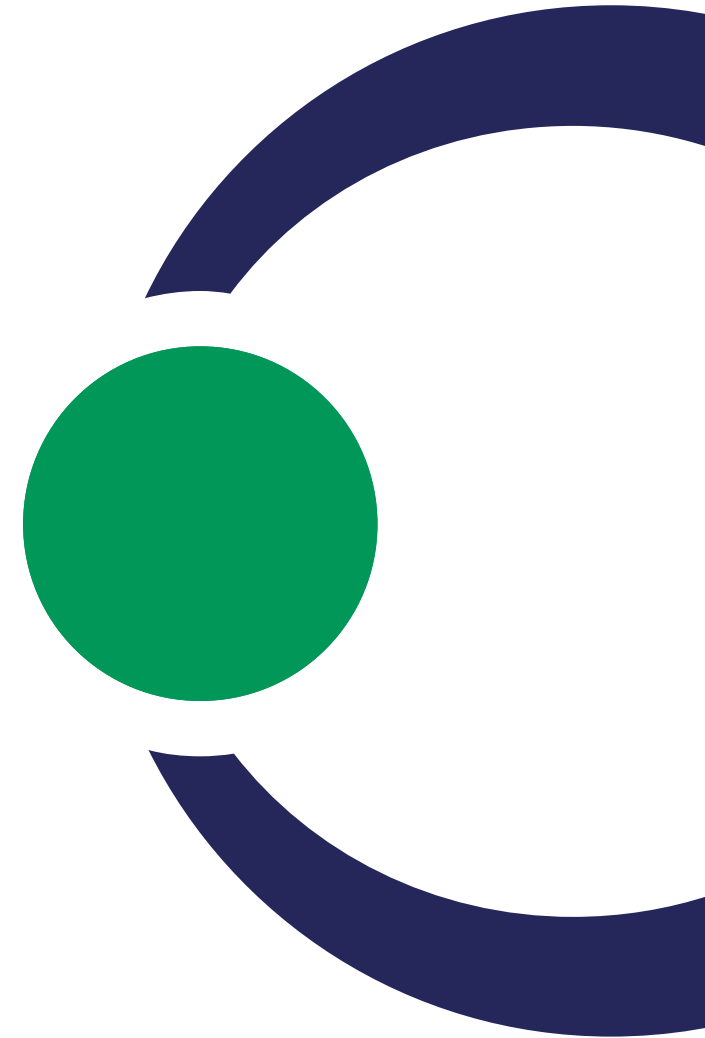


NUTRIENT RECYCLING

Quality matters! Volume matters! Reliability matters!

for circular economy

Christian Kabbe, PhD



Content

- Quality matters! (Processing and use)

+

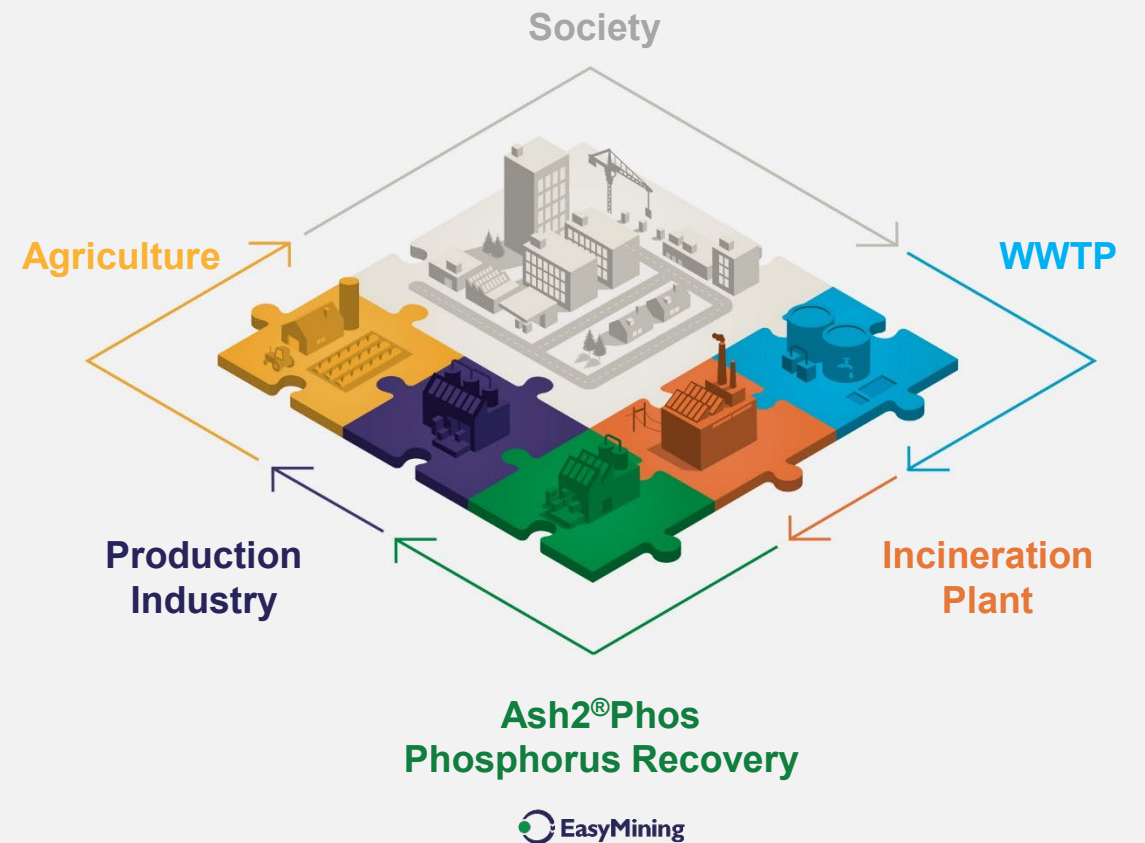
- Volume matters! (Relevance)

