Multi-sectoral wide EU approach for the closure of the loop of a critical raw material: the European phosphorus platform

Anna Laura Eusebi – Università Politecnica delle Marche

Phosphorus importance

Without mineral phosphate fertilisers

we could feed

maybe 1/5th

of the current

world population

Adapted from Dawson et al., Food Policy 2011:
http://www.sciencedirect.com/science/journal/03069192

https://phosphorusalliance.org

Without Haber-Bosch

(mineral nitrogen fertilisers)

We could feed half

of the world population

Fertilizers Europe / Wageningen University

Courtesy of C. Thornton European Phosphorus Platform

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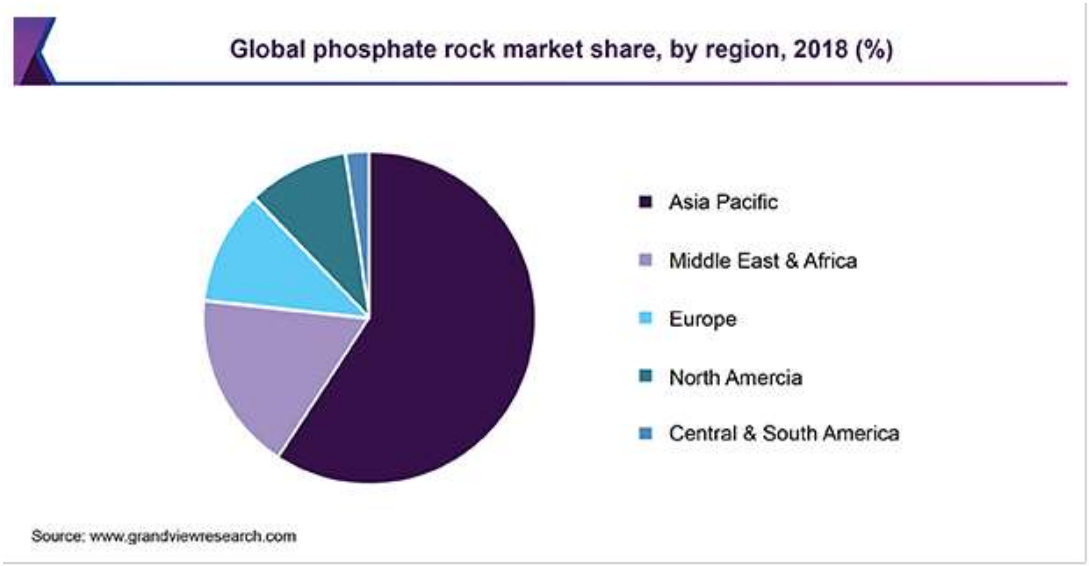
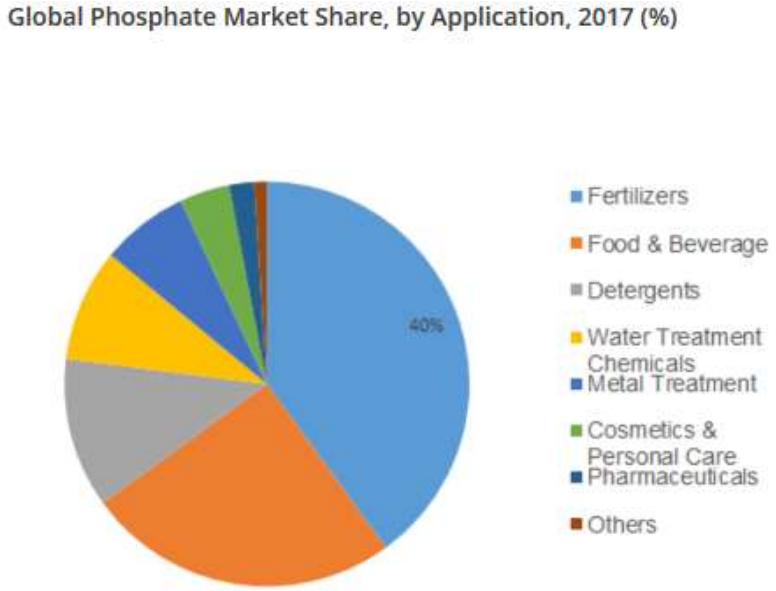
Requests and final uses





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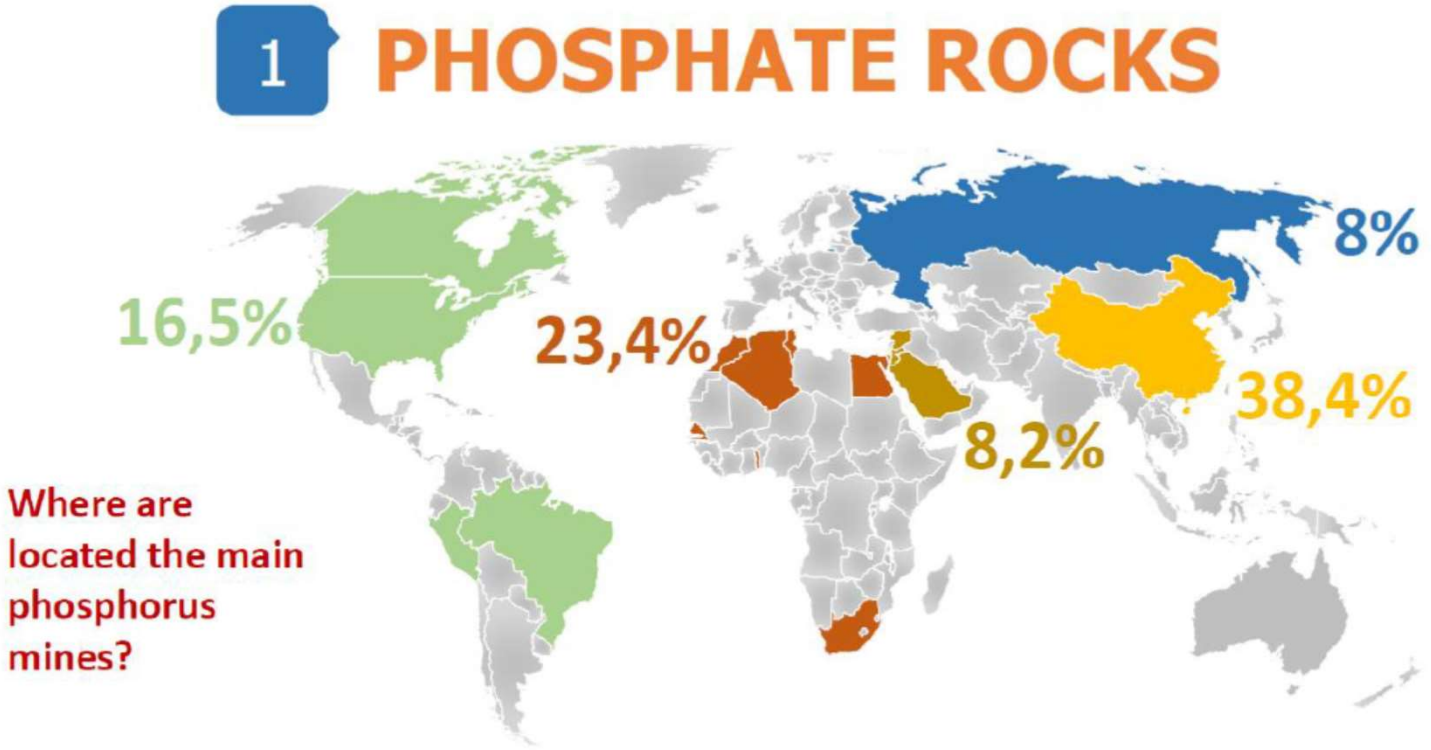
Location of resources in the word



