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Primary Sludge Fermentation – A Natural Step Towards Chemical-Free Phosphorus Removal

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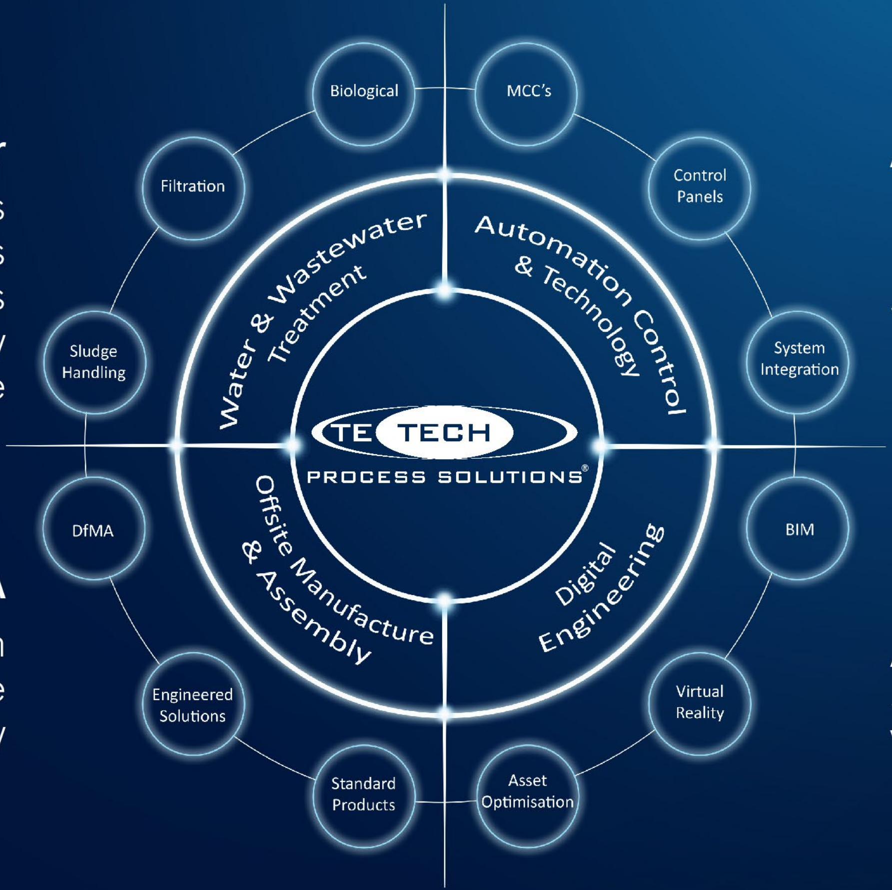

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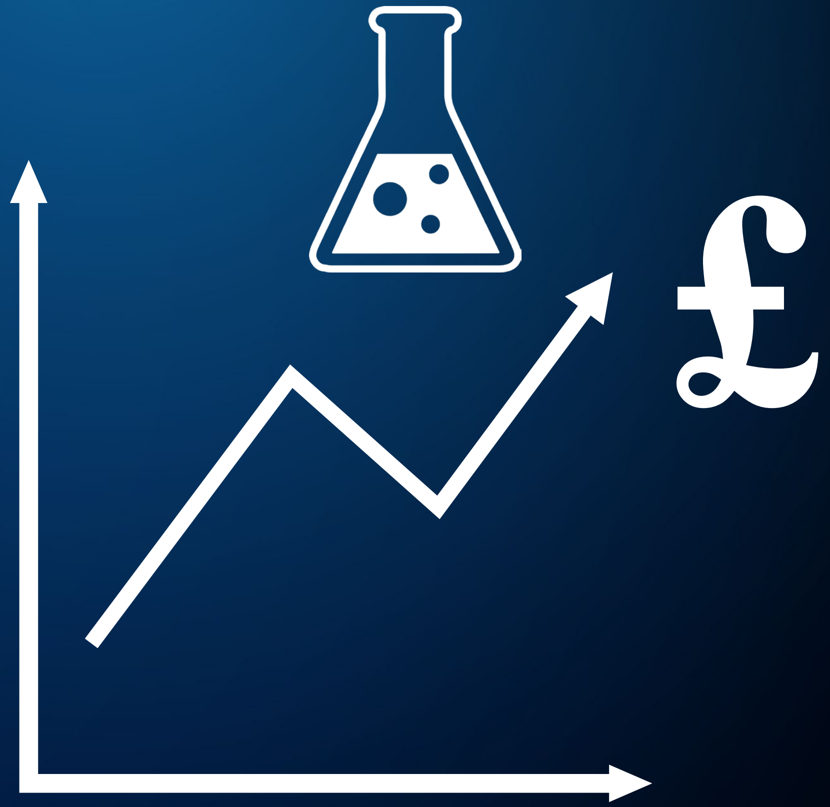
Context – what's the problem?

