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Review WUR - WENR

STRUBIAS Market study

Dries Huygens & Hans Saveyn, 2018*. DRAFT market study for recovered phosphates salts, ash-based materials and pyrolysis materials in view of their possible inclusion as Component Material Categories in the Revised Fertiliser Regulation. Interim Report. Circular Economy and Industrial Leadership Unit Directorate B – Growth and innovation, Joint Research Centre – European Commission*

This review of Wageningen University & Research – Wageningen Environmental Research (WUR –WenR (Alterra)) gives general remarks, answers on questions and detailed remarks.

General remarks

1. The interim report reads well, the index is logical and transparent. Some general remarks are made.
2. A comment made earlier is repeated. The term nutrient recovery rules is the current phrase for recovering valuable components from renewable sources used by the European Commission. As such the term is rightly used. In a technical report however it serves to specify what is meant with nutrient recovery rules as the term literally does not cover all value giving components of STRUBIAS materials. Acid neutralising value (liming materials) and organic carbon are in strict sense excluded from nutrient. Why not rules for renewable fertilising products?
3. The approach of the economic impact given in chapter 7 is questioned. Given benchmark, historical overview and forecast follow models from a linear economy. Although the report is placing the STRUBIAS material in a correct setting of cascading approach (e.g. lines 367-370; 2654-2657, 2887-2890), the economic impact is not taking into account this cascade of processes. The linear approach gives not the STRUBIAS products their merits. Often nutrient recovery is the result of a side-activity while the major process is another activity (e.g. biogas production, manure processing to reduce transport of water, waste control). The major process makes the business case, not the recovery of nutrients. Economic models serving circular economy are being developed. An example is Volaro et al 2016 (see Annex I with references). The economic impact should not be based on current prices of mineral fertilisers as a benchmark but - to stimulate circular economy - should use a more integral approach and a calculation of a market-based cost-benefit price (E.G. Volaro et al, 2016).
4. Additives (e.g. sodium sulphate, e.g. Line 1972) are addressed. Their effect of the quality is not taken into account in the assessment of the quality of the fertilising products which is considered an omission. The advice is given to include additives when assessing agronomic and environmental aspect of STRUBIAS materials.
5. Annex I gives the references. Publications in the public domain can be addressed by using the link.

Questions

Question 1

Question 1, sales prices

P salts and ashes are sold in the Netherlands and traded within EU27. Biochar that are confronted with end-of-waste criterions have not been regulated and are thus not yet in the market. Biochars for clean wood or peat are produced and traded but are not part of the STRUBIAS materials.

Recovered P salts (struvite) is traded in the Netherlands. Aquaminerals BV (http://aquaminerals.com/en/home/) trades struvites of Waste Water Treatment Plants amongst others to ICL fertilisers. There are three or four other intermediates (Ostara, Heijmans, Waterstromen and/or HVC). Struvite serves as a secondary raw material for fertiliser production. A similar purpose, a different production process, has struvite that is exported to France (Groupe Roullier). Fertilising products based on these struvites fulfil current requirements of the EU regulation on fertilisers 2003/2003. Sales prices of the use of these struvites as secondary raw materials are not available in the public domain. Estimates

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are given by Ros et al (2014), Schoumans et al (2014) and pers. communications with actors in this field leading to a rough estimate of 50-90 €/ton.

Sales prices reflects the total concept of processing techniques of which nutrient recovery are part of. Business cases of processes that deliver STRUBIAS materials are company owned. Information requested has been shared with RBC environment for their LCA analysis for poultry litter ash of BMC Moerdijk and the K struvite of Stichting Mestverwerking Gelderland.

Sales prices for biochar are not available in the public domain. Pers. Communications lead to a broad range of estimates (0 - > 500 €/ton). However there is no trade yet. Estimates cannot be verified.

Question 1, physical form and to whom materials are sold

Struvites are solid products with crystals. Suspensions are not traded (yet).

Poultry litter ash is a powder. For specifications see Ehlert and Nelemans (2015c).

Biochar is fine powdery product but can be pelletised. Product is available from a pilot plant based on gasification of a solid fraction of pig slurry but there is no trade yet.

Question 1, evolution of sales prices

All technologies in a TRL 8 phase are younger than 10 years. Next requested information is in not part of the public domain and thus the question cannot be answered.

Question 2

Question 2, Cost for REACH registration

General information (In Dutch: https://www.chemischestoffengoedgeregeld.nl/veelgestelde-vragen/zoeken/onderwerp/registratie/onderwerp/registratie-algemeen).

