Lessons Learned from More Than a Decade of

Full-Scale Struvite Recovery in the Netherlands

A difficult road — but a no-regret measure

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Why phosphorus, why struvite?

The challenge

- Phosphorus is indispensable for global food security
- Mined from finite, geopolitically sensitive sources
- Wastewater is a domestic, renewable P pool

The Dutch commitment

All regional water authorities collaborate in EFGF Sector ambition: recover ≥ 80% of influent P by 2030 (EFGF roadmap)

Struvite is the only

full-scale proven

phosphorus recovery route

1 t struvite

≈ 1 t CO_2 avoided

LCA confirms

CO_2-negative footprint

Replaces mineral fertiliser · Reduces sludge · Negative carbon footprint

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The puzzle: proven technology, underused assets

12 full-scale reactors built · only **~15%** of theoretical capacity used

Hypothesis

Underperformance of Dutch struvite reactors is driven by organisational and operational factors — not by technological limits — and modest interventions can multiply yield with existing assets.

→ What does it take to unlock the installed capacity?

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Approach: national optimisation programme 2021–2023

Amsterdam West	Den Bosch	Tiel	Land van Cuijk
AirPrex	*Anphos*	*Anphos*	*NuReSys*

Audited through (Mirabella Mulder Waste Water Management):

Data analysis · Site inspections · Operator interviews
Parameters: pH, Mg/P ratio, hydraulic loading, solids intrusion, maintenance, product quality

Benchmarks:

WAVES database · Benchmark Zuiveringsbeheer 2021 · additional potential from digested-sludge buffers (e.g. Beverwijk)

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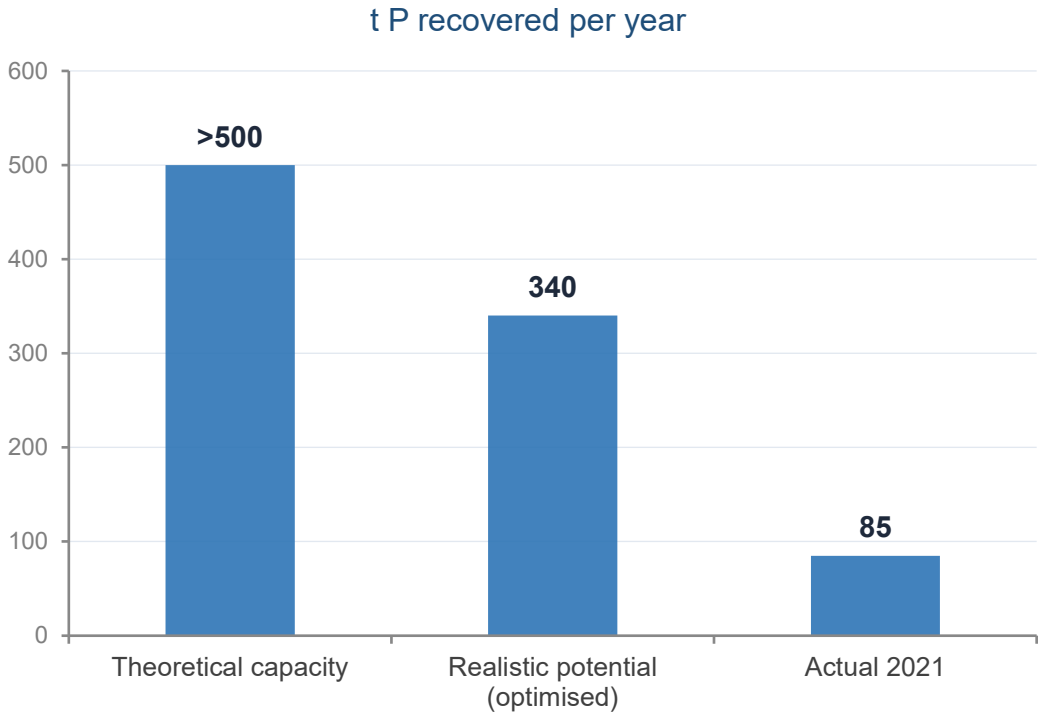
Today: a fraction of what's possible



Key finding

8 of 12

reactors produced struvite in 2021

~15%

of theoretical capacity utilised

Design specs often unrealistic under full-scale conditions

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The barriers are organisational, not technological

1

Mg/P dosing & pH control

High ratio (>1.5–3.0) and pH > 8 → over-supersaturation, fines wash-out, scaling.
Low ratio (<0.9) and pH ≈ 7.0 → incomplete precipitation.