Increase in phosphorus removal schemes – both new and tightening P consents:

→ Increase in chemical usage with demand expected to outweigh supply.

→ Increase in OPEX.

→ Biological phosphorus removal is an option, but the applicability of this largely depends on the nature of the incoming wastewater.



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Context – what's the solution?

Primary Sludge Fermentation (PSF) is a means of enabling Enhanced Bio-P Removal (EBPR) on sites where this could not occur naturally:

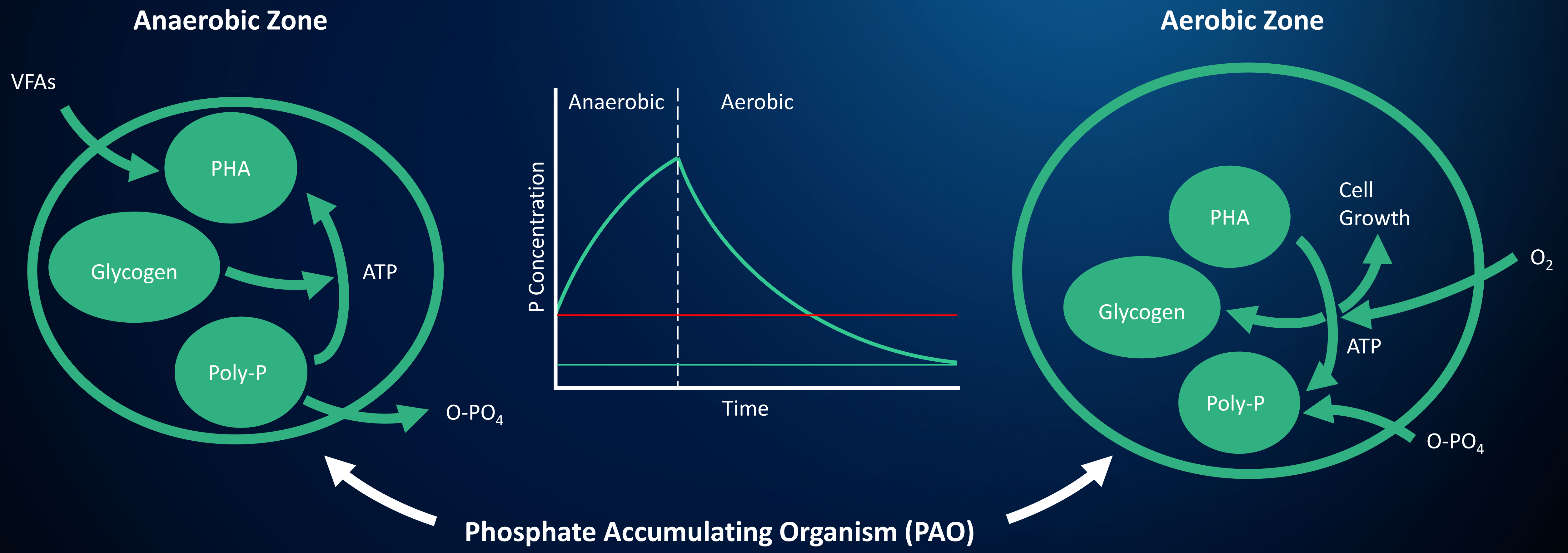
→ Reduced chemical usage – more sustainable solution.