+

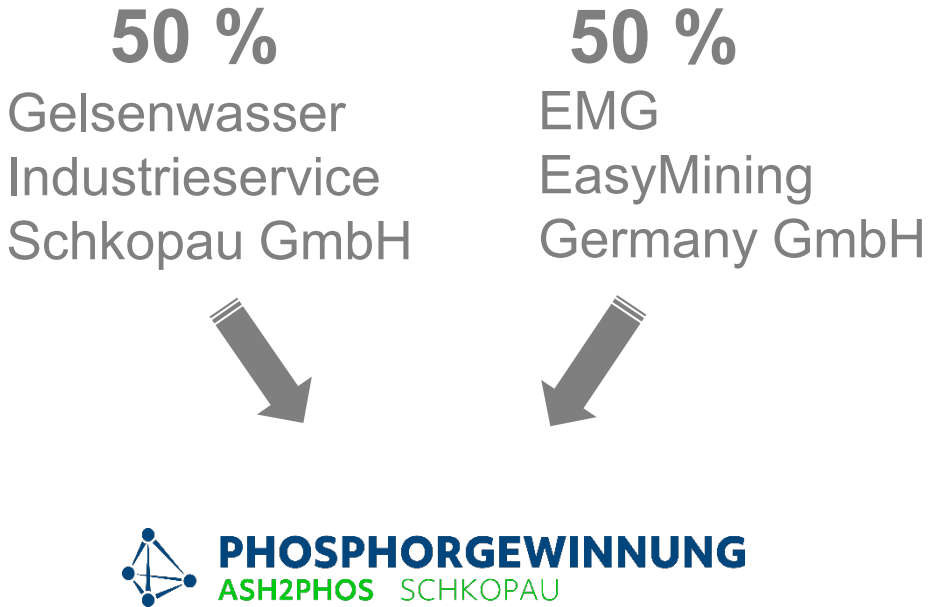
- Reliability matters! (Security of supply)

=

- Demand (Market uptake)



ESSENTIAL FOR CIRCULAR ECONOMY: PARTNERSHIPS AND SHARED AMBITIONS



Implementation and operation of Ash2Phos plants in Germany, starting in Schkopau with 30.000 t SSA/a capacity



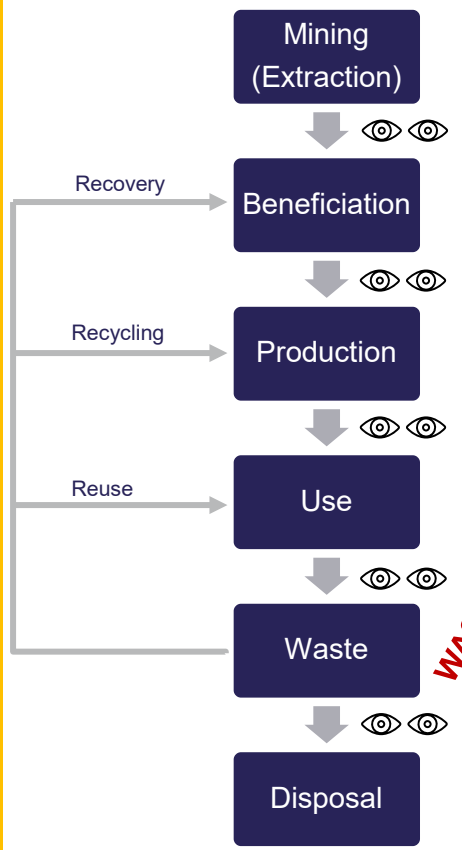
www.pg-schkopau.de

Common goal: 300.000 t SSA/a in 3-4 A2P plants

TRANSFORMATION – NOT JUST AN ECONOMIC QUESTION, RATHER A QUESTION OF ECONOMIC AND SOCIETAL SURVIVAL (AGE OF CHEAP ENERGY AND RAW MATERIALS IS OVER!)

Past Present Future

LINEAR



WASTE LOGIC:

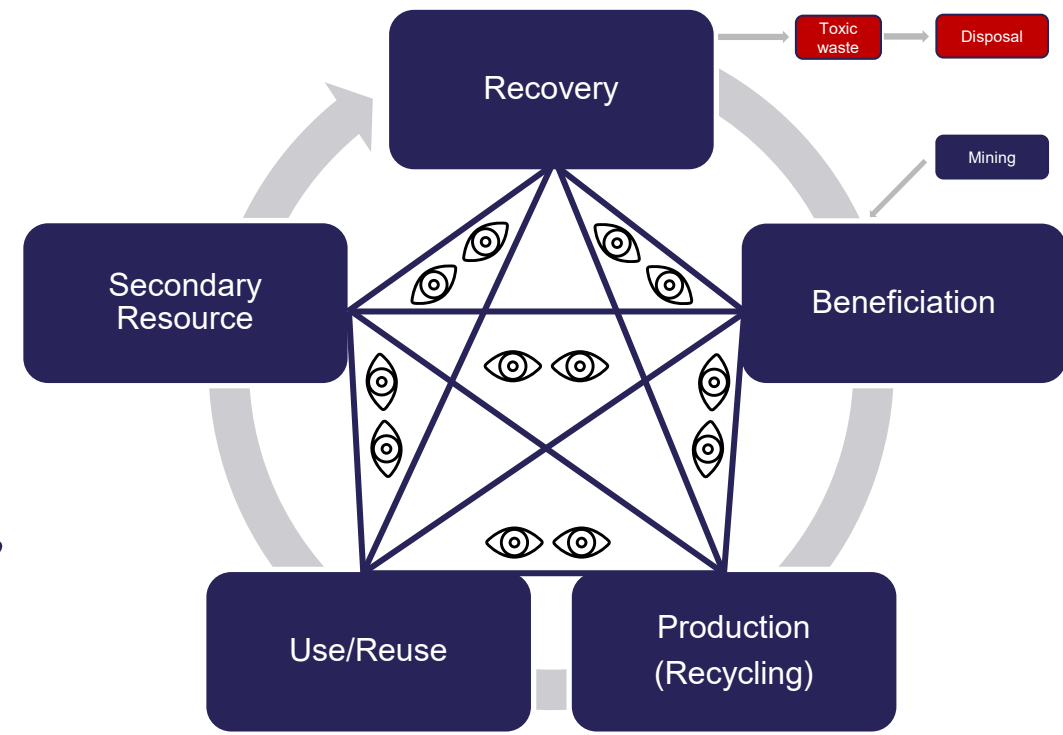
- getting rid of material
- as cheap as possible
- just as nasty as possible
- very low transparency and only between direct neighbours
- high degree of fragmentation
- cost driven quality downgrade/downcycling

VS.

Product responsibility:

- keep/get quality as good as possible
- multi sectoral transparency
- most materials kept in loops
- value driven recycling/upcycling

CIRCULAR



Low fragmentation of responsibilities (business and legislation)
If one stage fails, all stages effected! High transparency!

High fragmentation of responsibilities (business and legislation)
If one stage fails, only downstream fails! Low transparency

PHOSPHORUS – A

SUPER-CRITICAL?

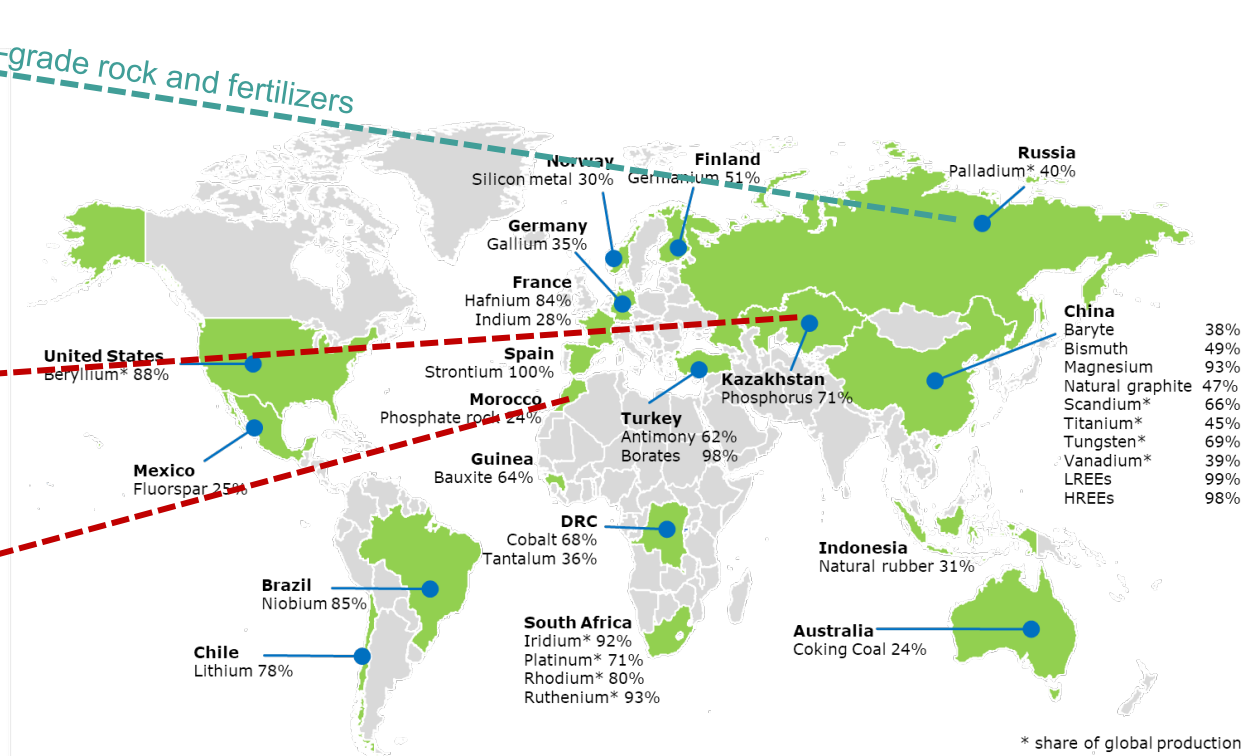
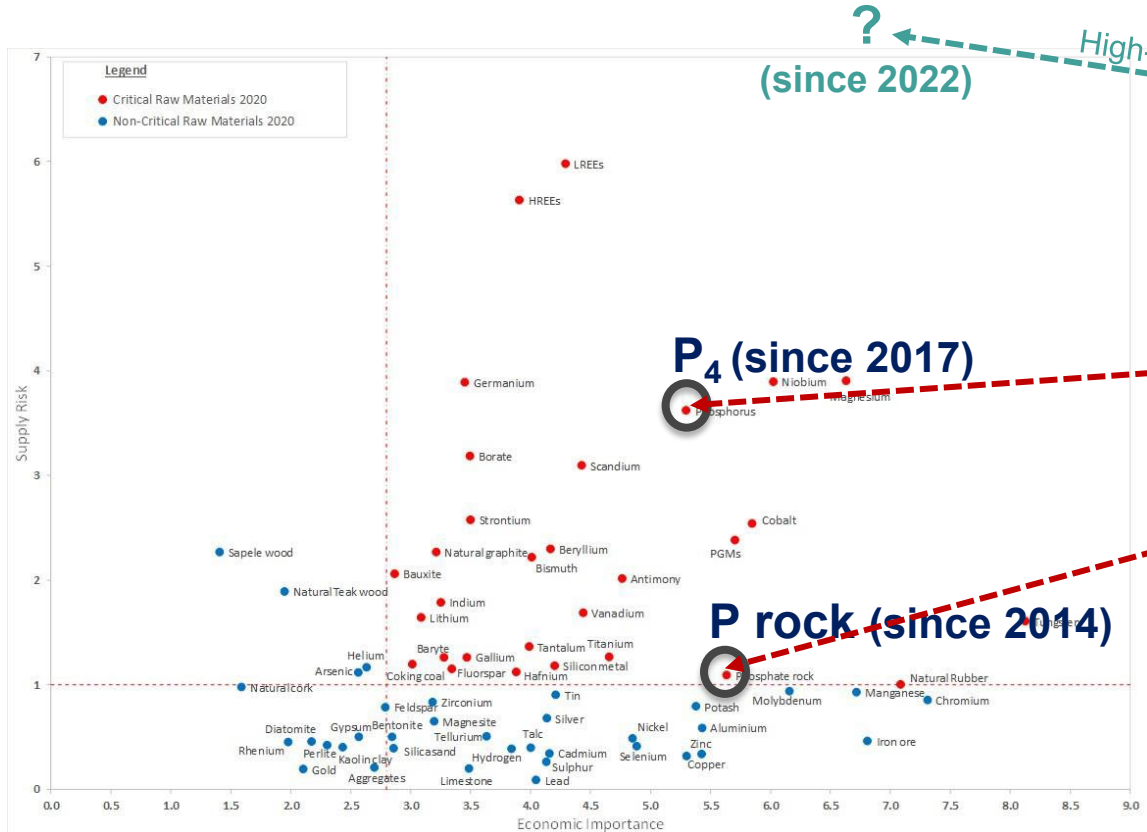
RAW MATERIAL FOR EUROPE

