.

PHORWater Final Conference. PHORWater: P-recovery towards closing the loop. Madrid (Spain). 14th July 2016.

Press releases have been distributed through general and technical media.

Laura Pastor's interview was published at http://www.aguasresiduales.info/ on December 2014.

1 technical article has been published at TSM 2014 ; 10 : 2–14

2 dissemination articles were published at Retema and Futurenviro on February 2015.

2.4. Dissemination results.

Nowadays EC considers including struvite in a new revision of the EC Fertiliser Regulation (2003/2003). PHORWater is contributing to this regulation change through the European Phosphorus Platform and is in contact with Spanish MAGRAMA to provide results from the project that validate the security of recovered struvite as fertiliser and the effects on soils and plants.

Several Spanish fertiliser industries and farmers co-ops came to our events to learn about the characteristics of the recovered product. Later on, several fertiliser industries have contacted DAM, interested on the recovery of struvite and the actual regulatory situation.

2.5. After-LIFE

Dissemination activities are going to continue after the end of the LIFE project.

Website: will be uploaded with news and documents from the project for at least the next 5 years.

Blog: will be will be uploaded with interesting news and comments about P-recovery for at least the next 5 years.

Events: PHORWater will be present at the following coming events

Nuevas Tecnologías Aplicadas al Sector de la Depuración de las Aguas Residuales. Valencia (Spain). 3rd November 2016. Organized by EPSAR.

XXXIV Jornadas Técnicas AEAS. Tarragona (Spain) 24-26th May 2017. Organized by AEAS

And we will keep on looking for nutrient recovery or innovative technologies conferences to share the results of the project at European level.

Technical articles: PHORWater is working now in the redaction of 10 technical papers to be published on international journals.

Dissemination via networking will be present with other LIFE projects contacted during the project. Also European Sustainable Phosphorus Platform has been very useful for networking during the project and DAM will still collaborating and sharing learned lessons and future concerns.

3. Estimated budget for the after-LIFE period.

Website	1,406.10 €
Blog	1,500.00 €
Dissemination events	2,220.00 €
Re-printing dissemimnation material	134.30 €
Technical articles	12,600.00 €
Dissemination via networking	300.00 €
Total	18,160.40 €

4. Project data.

Location	Spain
Code	LIFE12 ENV/ES/000441
Starting date	01/09/2013
Ending date	31/08/2016
Duration	36 months
Total budget	1,275,064 €
EU contribution	50%
Website	http://phorwater.eu

5. Partners and contact data.

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6. References.

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