→ Reduced sludge production.

→ Reduced OPEX.

→ Potentially remove need for chemical dosing altogether.

Enhanced Biological Phosphorus Removal Principle



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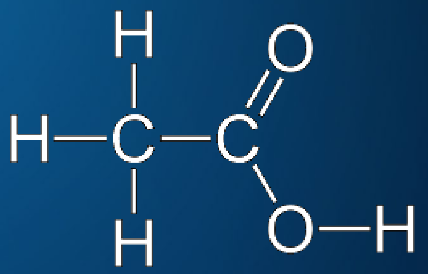
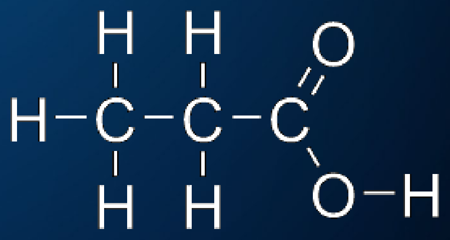
Volatile Fatty Acids

Readily Biodegradable COD (Soluble) → Volatile Fatty Acids

→ Acetic Acid



→ Propionic Acid



→ C4 – C6

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Sources of VFAs

VFA Source	Pros	Cons
Naturally Occurring in Sewage Influent	Free source of VFAs	VFA concentrations can vary wildly from site to site, limiting EBPR on some sites. Also difficult to assess at feasibility stage whether or not EBPR will be possible on greenfield sites.
External Carbon Dosing	Reliable source of VFAs for consistent EBPR performance	All issues generally associated with chemical dosing: increase in OPEX; increase in tanker deliveries; increase in H&S risks
Primary Sludge Fermentation	EBPR performance vastly improved without the need for external carbon dosing	Careful control is required to ensure that fermenters can react to the variable primary sludge characteristics. Without this, the EBPR performance is unreliable.

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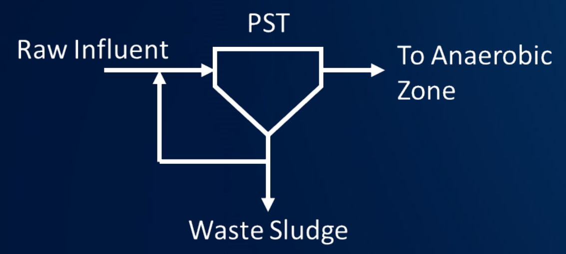
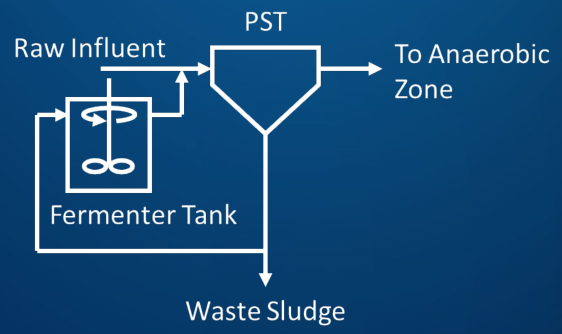
Conventional Primary Sludge Fermentation Designs

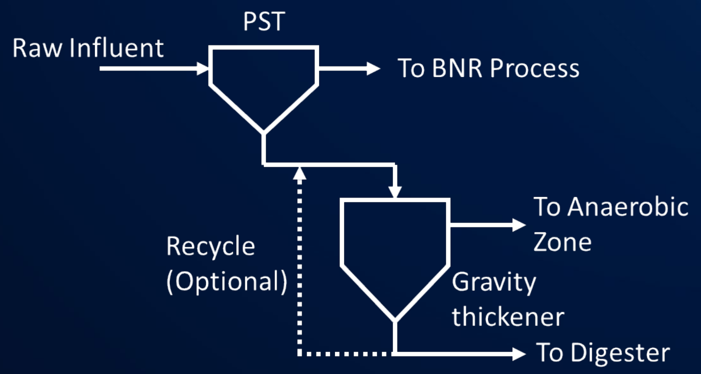
Primary Sedimentation Deep Tank Sludge Blanket Fermenter