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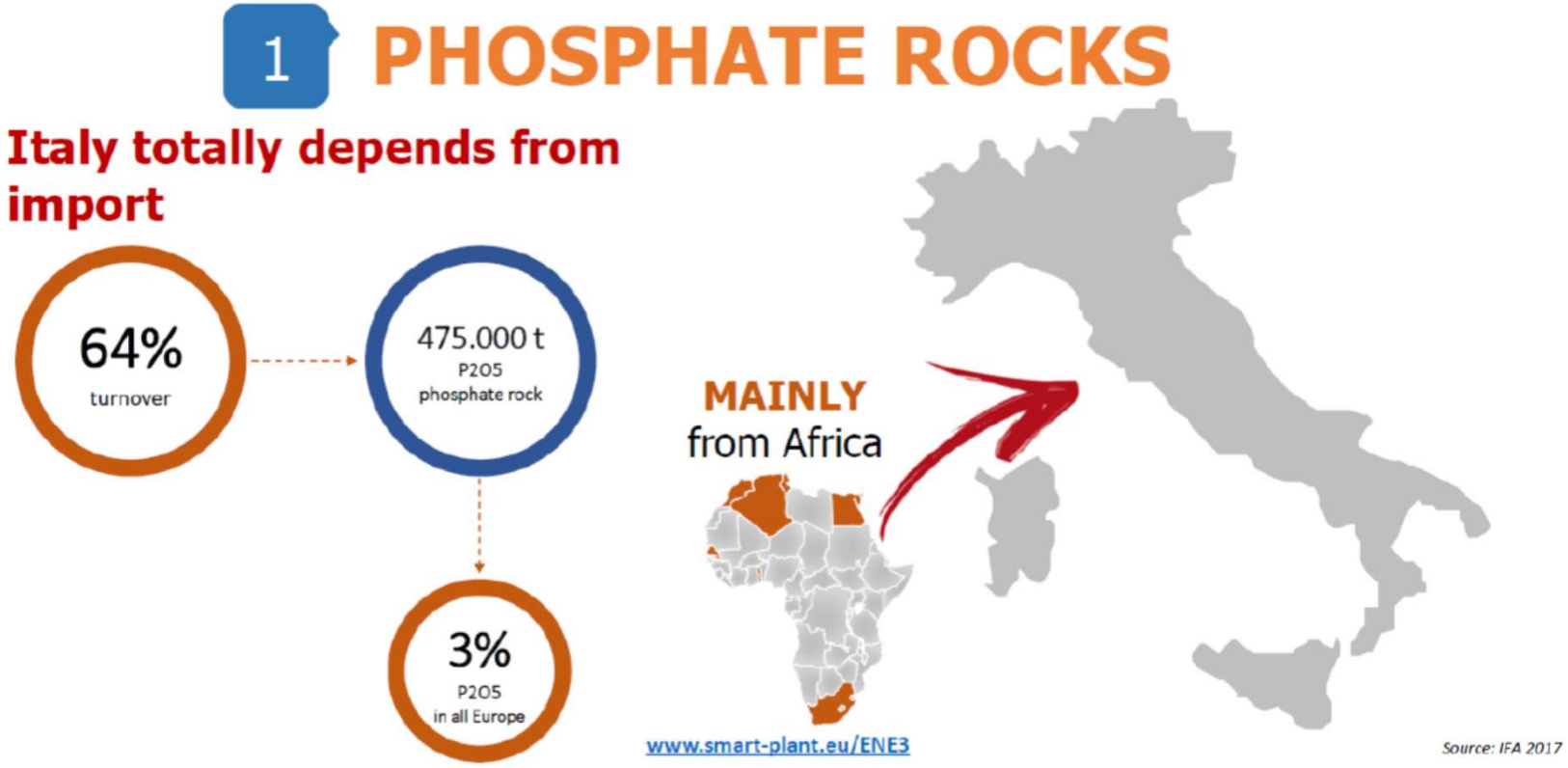
Location of resources in/for Italy



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Impurities of mineral Phosphorous

Phosphate Rock - Main Impurities

Country	Deposit	P2O5	As	Cd	Cr	Hg	U	V
		(wt %)	(ppm)	(ppm)	(ppm)	(ppb)	(ppm)	(ppm)
Israel		32	5	25	227	130	150	200
Jordan		32	8	5	92	48	78	70
Morocco	Bu Craa Kouribga Youssoufia	35.1 32.6 31.2	 13.4 9.2	37.5 15.1 29.2	 200 255	 855 120	75 88 97	 106 200
Togo		36.7	10	58.4	101	365	94	60
USA	Florida idaho N. Carolina	31.9 31.7 29.9	11.3 23.7 11.2	9.1 92.3 38.2	60 290 158	199 107 233	141 107 65	108 769 26
South Africa		39.5	11	<2			9	17
Tunisia		29.3	4.5	39.5	144		44	27
Senegal		35.9	17.4	86.7	140	270	67	523
Australia		28.9	14	4	35	75	84	63
Syria		31.9	4	3	105	28	75	140
China		31	26	2.5	33	4990	22.8	80

