Nereus Deliverable A.2.8 Market potential struvite produced in a decentral wastewater plant in Ghent, Belgium

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Introduction

DuCoop is operating a decentralized wastewater treatment facility at the Nieuwe Dokken neighborhood in Ghent, Belgium. It will treat the source separated wastewater of 400 houses and a city building by 2025. Now the first part of the district, being 100 houses and a city building, is fully inhabited and operational.

The wastewater treatment plant consists of two treatment steps. In a first stage, black water and kitchen waste is brought to an anaerobic digestion stage, where biogas is produced (see flow chart in **Figure 1**.). After that, struvite is recovered from the nutrient rich overflow of the digester. Subsequently this water is then mixed with the collected grey water. This water is further treated aerobically in a nitrification/denitrification reactor. The final step is a ultrafiltration step after which the produced water is given a second life at the nearby factory Christeyns.

In this report, we will report our experience with the struvite reactor, as well as what can be done locally with the produced struvite.

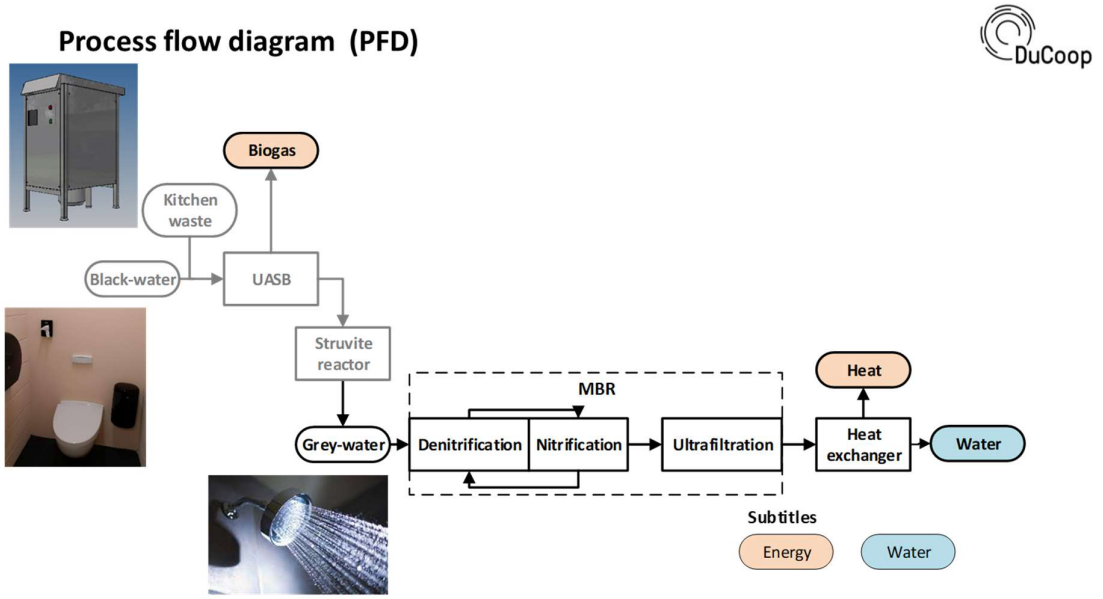

Figure 1. Process flow diagram of the DuCoop installation. Kitchen waste and black water are collected separately with a vacuum sewers system, after which they are pretreated with an biogas reactor (UASB) and struvite reactor. Further on, this stream is post treated together with the grey water.

Reactor Operation

In **Figure 2a**, the struvite reactor is depicted. MgCl2 and NaOH are dosed to create preferential conditions for struvite production. The struvite is then separated via a sieve. This system functions well and an almost waterless struvite is harvested from the reactor (see **Figure 2b and 2c**). By harvesting the struvite, a container is filled. When full, the struvite can be used as a product (see Potential end-users)

Figure 2. From left to right **2a**: struvite reactor, **2b:** harvesting system with container, and **2c:** struvite produced

In November 2020, the reactor was started up with a struvite-seed. The loading rate towards the water treatment gradually increased as more inhabitants came to live in the first completed building phase of the district. In between 10-15 kg of struvite is now formed per month (average flow rate 2-3 m3/d, 60 mg PO4-3-, 30-50% removal efficiency). These are small amounts, because the struvite is operated only at 15% of it's design load. It is expected that when the district is completed, about 125 kg struvite is formed per month, or 1,5 ton/year.