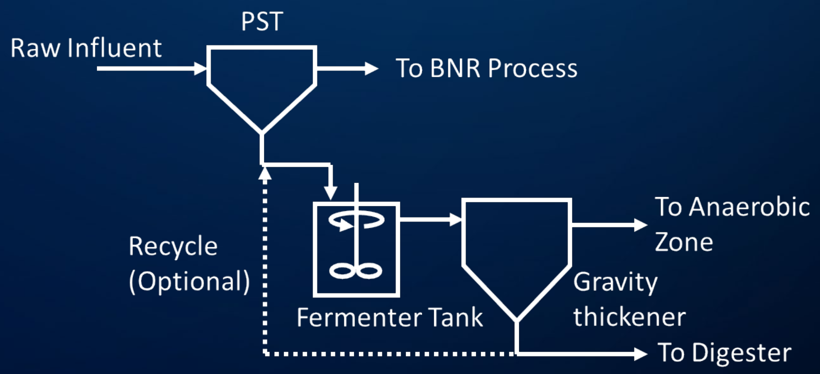
Mixed Fermenter Tank/Primary Sedimentation



Gravity Thickener Fermenter



Mixed Fermenter Tank/Gravity Thickener



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Package PSF Design

Production of VFAs by Fermentation

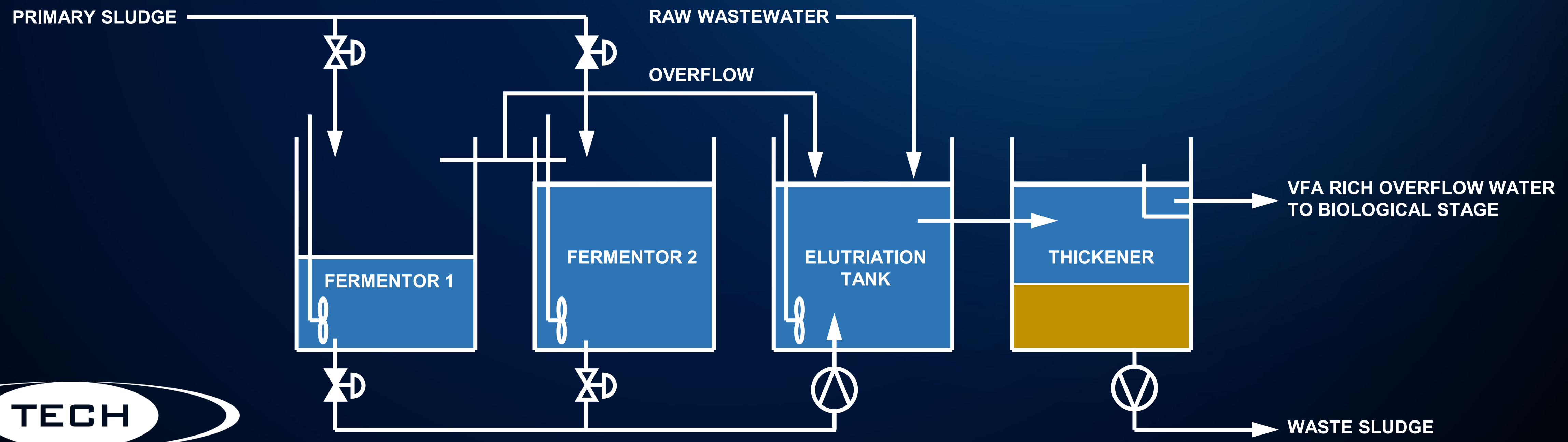
Always 2 fermenters operating in alternating batch cycles with phases out of sync. When 1 tank is filling, the other is fermenting.