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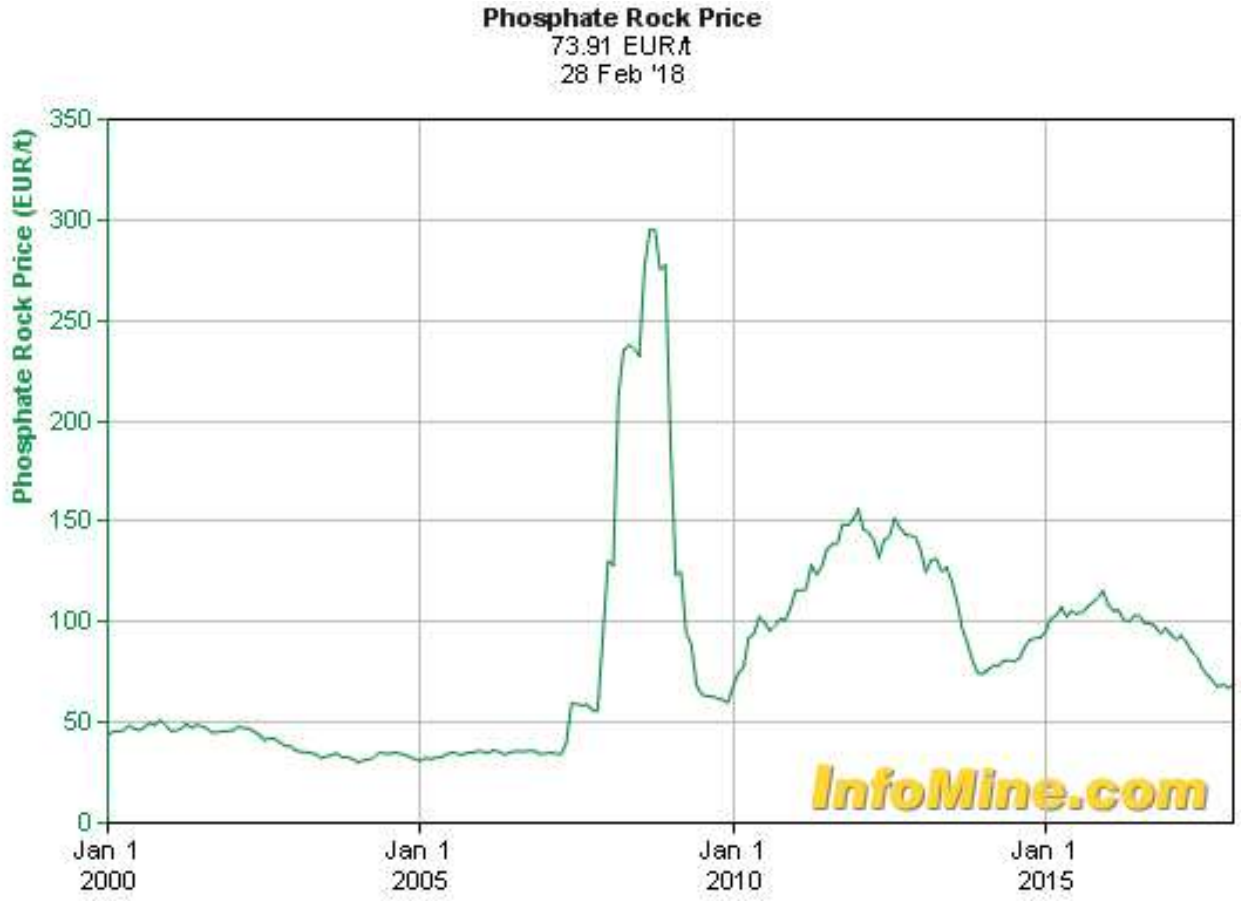
Price of mineral Phosphorous



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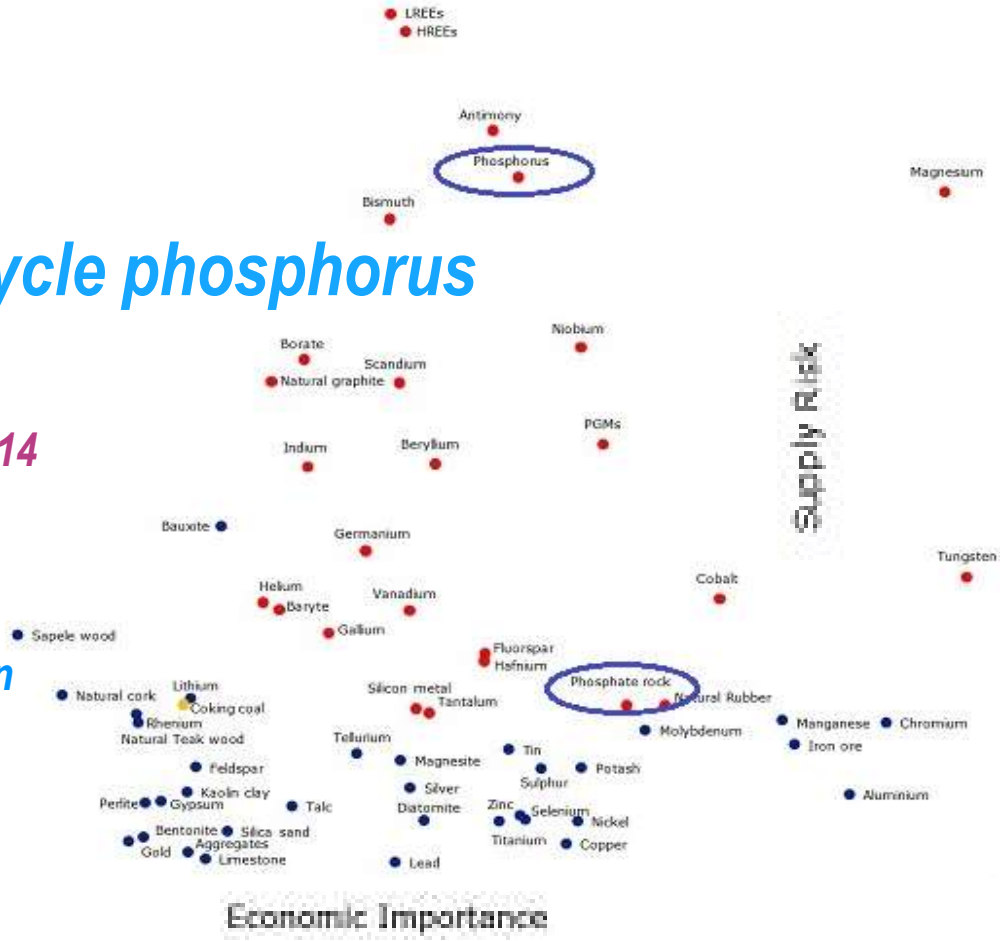
Summary…

Pressure to recycle phosphorus

Phosphate is on the EU Critical Raw Materials List since 2014 and White Phosphorus since 2017

- ***Non substitutable***
- ***Non renewable***
- ***Geopolitical resource concentration***
- ***EU 90% dependent on imports***



https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en
http://europa.eu/rapid/press-release_IP-14-599_en.htm

Courtesy of C. Thornton European Phosphorus Platform

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Pressure to reduce phosphorus losses

- ***Phosphorus is first cause of (non-morphological) quality status failure under the EU Water Framework Directive***
- ***55% of UK rivers and 74% of lakes exceed P level for good ecological status***
- ***… despite sewage works P discharge reduced 70% 1987 - 1996***

- *Urban Waste Water Treatment Directive 1991/271*
- *Nitrates Directive 1991/676*
- *Water Framework Directive 2000/2000*
  - quality objectives 2015 / 2021 / 2027
- *Groundwater Directive 2006/118*
  - phosphorus on monitoring list (2014)


ENDS Europe 3 July 2018

News

Threat of legal action after damning EU water report

The European Commission has warned that governments may face legal action over a failure to implement EU water quality legislation, as a report published on Tuesday

Courtesy of C. Thornton European Phosphorus Platform

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Summary…

Recycling potential

- ***European Commission [1]***
  STRUBIAS[1] recycled products could replace 25-40% of EU mineral phosphate fertilisers
- ***European Commission [2]***
  Phosphorus recycling could replace 30% of EU mineral phosphate fertilisers
- ***i.e. market value of recycled phosphates of c. 600 M€ [3]***

P recycling potential in EU-27

kton P/year	**Total**	**Recycled**	***Potential***
Sewage sludge	297	115	*182*
Biodegradable solid waste	130	38	*92*
Meat & bone meal	128	6	*122*
Total	**427-555**	**153-160**	***274-396***
Manure recycling =		**1 736**	
Mineral fertiliser use =		*1 448*	