Quality of the produced struvite

The produced struvite was assessed for a certain set of quality parameters: 1. Fertilizer value, 2. Heavy metal composition and presence of pharmaceuticals.

1. Fertilizer value.

In **Table 1,** the fertilizer composition is given. From the values we can see that we produced a struvite which has good nutritional value (NP). The main crystal formed is struvite (88-92%), with some side formation of magnesium phosphate and magnesium carbonates. Because the solubilities in water are very low, and 50% of the phosphate is released in neutral ammonium citrate, we can prove that the struvite has capabilities of being a slow release fertilizer.

2. Heavy metals

The struvite was also tested on heavy metals (Cu, Zn, As, Cd, Cr, Hg, Ni and Pb). All the heavy metals were below detection limits (resp. <0.002, 0.004, 0.001, 0.00005, 0.001, 0.00001, 0.001, 0.002 mg L^{-1}). The struvite complies thus to the regulations for heavy metals to be used as a fertilizer.

Table 1. Fertilizer composition of the struvite of DuCoop. Compared vs a theoretical value of pure struvite.

Parameter	DuCoop Struvite	Theoretical struvite	Necessary for permit FOD Belgium	New Strubias regulation
N (total)	4.46%	5.7%	>4%	
P2O5 (total - mineral acid soluble)	24%	28%	>20%	>16%
P2O5 (soluble in neutral ammoniumcitrate)	12.7%		>8%	
P205 (water soluble)	0.42%			
MgO (total - mineral acid soluble)	15.2%	13%		
MgO (water soluble)	0.76%			
K2O (water soluble)	1.2%	-		
CaO (total - mineral acid soluble)	<0.53%			
CaO (water soluble)	<0.06			

3. Pharmaceuticals and other trace elements

The struvite will be assessed in the final quarter of 2021, as an analysis part of the EU Run4life Horizon 2020 project. The report will be updated when the data are available.

4. Pathogens

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Legal Framework

Ducoop is producing struvite from kitchen waste and blackwater after anaerobic pretreatment. Therefore it has to comply to the following regulations:

1. Class I environmental permit (VLAREM-Flanders,issued by Flemish environmental organization VMM). This permit is needed to operate a biogas facility in Flanders. It is not necessary when operating a struvite reactor (alone), but when starting from kitchen waste and blackwater, biogas treatment is necessary as a pretreatment step. A class I environmental permit comes with an environmental coordinator which follows up the plant and visits it each quarter.

2. Commission Regulation (EU) No 142/2011 of 25 February 2011 for the processing of animal by products. Since DuCoop is collecting food waste from homes, it is de facto collecting animal by products and it has to comply to its regulation. Most important are the requirements for hygienization that needs to be complied to. Before being able to bring the struvite to the market, the struvite has to b processed through a hygienisation step or treatment train which can be considered equal[1]. There are different options to do this 1) have the digester and hygienisation step to be authorized as equal to an hygienization step by an external independent audit, 2) add a hygienization step in the process i.e. Increasing the temperature of the digester or a post treatment hygienzation step (heating, ...).3) Mix in acid solution to make a combined nitrogen/phosphate liquid fertilizer. The low pH will result in hygienisation. This

[1] http://www.beleidsplanning.nl/validatie-vergisting-compostering.php

regulation will not change in the upcoming EU Strubias regulation because the struvite reactor alone will not be considered as an animal by product endpoint. As stated before, the digester and struvite combination together can be authorized as an endpoint when it can be proven that both technologies together provide sufficient hygienisation.

3. VLAREMA Commodity statement (transl. from Grondstoffenverklaring). This legislation allows certain products, normally considered as a waste product to be used internally when they comply to regulatory environmental and hygienic quality requirements. The struvite has to be checked yearly on quality.