... and global food supply

CRM list keeps growing (2011-14 CRMs; 2020-30 CRMs)

Countries accounting for largest share of EU supply of CRMs

Supply Risk



Economic Importance

https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

EUROPE: P RELEVANT WASTE FLOWS (RENEWABLE P SOURCES)

[kton P/year]	Total	Recycled	Potential
Sewage sludge	297	115 (?)	182
Biodegradable solid waste	178	38	92
Meat & bone meal	28	6	122
Total	427-555	153-160	274-396
Manure recycling =	1 736		
Mineral fertiliser ≈	1 200		

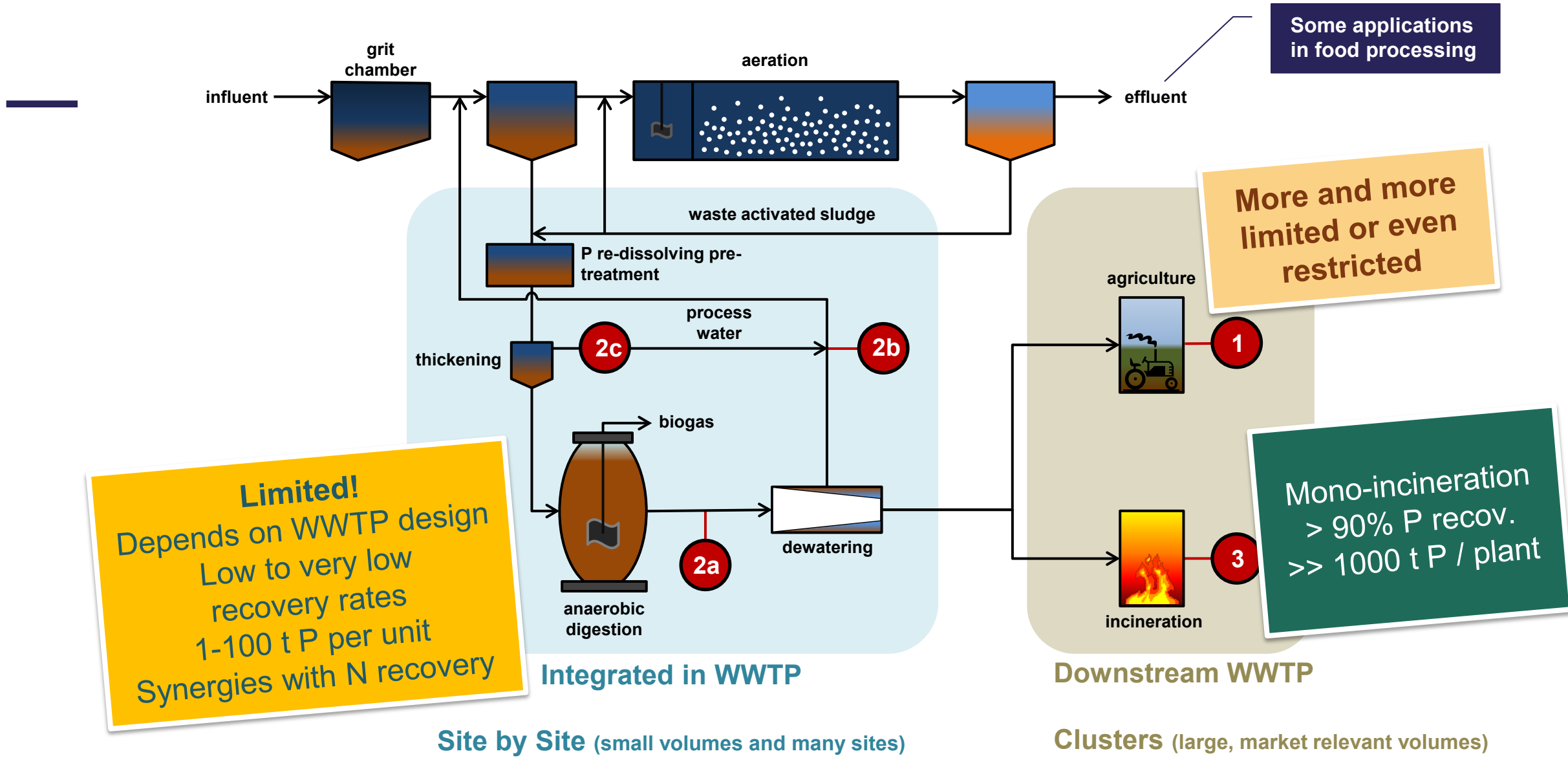
Van Dijk & Oenema "Phosphorus flows in wastes in Europe", 2013, Fertilisers Europe seminar, 6 Feb. 2013.