Struvite

Berlin Wasser (lead registrant) are proposing a simple cost-sharing scheme with prices for "dossier access" (right to refer) as follows:

4 k€ for production <100 tonnes per year struvite, dry weight

7 k€ for 100-1,000 tonnes per year

> 1 000 tonnes: to be defined if needed

Additional information's (In Dutch): https://www.nutrientplatform.org/wp-content/uploads/2016/01/20171027-Factsheet-Hoe-zit-het-met-struviet-en-de-wet.pdf

Poultry litter ash, information of BMC Moerdijk

Partner of Ash Consortium: €15k dossier

ECHA: €40k

Biochar

Exempted of REACH registration? No estimate available.

Question 2, Cost of compliance under existing national end-of-waste or similar regimes.

Struvite

Struvite as one of the recovered P salts, is regulated in the Netherlands. Free trade is possible and thus lead not to compliance cost. However phosphate use is regulated in the Netherland and leads to sampling costs and cost for analyses (~100 € per sample per freight).

Poultry litter ash, information of BMC Moerdijk

Poultry litter ash is not traded in the Netherlands but exported to other EU countries.

Costs in Belgium 1,5 k€ per permit for a period of 5 years and 1 k€/year for additional analyses. In France 1 k€ for obligatory analyses.

Biochar

No obligatory costs yet. To meet voluntary standards of the European Biochar Certificate 1500 €/sample.

Question 2, Estimated cost for compliance for P-fertilisers derived from primary raw materials

Guideline: 120 $/ton rock phosphate 32% P_2O_5.

Question 2, Cost associated to acquiring waste permits in other countries

See: https://www.ilent.nl/onderwerpen/afvaltransport-in-europa-evoa/vraag-en-antwoord/regeling-eg-verordening-overbrenging-afvalstoffen

For struvite and biochar not known. For poultry litter ash 5-8 k€

Question 2, Cost of sampling and analysis through accredited laboratories

Recovered P salts, Ash-based materials, Pyrolysis materials

Please note that given estimates are for routine analysis by accredited laboratories. Conformity assessment based on designated analytical methods of EU regulation 2003/2003 require other methods which have higher price labels.

Value giving components (nutrients, acid neutralising value (NV) and organic matter)

Per mineral:	21-23 €/ sample
Per solubility (NAC, water):	21-23 €/sample
NV:	20 €/sample
Heavy metals and metalloids:	100 €/sample
PAH16+PCB:	160 €/sample
PCDD/F:	550 €/sample
Estimated cost per ton poultry litter ash:	0.60 €/ton ash

Question 2, Standards, national, ISO/EN

Fertilising products meeting requirement of EU regulation 2003/2003[1] follow standards given in ANNEX IV — Methods of Sampling and Analysis.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02003R2003-20160101&from=EN

National standards[2] are given in Annex Ac of the Implementation Regulation of the Fertiliser Act (In Dutch).

Test laboratories (not laboratories performing conformity analysis within a framework of enforcement) use standards given in the table.

Parameter	***Standard***
Dry matter	Annex Ac, EN 12880; NEN-ISO 11465
Organic matter (loss of ignition)	Annex Ac
P total (mineral acid)	Annex Ac, EN 13346
P soluble in 2% citric acid	EU Regulation 2003/2003; 3.1.3
P soluble in NAC	Annex Ac, EN 15957
P soluble in water	Annex Ac, EN 15958
K total (mineral acid)	Annex Ac, EN 13346
K soluble in water	Annex Ac, EN 15477
Mg total	Annex Ac, EN 15960
S total	Annex Ac, EN 15960
Na total	Annex Ac, EN 15960
Acid neutralising value	Annex Ac, EN 12945
Particle size	Annex Ac, EN 12948
Heavy metals and metalloids	Annex Ac
PAH+PCB	Annex Ac
PCDD/F	NEN-EN-1948

Test laboratories develop their accredited methods based on EN / ISO standards by designate these with different standard codes (can be given on request).