Van Dijk et al. "Phosphorus flows and balances of the European Union Member States", Science of the Total Environment Volume 542, Part B, 15 January 2016, Pages 1078-1093
http://dx.doi.org/10.1016/j.scitotenv.2015.08.048

1 = JRC STRUBIAS draft « Market » report 20/12/2017
STRUBIAS products = recovered phosphate salts, ashes, biochars
2 = IP/18/6161 http://europa.eu/rapid/press-release_IP-18-6161_en.htm
3 = ESPP estimate

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EU nutrient recycling legal framework

EU Fertilising Products Regulation (FPR)

- *Flagship of Commission 'Circular Economy Package'*
- *All fertilisers (mineral & organic), plant materials, composts & digestates, soil amendments, growing media, biostimulants, liming materials, etc.*
- *First EU product legislation to confer "End-of-Waste" status*
- *Opens European market for recycled fertilisers and for recycling technologies*

Published 25th June 2019: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2019:170:TOC

- ***STRUBIAS**: aims to add struvite/phosphate salts, biochars/pyrol materials, ash-based materials*

Courtesy of C. Thornton European Platform

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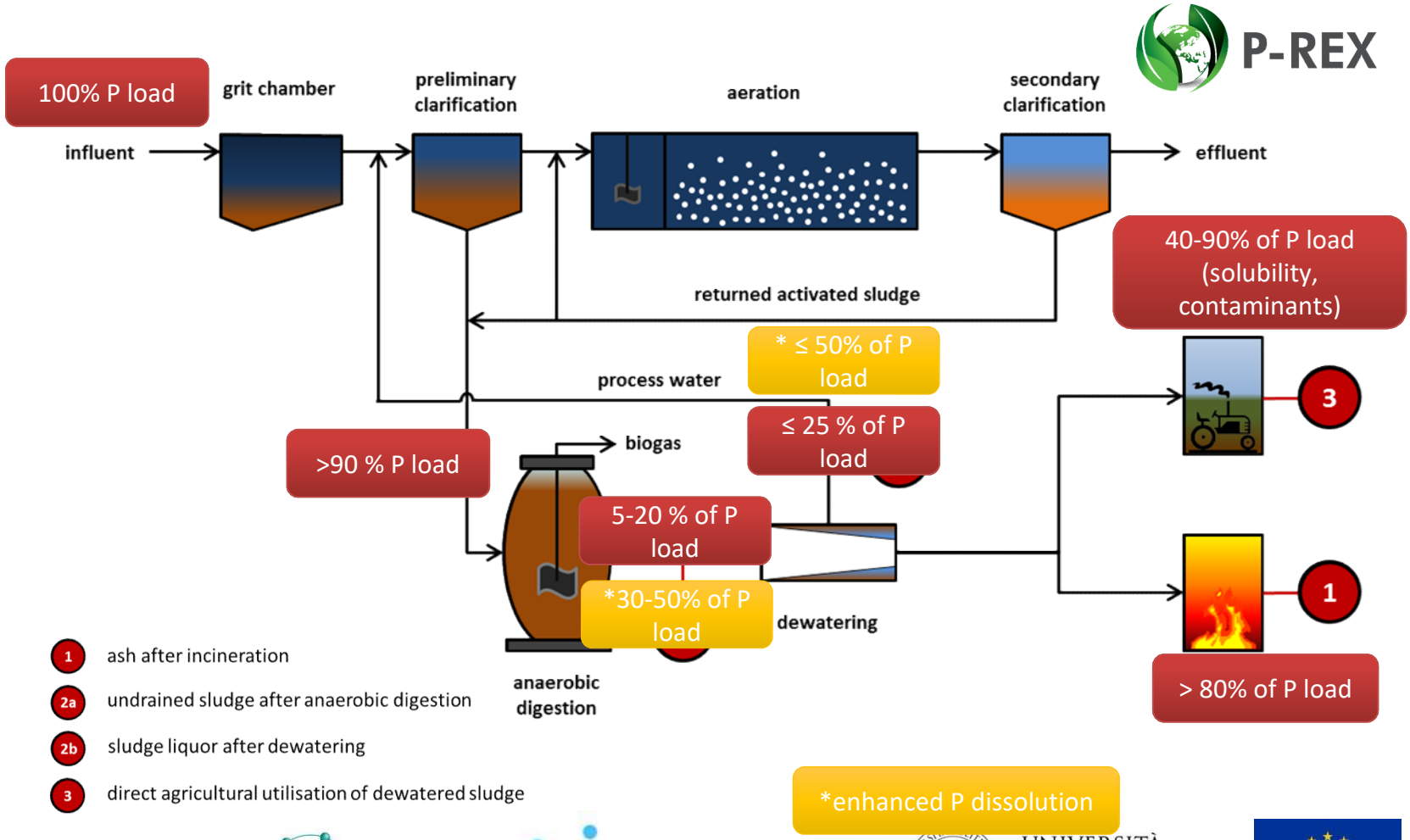
Opportunities to recycle wastewater nutrients?

under new EU Fertilising Products Regulation and STRUBIAS

in? or out?		Sewage	Manure	Animal By-Products		Food waste / biowaste	Food industry
				Cat 2&3	Cat 1		
CMC3: compost		✗	✓	✓	✗	✓	(✗)
CMC5: digestate		✗	✓	✓	✗	✓	(✗)
CMC6: food-industry by-products		✗	✗	✗	✗	✗	**ONLY** limes, molasses, vinasse, distillers grains
CMC11: animal by-products (ABPs)		Undefined empty box ….. (but already included in CMC3, CMC5, STRUBIAS …)					
STRUBIAS P-salts	***Including when used as fertiliser production ingredient***	✓	✓(sterilised ?)	✓(sterilised ?)	✗	✓	✓
STRUBIAS ashes		✓	✓	✓	✗	✓	✓
STRUBIAS biochars etc		✗	✓	✓	✗	✓	✗