Elutriation of VFA

Fermented sludge is mixed with raw wastewater in the elutriation tank for enhanced washout of the VFAs and pH regulation.

Sludge Separation / Thickening

The primary sludge and wastewater mix is then separated in a static thickener. The sludge is sent to sludge treatment, and supernatant is sent as overflow to the biological treatment stage.



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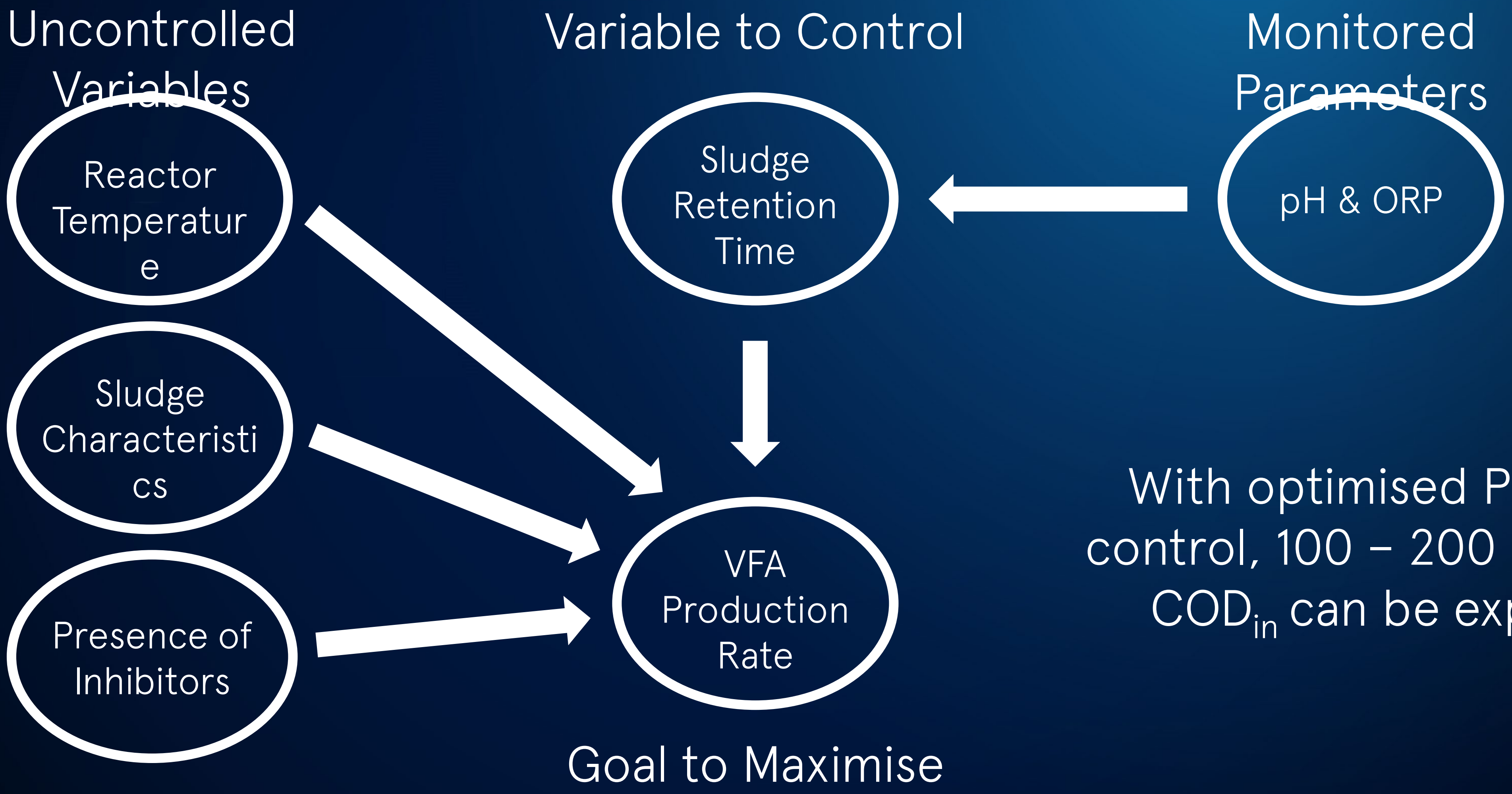
PSF Plant Control