4. Federal department of finances: EXEMPTION permit. If the struvite complies to all above legislation it can be brought onto the market as fertilizer, soil-improver, ... For that an exemption has to be come from the federal department of finances. Requirements are the assessment of purity, but also the farming value of the product. According to a Vito report of 2013[2], It has to comply to certain standards (see **Table 1**).

5. REACH regulation ((EG) nr. 1907/2006). REACH: Registration, Evaluation, Authorisation and restriction of Chemicals. With the production of an amount of product > 1 ton/year, registration is needed. This information is available in the European chemicals agency.

6. STRUBIAS regulation (not yet in place). For the new regulations on the market of EU fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 a new Strubias annex is under proposal for recovery of fertilizers from waste products. The proposed[3] regulation mentions that phosphate salts recovered from wastewaters will have to comply to the following qualifications. For the waste processing of DuCoop these samples will have to be taken 2 times per year.

a) a minimum P2O5 content of 16% of the dry matter content;
b) a maximum organic carbon content of 3% of the dry matter content
c) no more than 5 g/kg dry matter of detectable macroscopic impurities in the form of organic matter, glass, stones, metal and plastics above 2 mm;
d) no presence of Salmonella spp. in a 25 g sample; and
e) no presence of Escherichia coli or Enterococcaceae in a concentration of more than 1000 CFU/g fresh mass
f) no more than 6 mg/kg dry matter of poly aromatic hydrocarbons (PAH)
g) no presence of Clostridium perfringens in a concentration of more than 100 CFU/g fresh mass; and
h) no presence of Ascaris sp. eggs in a 25 g fresh mass.

Local market value

Product quality and application

The produced quality of the struvite is adequate and holds interesting fertilizer opportunities. Potential application can be done in:

- Grass, i.e. golf courts, .. Struvite results in good root development of the grass which aids in periods of drought
- Ornamental plants: flowers, hedges, ..

[2] https://esites.vito.be/sites/reflabos/onderzoeksrapporten/Online%20documenten/2013_Rapport_struviet-finaal.pdf

[3] https://phosphorusplatform.eu/images/download/STRUBIAS-Pre-Final-Report-circulated-13-8-18-p1-report.pdf

- Edible plants: less suitable due to the origin of the struvite. Tests on the struvite of DuCoop on strawberry plants however have resulted in encouraging fruiting compared to a traditional fertilizer. These tests were done in the framework of a VLAIO REUSE program.

Market value struvite

The market value of struvite is about 235/ton dry struvite (bulk) to 1500 euro/ton (small distribution for specialty markets). This data has been enquired from local fertilizer distributor (Flanders) for struvite.

Operational cost of small scale production vs potential sales

In **Table 2**. The operational cost and potential revenues of the struvite is given. Because we work on a decentralized scale, overhead costs to comply to legislation are high. Furthermore chemical costs are also higher than when large bulk amounts can be used. This makes the struvite production on a decentralized scale more expensive than in more centralized locations as for example a communal water treatment plant.

Table 2. Operational cost and potential sales struvite reactor DuCoop

What	Cost
Operational costs	
Chemicals (MgCl2, NaOH)	6500 euro/y
Operation	-
Legal requirements:	
Quality of struvite (yearly – current legislation)	377 euro/y
Quality of struvite (biyearly – Strubias legislation)	+-1000 euro/y (estimation)
Potential sales (for information, production = 1,5 ton year)	
Bulk	352 euro/y
Small distribution	2250 euro/y

Conclusion

The struvite formed by DuCoop complies to alle expected regulation requirements and has a proven fertilizer value. In test with strawberries it showed similar fertilizing potential as a traditional fertilizer.

The production of struvite is a by-product in the water treatment plant of DuCoop. The alternative is precipitation of Phosphorus with iron salts ($FeCl_3$). Chemical costs are similar for DuCoop for both $MgCl_2$ and $FeCl_3$ dosing. However, dosing of $FeCL_3$ increases (chemical) sludge production and thus overall costs for sludge disposal. It is therefore preferred that struvite is formed from operational, environmental and cost perspective.

Due to the limited amount of struvite produced decentral in the neighborhood, it is not economically feasible to create revenue because the costs for complying to all the legislation (yearly quality monitoring) will surpass the potential revenue of the produced struvite.