Courtesy of C. Thornton European Phosphorus Platform

Phosphorus load distribution



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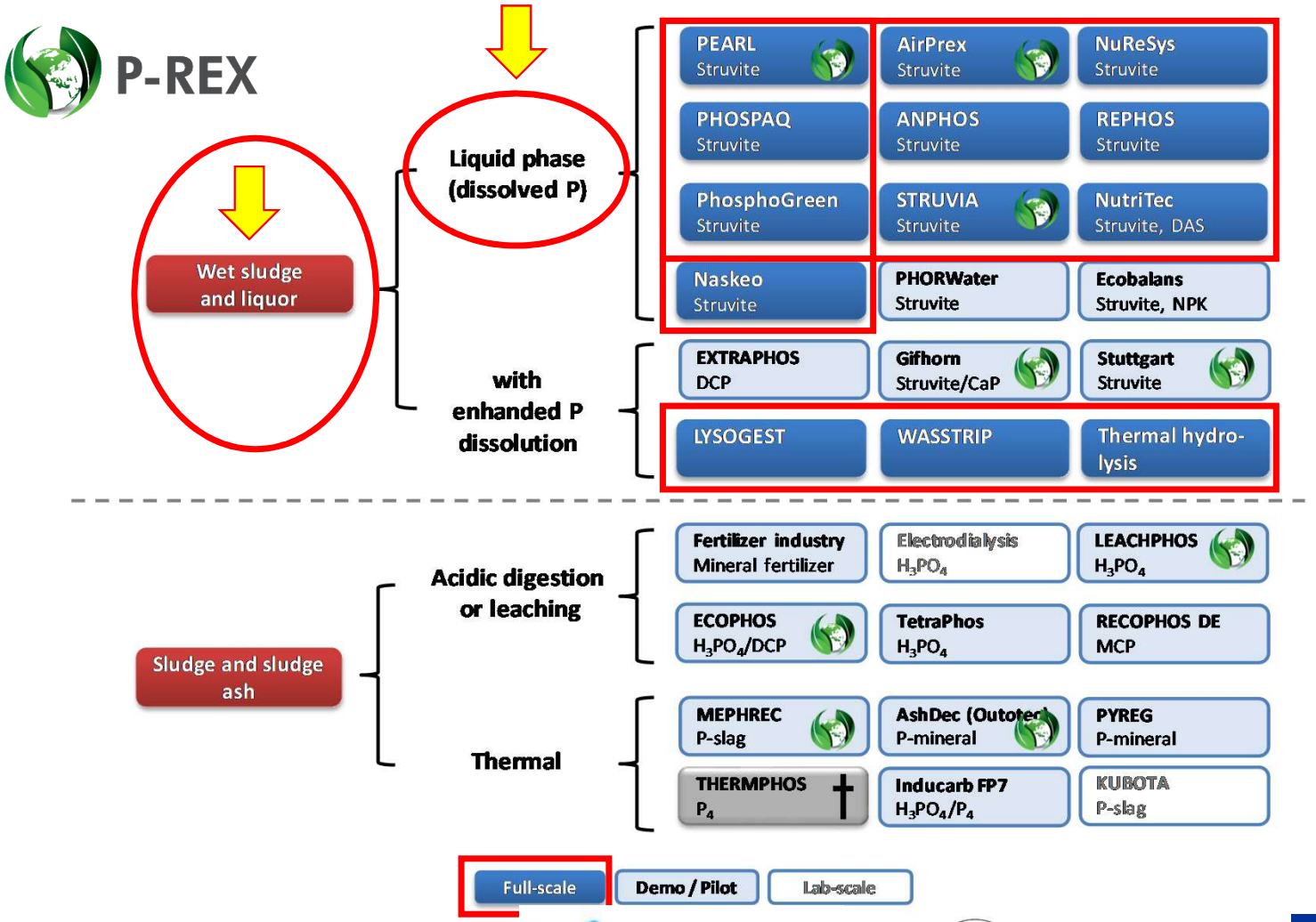
Technical solutions ? Several



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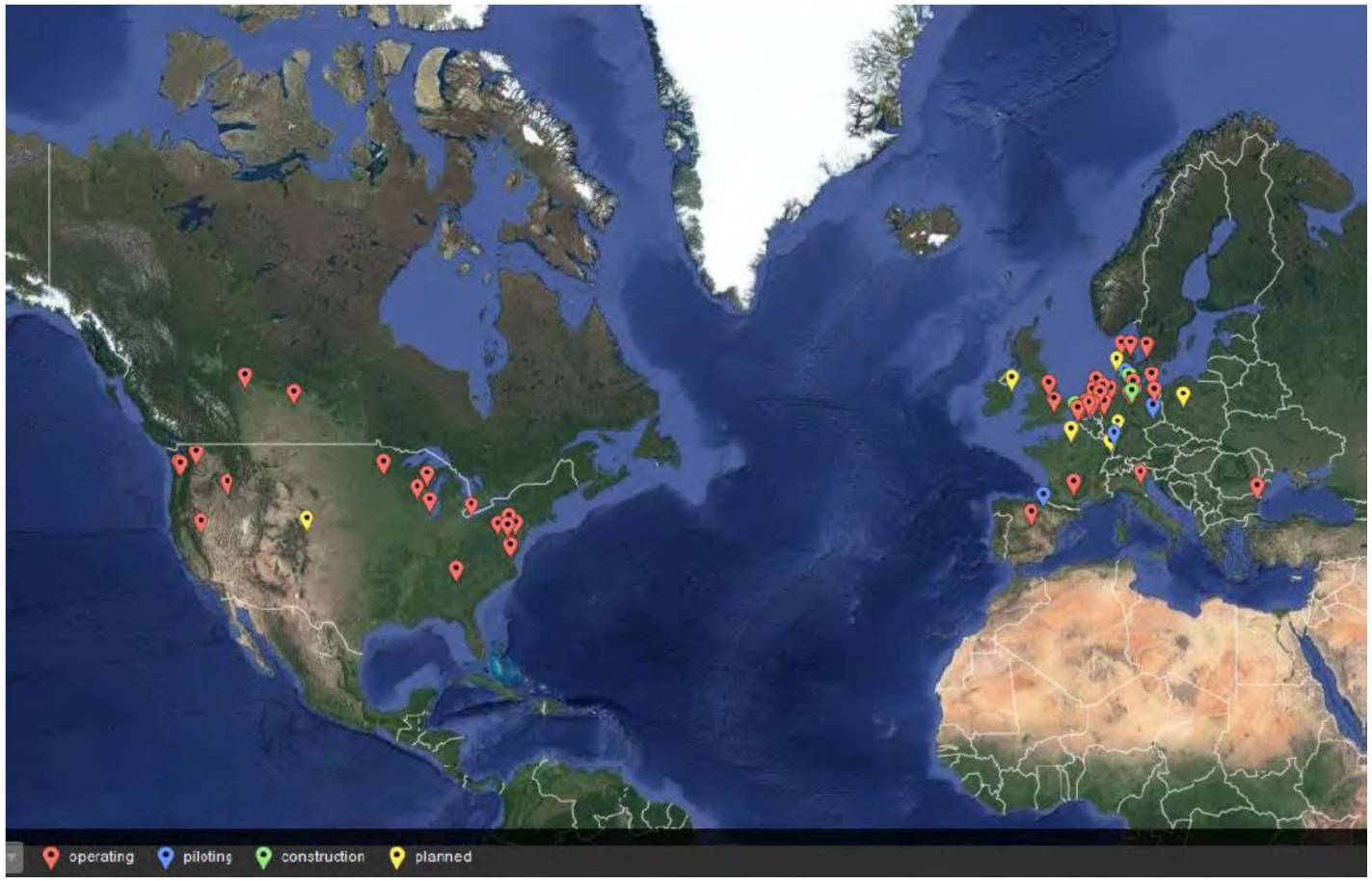
Global Implementation