2

Preventive cleaning & sensor maintenance

Insufficient routine maintenance leads to clogging, sensor drift and avoidable downtime.

3

Operator time & ownership

Typically < 0.1 FTE on the reactors.
Optimal performance needs ≈ 0.5 FTE operator + 0.3 FTE technologist.

Hit the operating window — triple the yield

The operating window

Mg/P ratio

1.1 – 1.5

pH

7.5 – 7.8

Maintenance: scheduled twice per year

Plus: SCADA integration · cyclones · national operator training

3–4×

yield uplift on existing assets

≈ 340 t P/yr

realistic recovery (≈ 3 400 t struvite)

> 15 000 t

sludge avoided per year

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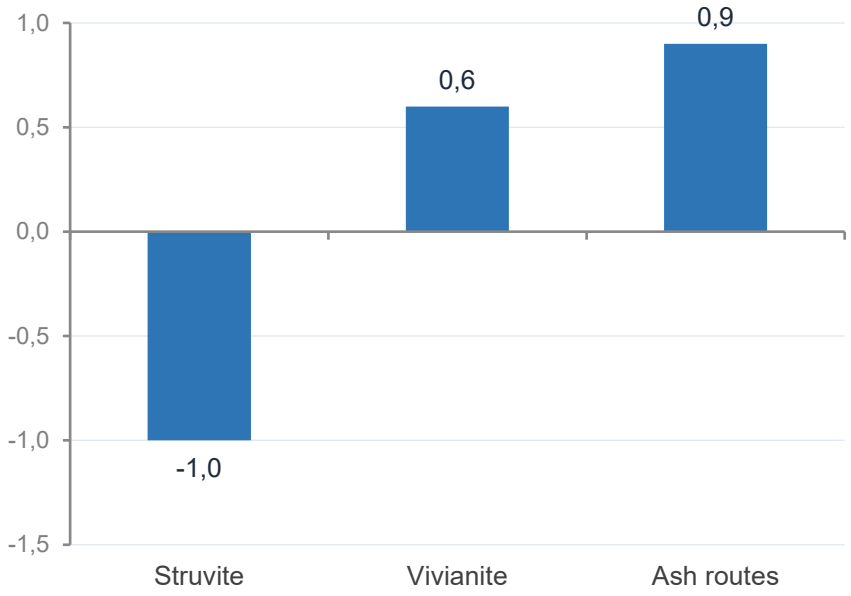
Climate-positive — and complementary, not competitive

LCA carbon footprint (STOWA 2023)



STOWA 2023: struvite −0.3 to −1.4 kg CO_2-eq./kg struvite; vivianite & ash routes indicative

A bridge, not a detour

- Struvite captures the easily recoverable P
- ≈ 15–20% of influent P recovered before incineration
- Does not undermine ash-route economics (negligible effect on ash P content)
- Available today — ash recycling at scale expected after 2030

→ The two routes work in parallel

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Confidence on the market side

Established

End-of-waste status

Dutch struvite recognised as a secondary raw material — a true product, not a waste.

via AquaMinerals

Stable offtake

Connecting producers and users — ensuring the right quantity and quality at the right time.

Next step

EU opportunity

A coordinated approach at EU level would accelerate circular phosphorus use and strengthen market confidence.

Demand is in place — the bottleneck is reliable supply.

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Take-home: a no-regret first step

No-regret measure

Every tonne of struvite recovered delivers CO_2 reduction and fertiliser substitution. Not recovering it increases emissions and cost.

Complementary, not competitive

Struvite recovery and ash recycling together maximise total P recovery and resilience of the national strategy.

Barriers are solvable

Under-performance stems from governance — targets, time, and training — rather than from technology.

Translate ambition into operational parameters

With active management commitment and the right Mg/P · pH · maintenance, production triples on existing assets.

Struvite is not the final step — but it is the essential first one no water authority will regret.

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Thank you

Questions & discussion

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