Updated Van Dijk

But, is „just“ waste recycling Circular Economy?

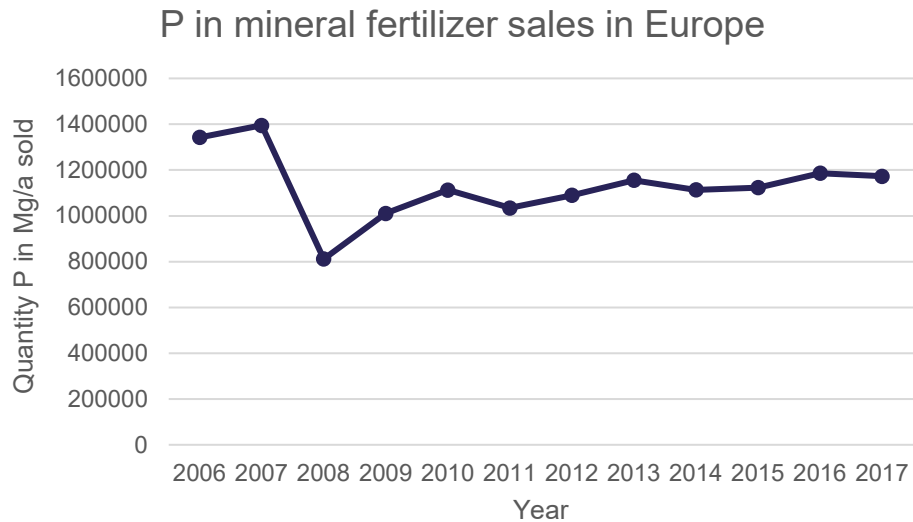
Sewage (sludge) is the second most relevant renewable P source in Europe!

P RECOVERY & RECYCLING ROUTES: POCKET DUST VS. REAL VOLUMES



EUROPEAN DIMENSION – P IN MINERAL FERTILISERS – P RECOVERY POTENTIAL FROM SLUDGE ASHES AT HAND AND MID-TERM

European market volume for P in mineral fertilizers



Source: Eurostat/Fertilizers Europe 2019

P potential in sludge ash today and tomorrow

2017: appr. 500,000 Mg SSA in Europe containing appr. 45 kt P (DE: 23 kt P, NL: 6 kt P in ashes)

2030/35: appr. 1.2 million tons SSA in Europe containing appr. 108 kt P (DE: 50 kt P, NL: 9 kt P in ashes)

With a 90% recovery efficiency, 97 kt P could be mined from SSA by end of decade annually

Compares to 4% (today) and appr. 8% (2035) of total P sales in form of min. fertilisers in Europe!

If all P in European sewage were tapped this way, 270 kt P (22 %)

SEWAGE SLUDGE ASH (SSA) – A HETEROGENIOUS, MINERAL CONCENTRATE

Element	%	mg/kg	%		Limits	
			von	bis		
P	9,4	94.000	5,9	13,1		
Fe	10,8	108.000	1,8	20,3		
Ca	10,1	101.000	7,1	16,2		
Al	5,5	55.000	2	20,2		
K	1	10.000	0,3	1,7		
Mg	1,3	13.000	0,3	2,5		
Na	0,6	6.000	0,2	1,1		
Ti	0,4	4.000	0,1	0,6		
Si	11,6	116.000	5	17,5	EU FPR	DÜMV
			mg/kg		mg/kg	
Cu	0,10	1.015	522	2.477	600	900
Zn	0,29	2.862	1.882	4.930	1500	5000
Cr	0,02	213	79	1.088	2	2
Mn	0,17	1.713	435	4.932		
Ni	0,007	73	39	191	100	80
Pb	0,01	139	63	363	120	150
As	0,002	18,7	4,4	124	40	40
Cd	0,0003	2,6	0,1	5,7	60	1,5 / 50
Hg	0,0001	0,7	0,1	2,1	1	1

Matrix elements

Esp. (Fe+Al) vs. P ratio!