With optimised PSF plant control, 100 – 200 g VFA / kg COD_{in} can be expected

Additional Considerations

Other than improved EBPR, Primary Sludge Fermentation also has the following effects on the downstream activated sludge process:

1. Reduction in excess sludge production

   → Reduced sludge disposal and treatment costs,

   → ...but reduction in biogas production on sites with anaerobic digestion

2. Improved denitrification due to improved rbCOD:N ratio

   → Lower activated sludge tank volumes required for new plants or for existing plants, treatment capacity is increased.

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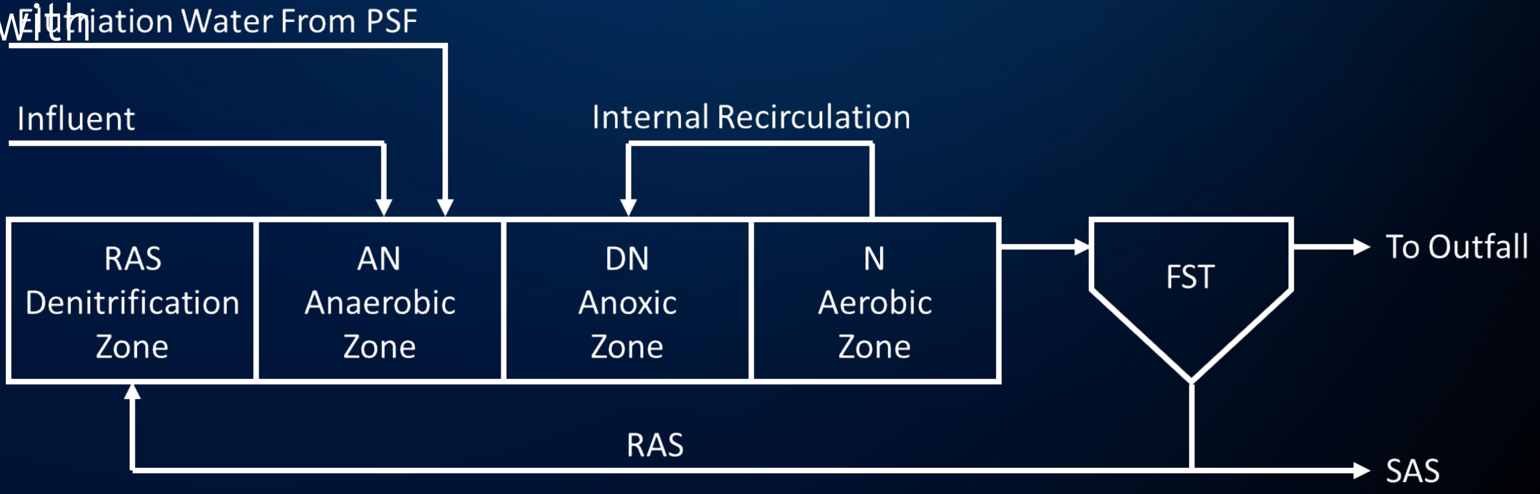
Influence of PSF on ASP Sizing – Case Study

Assumptions:

- Plant capacity: 100,000 PE
- Wastewater temperature: 12°C
- Total nitrogen removal: 70%
- Effluent T-P required: 1mg/l
- Aerobic Sludge age: 8 days
- PSF Plant VFA production: 140 g/kg COD
- ASP process type: Johannesburg with return sludge denitrification