Biochar, analytical method, voluntary European certification (https://www.eurofins.de/umwelt/analyse-pakete/untersuchung-von-pflanzenkohle/analysis-of-biochar/)

parameter/performance	**analytical method**
Biochar - Basic Package	
sample preparation	DIN 51701-3
water content	DIN 51718
ash content 550 °C	analog DIN 51719/EN 14775
Thermogravimetry	LECO
carbon, hydrogen	DIN 51732
nitrogen	DIN 51732
sulphur	DIN 51724-3
oxygen (calculation)	DIN 51733
carbonate-CO_2	DIN 51726
Corg (calculation from Ctot und C-carbonate)	calculation
H/C und O/C	calculation
trace metals Pb, Cd, Cu, Ni, Hg, Zn, Cr, B, Mn in microwave	EN ISO 17294-2 /EN 1483
main elements P, Mg, Ca, K, Na, Fe, Si, S in melting digestion	EN ISO 11885 /EN ISO 17294-2
PAK (EPA)	EN 15527 (extraction with toluene)
pH-value	DIN ISO 10390 (CaCl2)
bulk density	DIN 51705
conductivity (salt content)	DIN ISO 11265/BGK, Kap. III. C2
surface area analysis according to BET (incl. pure density)	DIN 66132/ISO 9277
Biochar - Additional Parameters	
cross calorific value Ho	DIN 51900
net calorific value, Hu, p	DIN 51900
PCB, dioxins/furans (high resolution)	HRMS
water holding capacity (WHC) on fraction <2mm	E DIN ISO 14238, appendix A
ash content 815 °C	DIN 51719
volatile matter	DIN 51720

[2] In Dutch uitvoeringsregeling meststoffenwet, bijlage Ac, http://wetten.overheid.nl/

Question 3

STRUBIAS materials are relatively new fertilising materials which are in an initial production phase. Quantification of benefits and drawback cannot be supported yet by peer reviewed publication or reports available in the public domain.

Question 3, reduced waste compliance costs

An end-of-waste status (EoW) implies that costs from EVOA fall due (see answer question 2). The STRUBIAS products enter a competing market and although an EoW is reached, the market is reluctant in accepting these new products. Effort is needed to introduce and accept the new STRUBIAS products on the market.

Question 3, reduced externalities

STRUBIAS materials used according to Good Agricultural practices have similar externalities as current mineral fertilisers.

Question 3, potential job creation

Although STRUBIAS materials have a potential to replace current mineral fertilisers, it is not expected that there is an impact on current mineral fertiliser industry (focus 2030). Current mineral fertiliser industries are already using STRUBIAS materials in the production of EU fertilisers meeting requirements of EU Regulation 2003/220. New fertilising materials have a focus for niche markets or can replace current raw materials (rock phosphates). Niche markets will have a slight positive effect on employment and rural economy.

Question 3, impact on rural economy

See given argument above: Niche markets will have a slight positive effect on employment and rural economy.

Question 3, benefits of restoring soil organic carbon for soil fertility

Biochar can contribute to restoring soil organic carbon (Beesley et al (2018), Lal (2009), Thomas and Gale (2015) and Wu et al (2016)). These peer-reviewed articles point on a potential. Other STRUBIAS materials have an equal potential as current fertilisers used according to good agricultural practices.

Question 3, cost associated to new logistics

Costs for new logistics or restructuring are not expected for STRUBIAS materials. A reduction of cost is expected if the total of cascading processes is taken into account (e.g. avoided transport of water of manure).

Question 3, implication for restructuring

Costs for new logistics are not expected for STRUBIAS materials. Restructuring, e.g. the building of a new plant for nutrient recovery can be an additional cost. However, these cost are part of a cascading approach of processing a feedstock. Cost connected to recovery of nutrients is modest compared to the total business case.

Question 3, agricultural equipment adaptations

Adaptions of agricultural equipment is not expected unless liquids are produced with a low concentration of nutrients. Than the equipment has to be modified. Current equipment can handle concentrated liquid fertilisers up to 2 m^3/ha. Liquid slurries can be applied with a minimum of ~ 10 m^3. A application rate of 5 m^3/ha askes for specialised equipment (~50 k€).

Question 4

Question 4, evolution

WUR WENR (formerly Alterra) is conducting long term field trials with mineral phosphorus fertilisers. The field experiments started in 1972/1986 and are still continued. A synthesis report is currently in review and will be available in the public domain within 2 months (Ehlert et al, 2018). Agronomic results of slags from metallurgic industry and fertilising products based on slags on sandy soils are reported. These slags performed equal to super phosphate or better (sugarbeet) which is contributed to a liming effect.

Although the field experiments are continued, the treatments with these slag based products had to be ended as the products are not available any more on the market.