Heavy metals

SSA in Germany: composition based on SSA monitoring (BAM 2014) and own analyses

TEXTE
49/2014

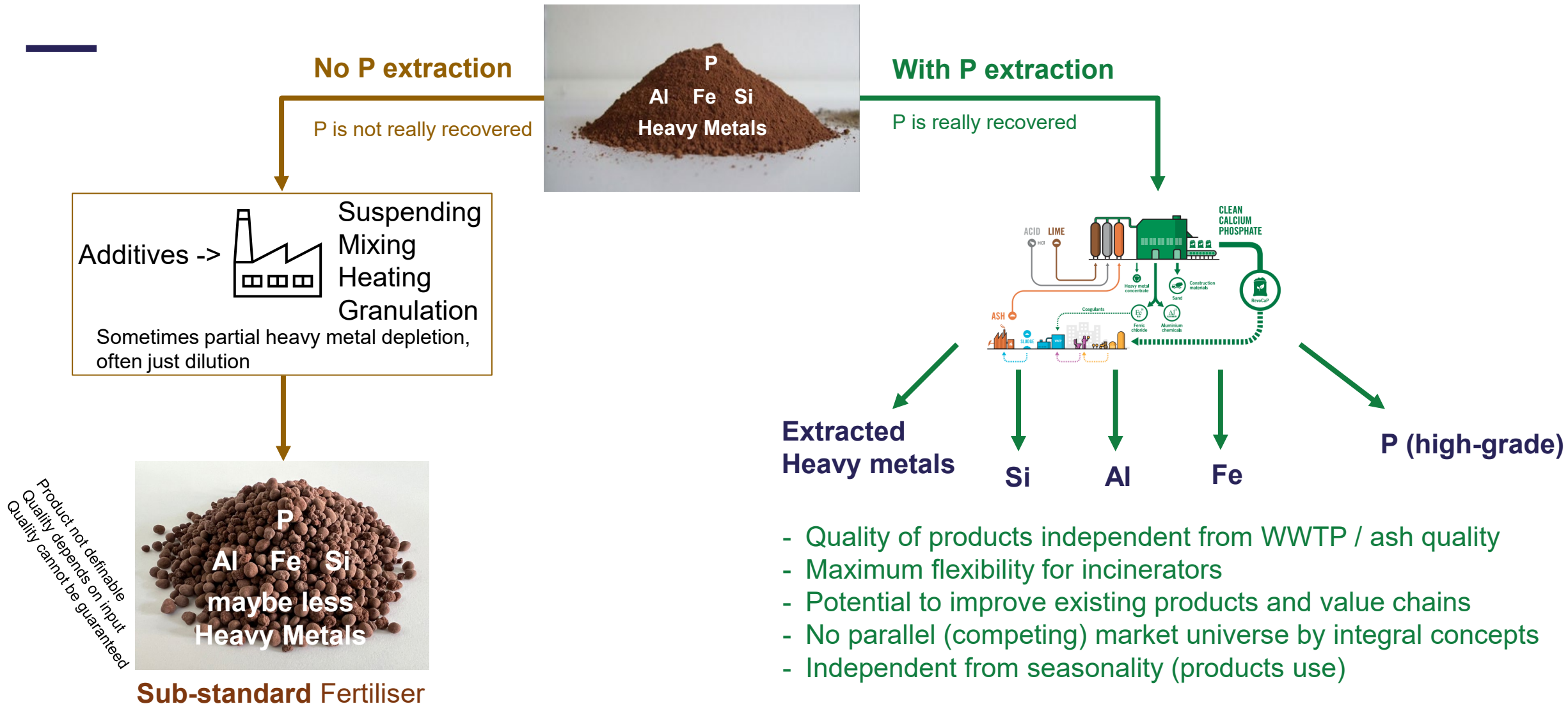
Monitoring von Klärschlammmonoverbrennungsaschen hinsichtlich ihrer Zusammensetzung zur Ermittlung ihrer Rohstoffrückgewinnungspotentiale und zur Erstellung von Referenzmaterial für die Überwachungsanalytik

Umwelt Bundesamt
Für Mensch & Umwelt

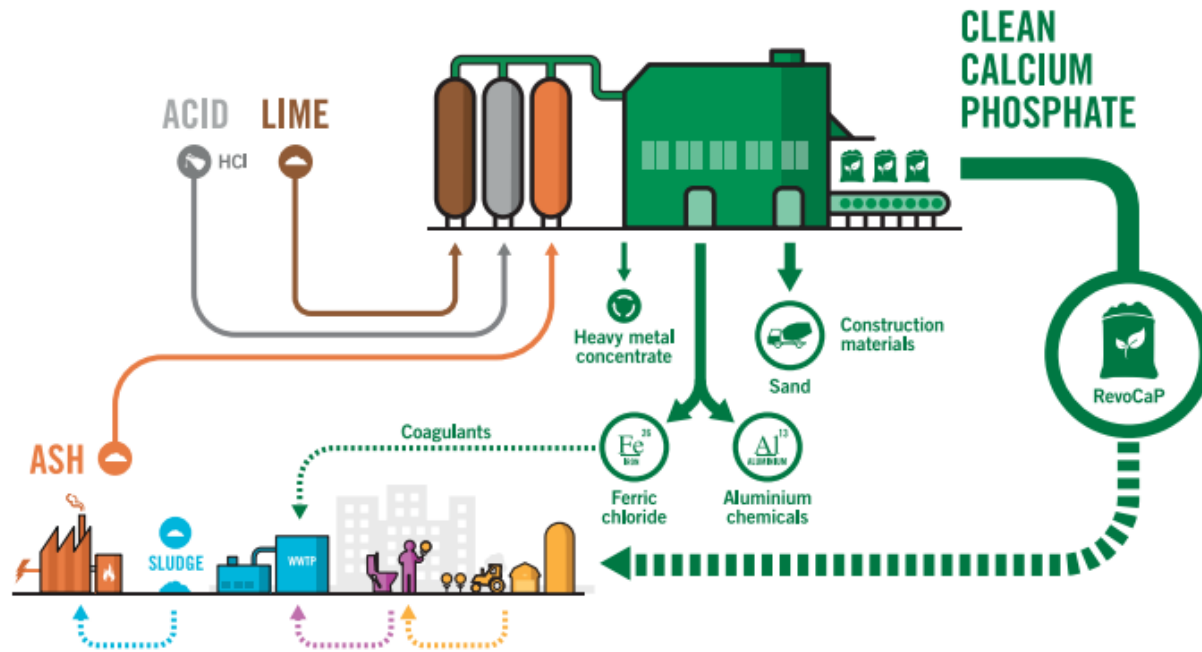
P RECYCLATES, P ROCKS MIRRORED AGAINST DÜMV AND EU-FPR ... EVEN MORE RELEVANT, WHEN USING XY MG/KG P