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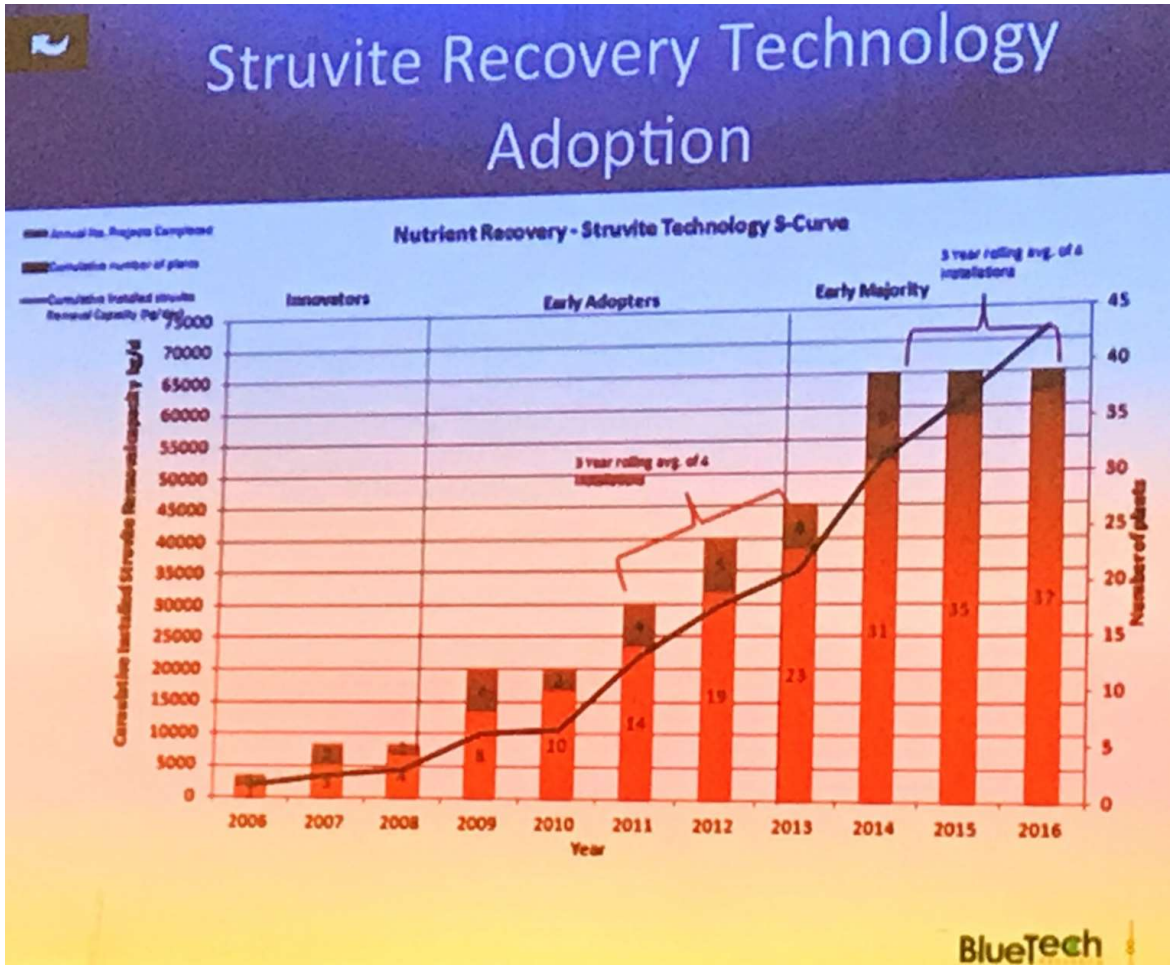
Global Implementation



Plants to struvite recovery

(Source: O'Callaghan – IFAT 2018)

Struvite – essentially a by-product

- Driven and paid-back by maintenance improvements and savings in EBPR plants
- <10% of European wastewater treatment plants qualify for the current „struvite“ process
- Average P recovery rate from the aqueous phase 8-15% of the potential, up to 40% recovery with sludge pre-treatment
- Plants produce a few hundred to few thousands tons of P-fertilizer. Different shapes, impurities, pollutants and fertilizing efficiency.
- Constant high quality products from Ostara.

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P-recycling from sewage sludge ash

> 85% P-recovery rate

- Several financially sound, industry owned technology suppliers
- Independent of P-removal process in sewage plant
- Some processes recover iron/aluminium salts for P-removal in wastewater treatment plants
- Some processes recover silicates for cement production

EasyMining
EcoPhos - Technophos

But…still no full scale

Agronomics Characteristics and Depollution necessity *Fonte P-Rex*

Technology	Recovery potential		TRL	Depollution technology and potential									Recovered material: solubility, relative fertilizer efficiency, pollution potential, handling							
	Recovery process	Related to WWTP influent		heavy metals	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	OM	Recovered material	Solubility			Relative fertilizer efficiceny		Pollution		Handling
															H_2O	CA	NAC	acidic soil	alkaline soil	DU_P	RSM (yr)	
REM-NUT®	90%	50-60%	5-6/-	ion exchange									(+)[1]	MAP	<1%	90-100%	90-100%	100%	75%	0.010	50,502	+
AirPrex®	85-90%	10-max. 25%	9/9	not necessary									(+)[1]	MAP	<1%	90-100%	90-100%	100%	75%	0.015	21,510	++
DHV Crystalactor®	85-90%	10-max. 25%	9/9	not necessary									(+)[1]	CaP	<1%	90-100%	90-100%	75%	50%	0.018	13,681	++
Ostara Pearl Reactor®	85-90%	10-max. 25%	9/9	not necessary									(+)[1]	MAP	<1%	90-100%	90-100%	100%	75%	0.011	14,514	++
P-RoC®	85-90%	10-max. 25%	5-6/8	not necessary									(+)[1]	CaP/MAP	<1%	80-100%	80-100%	100%	75%	0.007	20,434	+
PRISA	90%	10-max. 25%	5-6/-	not necessary									(+)[1]	MAP	<1%	90-100%	90-100%	100%	75%	0.072	9,058	+
Sewage sludge	100%	90%	-	no									(-)	sludge	<1%	85%	80-90%	50-90%	70%	0.499	832	-
AquaReci®	~70%	~60%	5-6/7-9	caustic leaching									(+)[2]	CaP/FeP	<1%	90%	-	75%	50%	0.016	26,875	+
MEPHREC®	~80%	~70%	5-6/7-9	iron slag									(+)[3]	P-rich slag	<1%	80-90%	25%	0%	75%	0.105	1,419	++
PHOXNAN	~60%	~40-50%	5-6/-	(ultra/nano-) filtration									(o)[2]	MAP	<1%	90-100%	-	100%	75%	0.004	80,613	+
Gifhorn	max. 50%	35-50%	9/9	precipitation									(o)	MAP/CaP/FeP	<1%	50-90%	95%	100%	75%	0.004	71,057	+
Stuttgart	max. 50%	35-50%	5-6/9	complexation									(o)	MAP/CaP/FeP	<1%	60%	50%	100%	75%	0.033	18,363	+
Sewage sludge ash	100%	87%	-	no									(+)[3]	ash	<1%	30-50%	30-40%	25-50%	20%	0.352	1,103	o
AshDec® depoll.	98%	~90%	5-6/9	thermo-chemical									(+)[3]	depolluted ash	<1%	30-60%	85%	90%	0%	0.052	2,776	o
AshDec® Rhenania	98%	~90%	5-6/9	thermo-chemical									(+)[3]	partly depoll. Ash	<1%	80-90%	-	90%	75%	0.206	762	+
LEACHPHOS®	~70-80%	~60-70%	5-6/7-9	leaching									(+)[3]	CaP	<1%	40-90%	90-100%	100%	75%	0.131	878	+
PASCH	~70-80%	~60-70%	5-6/7-9	leaching + organic agent									(+)[3]	CaP	<1%	80-90%	90-100%	75%	50%	0.025	14,965	+
EcoPhos®	95%	~85%	9/9	leaching + ion exchange									(+)[3]	Phosphoric acid	100%	100%	100%	100%	100%	0.002	-	++
RecoPhos®	100%	87%	9/9	no									(+)[3]	Mineral fertilizer	75%	100%	75%	100%	100%	0.158	3,408	++
Fertilizer Industry	100%	87%	9/9	no									(+)[3]	Mineral fertilizer	40-50%	80-90%	20-40%	100%	75%	0.352	1,103	++
Thermphos®	95%	~85%	9/-	silica slag									(+)[3]	P_4	-	-	-	-	-	-	-	++
Single Superphosphate	-	-	-	-	-	-	-	-	-	-	-			Mineral fertilizer	80%	100%	100%	100%	100%	0.225	1,450	++