Question 4, data on metals/metalloids

Data are published by Dittrich and Klose (2005).

Question 4, information on production process

The market for fertilising products based on slag ended amongst others due to changes in the production process and the use of P poor iron ores. New process technologies for primary metal production are developed to reduce the environmental impacts of metal production (Norgate et al 2007) and increasing efficiencies (Rudyka, 2017).

Question 4, agronomic efficiency

See Spiegel et al (2001), Lindenthal et al (2003) and Ehlert et al (2018).

How the newest products from modified metallurgic industry perform remains unclear. Perhaps EUROSLAG can provide information (http://www.euroslag.com/applications/fertilizer/).

Question 4, Evolution average sale prices

Perhaps EUROSLAG can provide information (http://www.euroslag.com/applications/fertilizer/).

Question 5

Question 5, eligible input materials

A new development is the production of calcium phosphate (most likely DCP) by dissolution of phosphorus from co-digested solid fraction of pig slurry. This process is currently in a TRL 7 level but will change at the end of this year to a TLR 8 system. This plant is called (In Dutch) the *Groene Mineralen Centrale* (Green Mineral Plant) and will be built at Groot Zevert Vergisting B.V. in Beltrum the Netherlands (http://www.groenemineralencentrale.nl/nl/groene-mineralen-centrales-0).

This plant is one of five plants on nutrient recovery plants of the EU project SYSTEMIC (https://systemicproject.eu/).

Current tests show the following composition of the calcium phosphate. The fertilising product contains currently calcium phosphate, organic matter and calcium sulphate. WUR-WENR is adapting the processes (called RePeat) to higher mineral P contents, lower water contents and lower contents of organic carbon. Table 1 gives insight in the state of the art. Schoumans et al (2010, 2014 and 2017) give information on the development and experiments leading to RePeat.

Table 1 Composition of the calciumphosphate fertiliser (pilot experiments)

Parameter	**Unit**	**Ca~P~S**	**Ca~P~S**
		Slurry	**Dried**
Dry matter	(%)	12%	80%
Organic matter	(% of dm)	<25%	<25%
pH	(-)	8.0	8.0
P_2O_5 –total	(% of dm)	12 – 14	12-14
P_2O_5 – NAC	(% of dm)	12 – 14	12-14
N	(% of dm)	0.2	0.2
S	(% of dm)	10	10
CaO	(% of dm)	16	16
MgO	(% of dm)	6	6
K_2O	(% of dm)	3	3

- The product originates from anaerobically digested animal manure (pig slurry) and is produced by Groot Zevert Vergisting BV in Beltrum.
- The product is hygienised by thermal treatment (70 ºC).
- The phosphorus is for 97% NAC-soluble
- Sulphate is for about 50% present as $CaSO_4$ /$MgSO_4$ and for 50% water-soluble K_2SO_4/Na_2SO_4
- GZV will produce about 800-1000 ton product per year (80% d.m) from 2019 onwards, with a possibility to double the production at a later stage.

Question 5, associated technological readiness

Currently TLR 7, at the end of 2018 the plant is build and has a TLR 8 level. This process will be full scaled in 2019 but requires some fine tuning.

Question 5, cost/gate fees

The business case is given by Schoumans et al (2017).

Question 6

Question 6, outlook other fertilising products and C-rich pyrolysis materials

Currently (March 2018) the EU project SYSTEMIC (https://systemicproject.eu/) conducts an inventory on the following fertilising product based on animal manure and other biomass:

I. Nitrogen fertilising products:

Ammonium sulphate from an ammonia stripper/scrubber;

Ammonium nitrate from an ammonia stripper/scrubber;

NK concentrate of reverse osmosis;

N concentrate of reverse osmosis and evaporation;

Struvite/K-struvite.

II. **Other fertilising products:**

Other phosphorus salts;

Potassium concentrate;

Organic soil amendment after removal of nutrients;

Liming materials (Limed products).

Targeted are EU Projects on Research and Development.

The results will be available in May 2018 (https://systemicproject.eu/)

Question 6, outlook ashes forest-based industry

Wood ashes are not used as fertilising product in the Netherlands. Exemption is a (ever so small) niche market on farm following biological production methods. There is an interest in recycling in forests (Oosterbaan et al, 2013). Recycling requires guidance (Mead et al, 2012). Recycling is confronted with conflicting interests (Riding et al, 2015). An outlook lacks if principles of a linear economy are followed, a specific circular approach is needed (Mead et al, 2012, Riding et al, 2015). Fertilisation once in the 20-30 years of forest might require adapted environmental standards for fertilising products than fertilisation products which are used each year.