Material	Parameter	P ₂ O ₅ [%]	Fe [%]	Al [%]	As [ppm]	Cd [ppm]	Cr [ppm]	Cu [ppm]	Hg [ppm]	Ni [ppm]	Pb [ppm]	Tl [ppm]	U [ppm]	Zn [ppm]	Typ
	Ash mixed with P acid	36	2,8	3,1	6.2	1.3 (3,6)	144	427	1	39	46	<0,4		1092	P recyclates and relevant elemental composition
	Ash mixed with P acid	42	4,8	?	27	2,5 (5,9)	98	612	0,3	74	107	<0,4		1860	
	Rotary kiln and additives	3% MgCl ₂			10			940		89	34			2100	
		6% MgCl ₂	21	?	?		<0,4	?	<0,05		65	15	<0,4		
	Extracted Ca-Phosphate (CaP)	39	0,1	0,3	1,4	<0,1	1	5	<0,1	2,5	3,6	<0,4		34	
	Limit EU FPR PFC1				40	3 bzw. 60 (mg/kg P ₂ O ₅)	2 (Cr ^{VI})	600	1	100	120			1500	Regulations and limit values
	Limit DÜMV				40	1,5 bzw. 50 (mg/kg P ₂ O ₅)	2 (Cr ^{VI})	900	1	80	150	1		5000	
50%	Russia (KOLA)	39			1	0-0,4	0,5-1,3	26-35		4,7-7,3	2,9-5,5	0,0	3,0-3,35	10,5-26,7	Phosphate rocks and relevant elements
29%	Israel Nahal Zin, Oron	33			3,8-9,1	5-19	47-214	13-46		21-97	3,6-6,2	0-0,5	129-215	328-499	
14%	Senegal (Taiba)	37			1,3-3,1	68-106	118-156	47-52		34-45	6,4-7	0,0	104-115	398-488	
7%	Morocco 4 Minen	33			3,7-14,8	3-41	118-335	10-55		10-78	4-9	0-0,4	71-245	128-476	

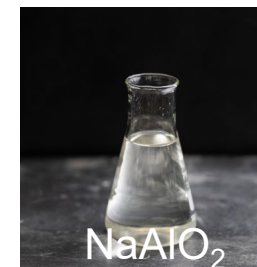
P RECOVERY FROM SEWAGE SLUDGE ASHES FOR FERTILISERS, ...



SUSTAINABLE TO CARE FOR ONLY ONE ELEMENT IN WASTE MATRIX? – DEFINITELY NOT!



- › High P recovery rate (> 80%)
- › High P product purity (>98%)
- › Efficient heavy metal separation (>96%)
- › Commercial co-products (i.e. FeCl₃)
- › Defineable product qualities independent from input ash
- › Real waste reduction (>95%)
- › Industrial symbioses in chemical industry parcs



MARKET SEGMENTS FOR P IN GERMANY

	Fertilisers	Animal feed	Detergents etc.	Food additives	Flame retardants
Market Volume GER [kt P/a]	100	30-40	10	10	6
Purity requirements	increasing towards right				

Nutrient recycling from sewage in EU is discriminated by origin, not by quality!

- Fertilisers are currently the only legal route to recycle P from sewage as a nutrient!
- Sewage based nutrients are excluded by origin from feed no matter of quality
- Sewage based nutrients are banned from food additives, no matter of quality

INTEGRATION – QUALITY RECOVERY AND RECYCLING ALLOWS TO SUSTAIN DOMESTIC PRODUCTION, JOBS, KNOW-HOW AND INCREASES SUPPLY SECURITY BY REDUCING IMPORT DEPENDENCY