Parameter	Unit	Raw Wastewater	PST Effluent without PSF	PST Effluent with PSF
Average Daily Flow	m^3/d	20,000	20,000	20,000
COD	mg/l	600	360	450
TN	mg/l	55	50	51
TP	mg/l	10	9	9.5



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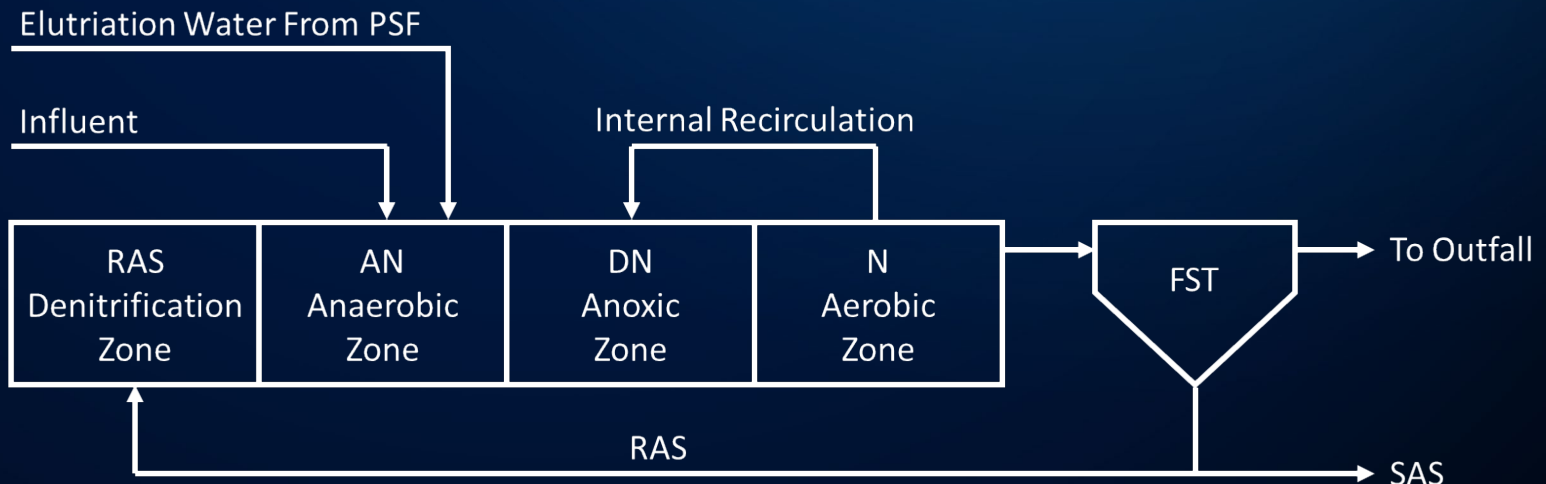
Influence of PSF on ASP Sizing – Case Study

Parameter	Unit	Without PSF	With PSF
Anoxic + Aerobic Zone Volume (V_{N+DN})	m^3	16,900	15,800
Denitrification Zone Volume (V_{RAS})	m^3	2,300	1,800
Anaerobic Zone Volume (V_{AN})	m^3	2,000	2,000
Total Volume (V_{TOT})	m^3	21,200	19,600
V_{DN} / $V_{N + DN}$	-	0.54	0.35
Total Sludge Production	TDS/y	2,190	2,059
Effluent Phosphate	mg/l	4.7	2.4
Additional Ferric required for 1mg/l T-P	t/y	529	200

8% Reduction in total volume

6% Reduction in sludge production

62% Reduction in chemical usage



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Influence of PSF on ASP Sizing – Case Study

Parameter	Assumed Unit Price	Cost Difference with PSF	Unit
Chemical Precipitant Costs	117.5 £/te	-0.39	£/PE/y
Sludge Treatment and Disposal Costs	289 £/TDS	-0.38	£/PE/y
Energy Usage Costs*	17.4 p/kWh	+0.51	£/PE/y
Total Costs		**-0.26**	**£/PE/y**

* Includes additional energy for PSF plant mixers, additional aeration required for ASP, and less energy required from biogas plant

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Next steps

1. Finalise package PSF plant design with full TOTEX assessment

2. Run pilot trials on live treatment works to obtain real-world data

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Summary

Primary sludge fermentation has the potential to significantly enhance EBPR and is a step in the right direction towards chemical free phosphorus removal.