Depollution related to the input flow
no data
<20%
20-40%
41-59%
60-80%
>80%

Organic Micropollutants (OM)	
+	total destruction of OM
o	OM significantly reduced
-	no OM destruction/depollution
[1]no incorporation of OM during crystallisation process	
[2]OM (partly) destruction due to oxidation process	
[3]OM destruction due to sludge incineration	

Handling	
++	Direct use in agriculture/industry
+	Processing as e.g., granulation necessary
o	Extraction/Mixing and granulation
-	reactive, high water content

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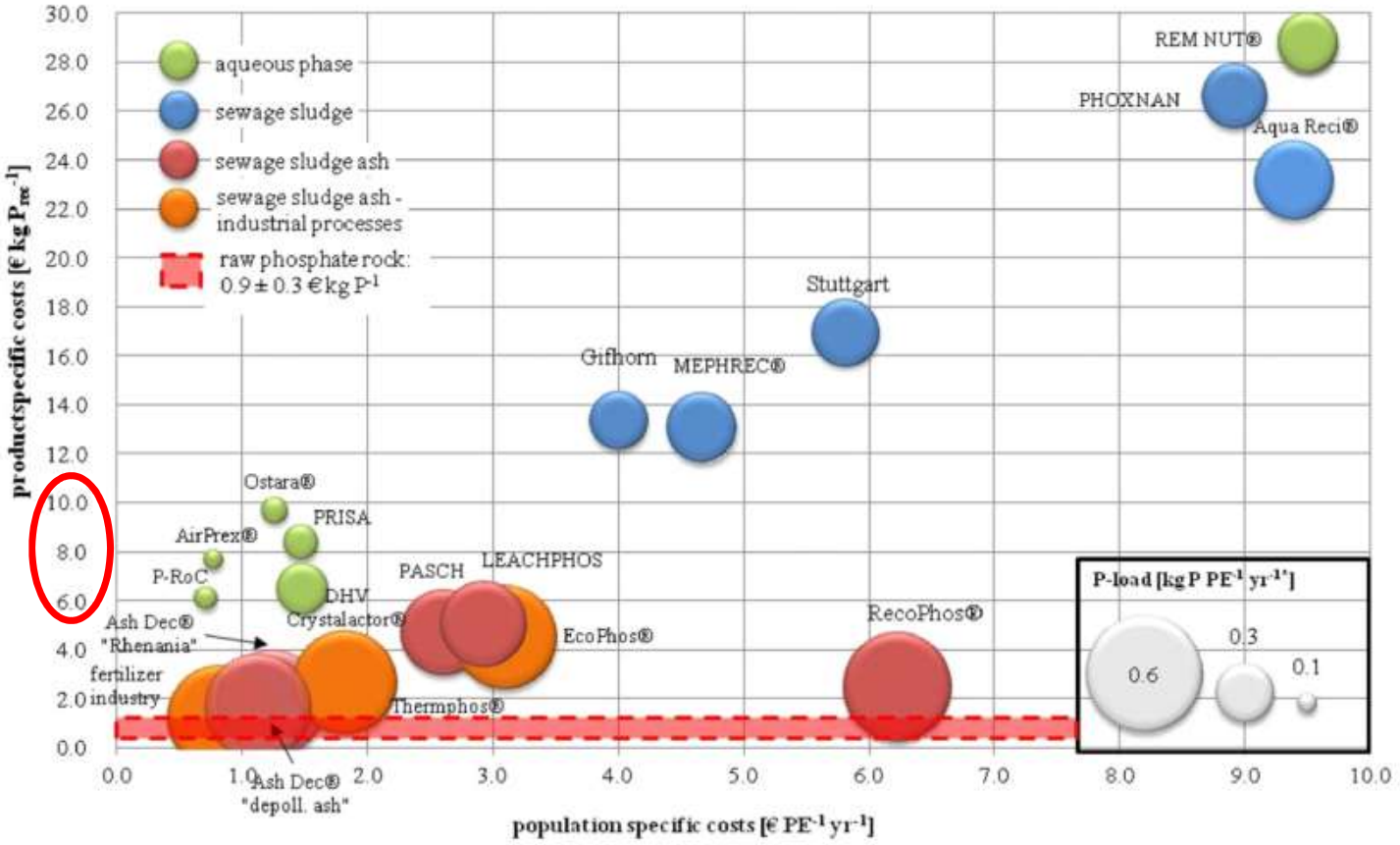
Management costs



Engle et al., 2016

Legislation as driver ?
Example Germany 2017+

National phosphorus recycling legislation

Germany

- ***Legislation May 2017***
  makes phosphorus recovery obligatory
  - within 12/15 years
  - for all wwtp > 50 000 p.e.
  - if sewage sludge P > 2% of dry matter

- ***Requires to either recover >50% of P or to reduce sludge P to <2%***
  - national guidance document under discussion (2019):
  %P depends on organics: change with hydrolysis, digestion → may favour mono-incineration (80% of P recovery)
- ***Land sewage biosolids use banned for larger sewage WWTP,***
  and lower contaminant limits will reduce spreading for smaller WWTP

Courtesy of C. Thornton European Phosphorus Platform

Legislation as driver ?

National phosphorus recycling legislation

Switzerland

- *2016 Decree makes phosphorus recovery obligatory by 2026*
  from sewage sludge incineration ash and meat and bone meal ash*
  ** Switzerland banned land use of sewage biosolids in 2006*
- *Still under discussion:*
  - %P recovery to be required
  - recycled fertiliser criteria
  (Bundesrat decision expected 24/10/2018)

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Principales nouveautés dans l'ordonnance sur le traitement des déchets

L'ordonnance sur le traitement des déchets (OTD) est soumise à une révision totale. Voici en résumé les principales modifications :

- Des exigences sont formulées pour la valorisation de certains déchets, laquelle n'était pas encore réglementée dans le droit fédéral. Il s'agit notamment des biodéchets (y compris règlementation relative aux possibles installations de traitement) et des déchets riches en phosphore.
- Un plan d'élimination des déchets est exigé pour tout projet de construction. Le maître d'ouvrage est tenu de déterminer les déchets dangereux pour la santé et pour l'environnement (p. ex. amiante, déchets de chantier contenant des biphényles

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Legislation as driver ?