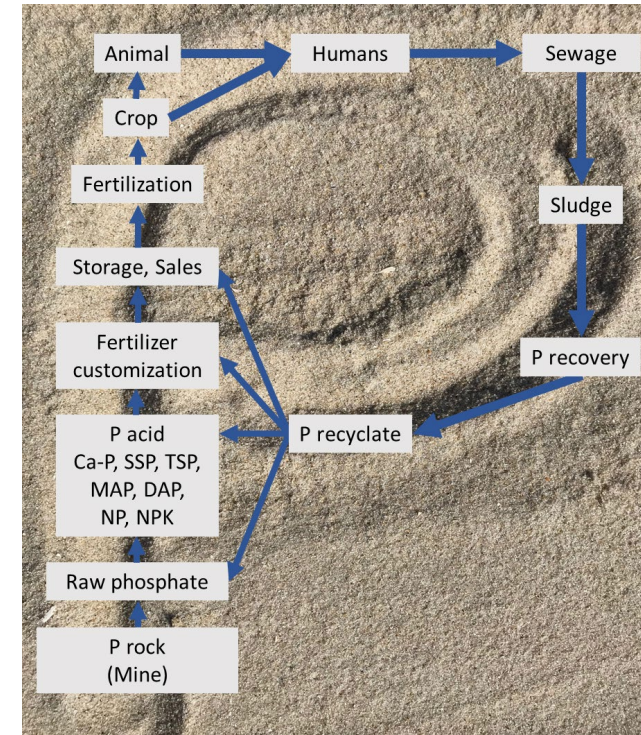
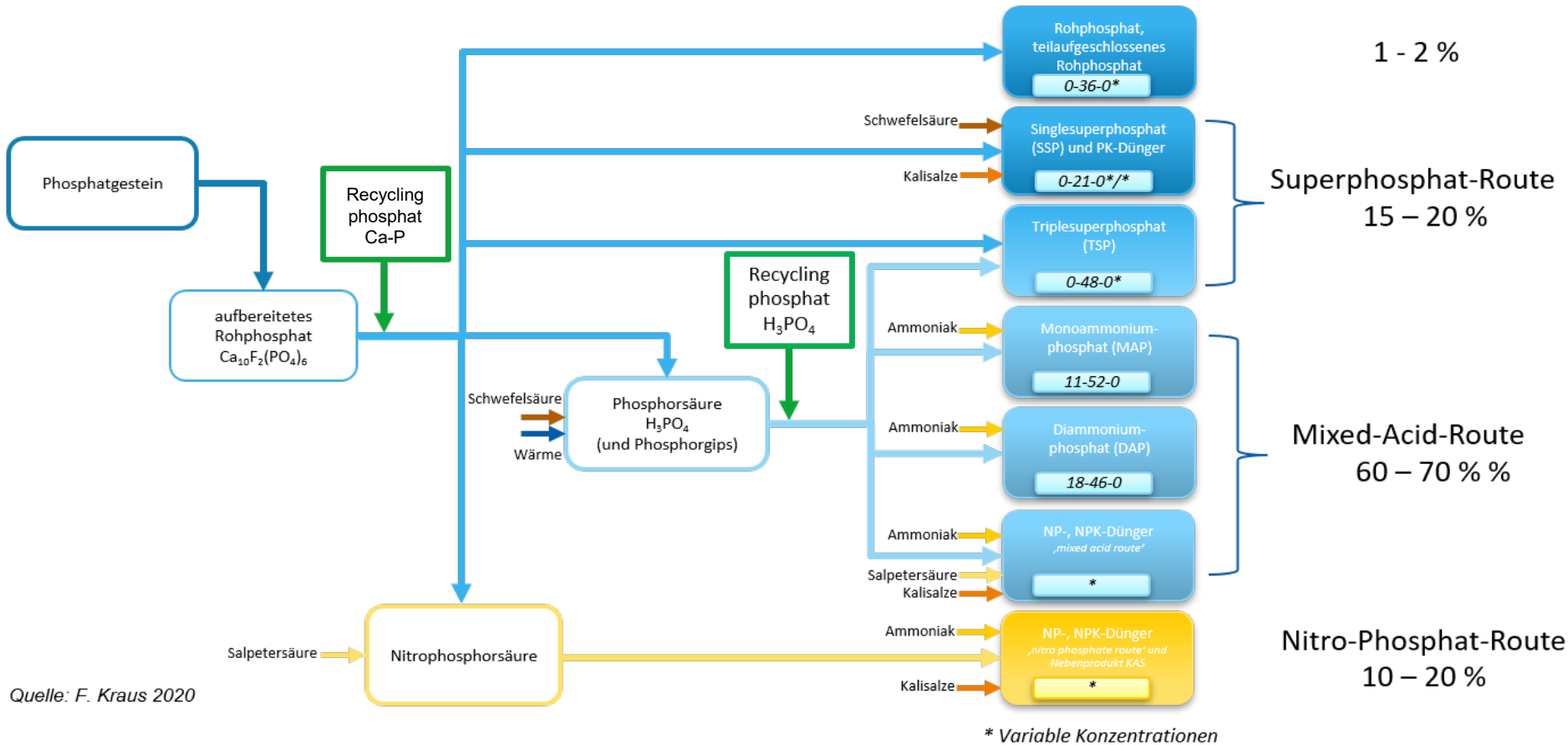
Rohmaterial

Zwischenprodukte

Dünger

Anteil in Deutschland

Closing the loop at several hubs



Quelle: F. Kraus 2020


SUMMARY & OUTLOOK

- We are still stuck in linear mine to dump (mine) scheme (high degree of extraction of (limited) global natural resources)
- Waste logic (getting rid of waste at lowest cost) and high fragmentation (legislation and value chains) are biggest obstacles for transformation
- Need for paradigm shift from waste logic to value driven (economic and societal) resource/product logic
- Market deployment will gear up once relevant volumes become reliably available (no material, no market)
- Centralized P recovery (i.e. from ash) allows market relevant qualities, volumes and reliability!
- The longer we wait, the higher the cost of inaction for society!
- Knowing is not enough, we must apply! Willing is not enough, we must do! (J.W. v. Goethe) Now!!!



 www.easymining.com

 Christian.Kabbe@easymining.com

 +49 (0)30 61647943