Thank you for listening – any questions?

Contact us

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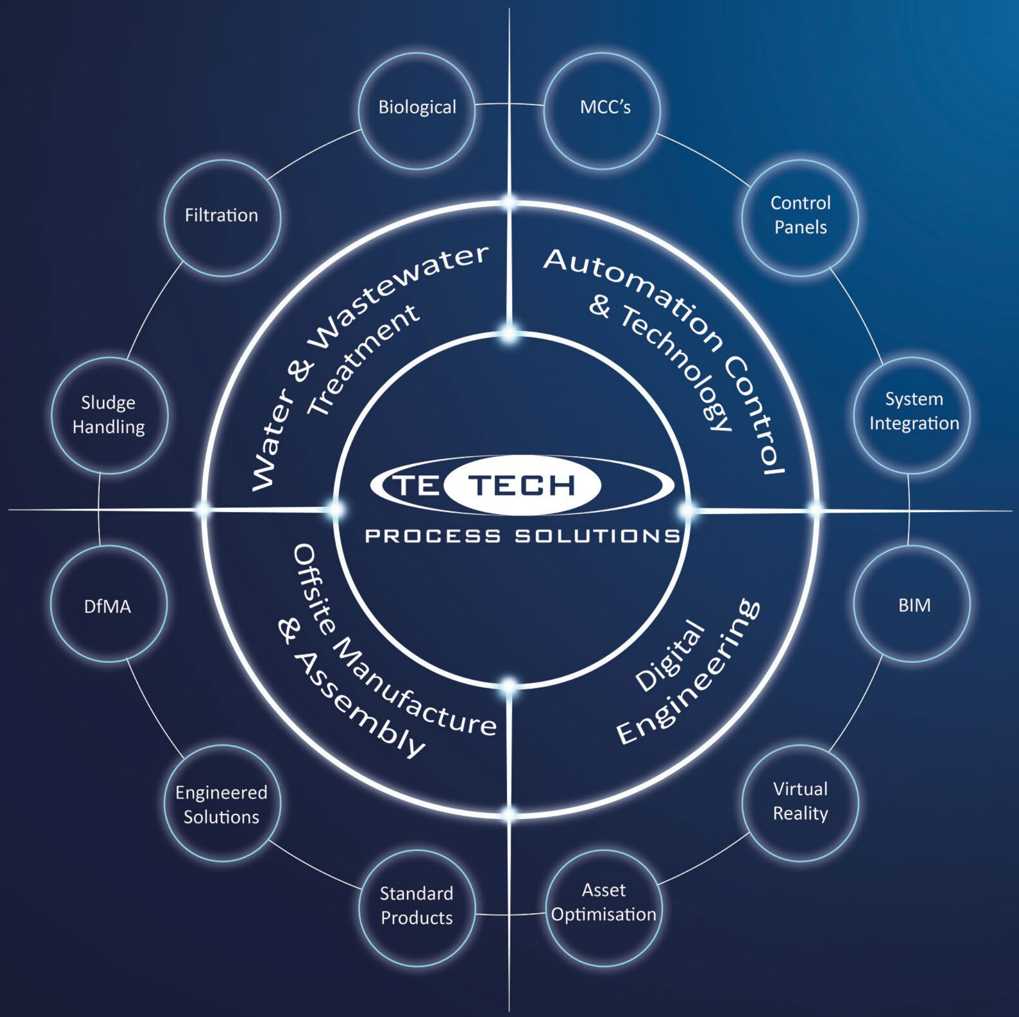

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