National P-recycling policy developments

Baltic

- ***HELCOM:***
  8 EU Member States, plus Russia and the EU
- ***"Recommendation" March 2017 = obligation***
  - maximise phosphorus and other useful substance recycling
  - regular State reporting on measures taken to implement this
- ***Ministerial Declaration March 2018:***
  - define Nutrient Recycling Strategy by 2020

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Legislation as driver ?

National P-recycling policy developments

Sweden

- *13 July 2018:*
  Government announces 'enquiry' into
  - ban on agricultural use of sewage sludge
  - phosphorus recycling regulation
- *Currently working on regulatory proposal - Conclusions mid 2019?*

Government Offices of Sweden

http://www.government.se/press-releases/2018/07/inquiry-to-propose-ban-on-spreading-sewage-sludge-on-farmland-and-a-phosphorus-recycling-requirement

Austria

- *P-recovery obligation included in Government mandate plan*
- *Waste Management Plan 2017: P-recovery from 65-85 of sewage sludge by 2030*

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Legislation as driver ?

EU regulation and studies underway

"SAFEMANURE" study

ED ENVI study on recycled nutrient products from manures for the Nitrates Directive ("processed manures")

https://ec.europa.eu/jrc/en/science-update/call-participation-eu-wide-monitoring-campaign-manure

REACH contaminants studies

to prepare possible "Restrictions' under REACH

- → ***composts and digestates – completed not published***
- → ***mineral and organic fertilisers – tender underway***

https://etendering.ted.europa.eu/cft/cft-display.html?cftId=5131

REACH 'Registration' (Annex V) exemption

for digestates: regulation expected to be published soon

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
JOINT RESEARCH CENTRE
Directorate D – Sustainable Resources
Water and Marine Resources Unit

Ispra, Thursday, 31 May 2018

EU-wide monitoring of manure supporting the development of safe processed manure criteria

In order to promote the sustainable recovery of nutrients from manure, a careful evaluation of agronomic benefit versus possible risks to the environment and health is of pivotal importance. Such an evaluation should be the basis for the development of harmonised criteria that better assess nitrogen fertilisers that are partially or entirely derived from manure.

Within this framework, the role of agricultural application of manure (processed or not) in the propagation of anti-microbial resistance (AMR), interspecies exchange and antibiotic resistant genes as well as the role of veterinary antimicrobial agents is a priority field of research of the European Commission. Indeed, there is a significant

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European Founding possibilities?

EU R&D funding

- *R&D funding:*
  - *FP7 (e.g. P-REX project)*
  - *Horizon 2020*
  - *Horizon Europe (2021-2028)*

- *Agriculture R&D funding*
- *DG ENVI: - LIFE*
- *DG REGIO: - InterReg*
- *National / regional programmes:*
  - *e.g. Baltic Bonus*

Upcoming Horizon 2020 calls 22/1/2020	
CE-RUR-08-2018-2019-2020	**Closing nutrient cycles - IA Innovation action + RIA Research and Innovation action**
CE-FNR-17-2020	**Pilot circular bio-based cities – sustainable production of bio-based products from urban biowaste and wastewater**
CE-FNR-15-2020	**A network of European bioeconomy clusters to advance bio-based solutions in the primary production sector**
FNR-18-2020	**Sustainability of bio-based products – international governance aspects and market update**

European Phosphorus Platform (2013)

http://www.phosphorusplatform.eu/members

ESPP: a coalition for action

- **Wide objectives: phosphorus stewardship**
  - *global food security*
  - *circular economy*
  - *environmental protection*
  - *healthy diet and food safety*
- **Bringing together:**
  - *water & waste industries,*
  - *mineral and organic fertilisers, chemicals,*
  - *P-recycling technology suppliers,*
  - *national & regional governments,*
  - *knowledge institutes …*

- **Actions:**
  - *vision & awareness*
  - *stakeholders & networking*
  - *dissemination*
  - *policy and regulation dialogue*

More information: *www.phosphorusplatform.eu*

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European Phosphorus Platform

How ESPP operates

Legally established
not-for-profit association

→ important for transparency, clarity of decision making, representation

http://www.phosphorusplatform.eu/members

- statutes are public https://www.phosphorusplatform.eu/platform/about-espp
- EU Transparency Register no. 260483415852-40 http://ec.europa.eu/transparencyregister/

100% membership funded

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European Phosphorus Platform: Events

ESPP and research

- ***1st European nutrient research event, Berlin 2015***
  at ESPC2 (European Sustainable Phosphorus Conference)
  with FP7 project P-REX, see ESPP SCOPE Newsletter n° 111
  conclusions published by European Commission
  http://bookshop.europa.eu/en/circular-approaches approaches approaches-to -phosphorus -pbKI0115204/ pbKI0115204/ pbKI0115204/
- ***2nd European nutrient research event, Basel 2017***
  with InterReg project Phos4You, see ESPP eNews n° 16
- ***3rd European nutrient research event, Rimini 2018***
  with Horizon2020 project SMART-Plant, see ESPP eNews n° 28
- ***4th European nutrient research event - planned at ESPC4***
  Vienna, 15-17 June 2020 https://www.phosphorusplatform.eu/espc4

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Nutrients Platform in the word

Nutrient platforms and networks worldwide

Netherlands 2010 http://www.nutrientplatform.org/

Germany 2015 www.deutsche-phosphor-plattform.de

Baltic: ESPP works with Baltic Sea Action Group www.bsag.fi

ESPP European Sustainable Phosphorus Platform 2013

North America Sustainable Phosphorus Alliance (SPA) 2017
(launched as NAPPS in 2015) https://phosphorusalliance.org/

Japan PIDO 2011 (Phosphorus Industry Development Organization of Japan) www.pido.or.jp

Global Partnership for Nutrient Management (UNEP)
http://www.unep.org/gpa/what-we-do/global-partnership-nutrient-management

Nutrients Platform in the word

Nutrient platform projects

Czech Republic **Česká Fosforová Platforma** www.fosforovaplatforma.cz

Ireland **All Ireland Phosphorus Pla**tform www.nutrientsustainability.ie

Italy **Piattaforma Italiana del Fosforo** Contact ENEA roberta.decarolis@enea.it

Norway Phosphorus Platform

Contacts Daniel Mueller Helen Ann Hamilton helen.a.hamilton@ntnu.no

Switzerland

Swiss Phosphorus Network www.pxch.ch

AMTP Platform for cooperation on phosphorus recovery technologies

http://www.klaerschlamm.zh.ch/

United Kingdom Nutrient Platform Contact r.sakrabani@cranfield.ac.uk

Canada Phosphorus Hub https://www.phosphorushub.com

IRISH Nutrient Sustainability PLATFORM

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http://www.phosphorusplatform.eu/members

Thank you for your attention!

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