Detailed remarks

The table gives detailed remarks.

Observation	Location in document	Correction/alternative proposal	Techno-scientific rationale that supports the comment raised	Reference to techno-scientific data
Citation data Van Dijk et al 2016	342, 886, 1124, 3940	234	Data of Van Dijk et al, 2016 are cited from presumably appendix A of the article. Most the Raw data are cited, however sometimes the Balanced data are cited. Why is not clear.	dna (does not apply)
Data for Cu and Zn differ from data of manures from the Netherlands	538-540	See annexes of Romkens and Rietra (2008)	Farming systems do differ between EU27.	Romkens & Rietra (2008)
MBA = BMA (Bureau MestAfzet) Data of BMA can be updated	586	See table of BMA (2017)	Data of BMA are updated each year	BMA (2017)
Tarra is not taking into account	627	Export of soil with the (root) crops (tarra) should be taken into account	Minerals are also 'lost' from the field by exporting soil with harvested products	dna
Updated value for the Netherlands	665	For the Netherlands 40.3 million kg P_2O_5 in manure is processed (not only STRUBIAS materials).	Update of the survey	CDM 2017 citing BMA 2017
feedstock	710-711	Fibrophos incinerate combinations of feedstocks. BMC Moerdijk has virtually a mono incineration of poultry litter.	Fibrophos incinerate combinations of feedstocks. BMC Moerdijk has virtually a mono incineration of poultry litter.	http://www.fibrophos.co.uk/ https://www.bmcmoerdijk.nl/en/home.htm
Pant = plant	923	Pant = plant		
See general remarks on cascading processes	1449-1457	STRUBIAS materials are derived from processes that are part of larger, cascading processes. The total of these processes makes the business case.	See general remarks on cascading processes on the first page of this review.	
Cg = Cd	1728	Cg = Cd		
That reduce...	1772	The conditions of incineration and the additives (e.g. sodium sulphate) determine if a reduction of the P-solubility and plant availability occur.	that reduce = that can reduce.. reduction is minimal for designated feedstock's supported by additives (see ASH DEC line 1973).	

Woehler = Whoëler	2011	Woehler = Whoëler	The Whoëler reaction is described. The Woehler reaction is a different reaction involved in the synthesis of ammonium cyanate	
Derived from phoshate rock	2183	P-fertilisers derived from phosphate rock = regular mineral P fertilisers.	DCP is an regular EG fertiliser that is derived from animal bones or phosphate rock.	EU fertiliser regulation 2003/2003 Annex I. A.2. Phosphatic fertilisers 4
More data on ashes	2233, 2274-2278	See references	More data are available	Ehlert and Nelemans (2015a, 2015b), Ehlert (2017)
Climatic conditions	2597-2600	The experimental conditions of the pot experiments can be different from those of the field experiments at the same latitude. Has this been taken into account. If not, the figure is questionable. Advice is given not to include the figure if climatic conditions of pot experiments have not been taken into account.		
7.1.3 Price settings	2770 - >	Price settings of CMC are considerably lower than those for PFC		
Table 10	2848-2851	Is this standardised to rock phosphate with 32% P_2O_5? If not, the table is confounded with different qualities.		
alternative	2998	Manure is an alternative P source		

could	3341	could = are	Currently fertiliser industries are blending STRUBIAS materials in fertilising products that meet current EU requirements of EU regulation 2003/2003. The new proposal of the Commission aroused anxiety amongst producers. Fertiliser Europe has organised on March 7th an workshop on this issue.	https://phosphorusplatform.eu/events/upcoming-events/1583-symbiosis-and-circular-economy-in-fertilizers
Update data	3579	Data can be updated for the Netherlands	See line 665	CDM 2017
Not justified	3893	Biogas yields from manure are too modest and co-materials are too expensive.		
De Graaff et al (2017	4013	More cases can be added, De Graaff is citing Ehlert and Nelemans (2015a, 2015b)		Ehlert and Nelemans (2015a, 2015b)
0.90	4016, 4041	This is not in line with Figure 9. PUE in Figure 9 is larger than 1.25		
Appendix 1 lacks	4358			
danger	5009	Addition of sulphuric acid prior of the digestion process caused a severe risk on evolution of H_2S and should strongly be discouraged.		

Annex I. References

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