NUTRIENT RECOVERY FROM SMALL WASTEWATER TREATMENT PLANTS

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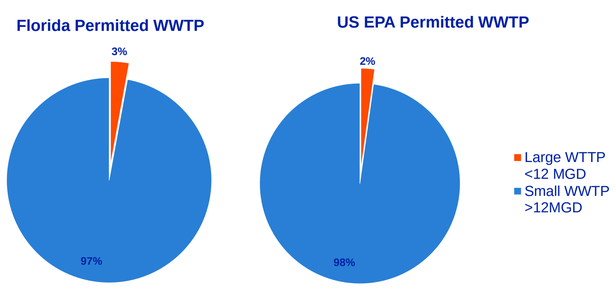
Problem

Global demand for phosphorus (P), a finite resource derived from phosphate rock (P_2O_5), is estimated at 40 million tons per year, and is increasing by 1.5% annually. An estimated 7 billion tons of P_2O_5 remain in reserves that can be economically mined but are expected to be exhausted within this century[1]. A sustainable source of phosphorus is essential to feed the world's growing population.

Project Overview

- Municipal wastewater treatment plants (WWTPs) may be an attractive source of renewable phosphorus (P).
- The mineral struvite ($MgNH_4PO_4 \cdot 6H_2O$) is thermodynamically favorable to form in some wastewater streams.
- Struvite may be used as a renewable P fertilizer.
- Spontaneous struvite precipitation in WWTPs was documented as early as 1937[2].
- Control of struvite as a nuisance product has been studied since the 1970's.
- Struvite precipitation as a means for nutrient removal from wastewater streams began in the 1990s.
- Struvite precipitation for P recovery has focused on large WWTPs, using digestate from anaerobic biosolids digestion.
- Approximately 97 to 98% of state and nationally permitted WWTPs are small, aerobic systems, with discharges less than 12 MGD[3].
- On the national scale, the total combined discharge of small WWTPs can theoretically produce nearly 1,000 MT of struvite per day.

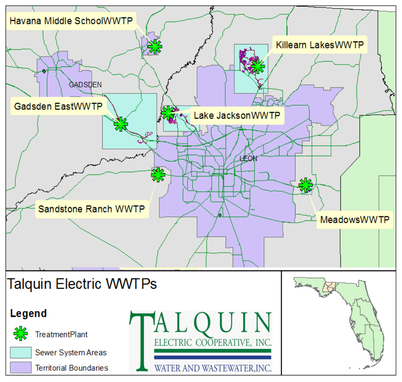


- Small WWTPs have the same permit limits for nutrients as do large WWTPs and they must achieve these nutrient reductions without the benefit of revenue from large customer bases or economies of scale. Struvite production at small WWTPs may provide an economic benefit while assisting to meet future permit regulations and fertilizer P demands.

Hypothesis

Struvite recovery from small, aerobic WWTPs can provide a economic and environmentally sustainable option for addressing global phosphorus deficits.

Study Location

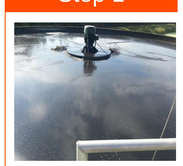


Talquin Electric Cooperative, Inc. is a member-owned, not-for-profit electric distribution cooperative utility headquartered in Quincy, Florida with a four-county service area comprised of Gadsden, Wakulla, Liberty, and Leon Counties. TEC has six separately permitted WWTPs that serve approximately 4,500 TEC member accounts with a population of approximately 11,000. Four locations were selected for the study as they represent two of the three most common variations of the activated sludge process[6]. All the locations use aerobic digestion of biosolids.

WWTP	Killearn Lakes	Lake Jackson	Gadsden East	Meadows
County	Leon	Leon	Gadsden	Leon
Population Served	5,581	2,672	81	494
Plant Capacity (mgd)	0.700	0.500	0.250	0.098
Capacity Used	67.8%	45.4%	40.6%	32.8%
Plant Type	Complete Mix Activated Sludge	Activated Sludge Sequencing Batch reactor		

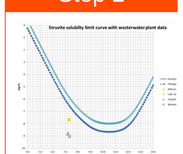
Procedure

Step 1



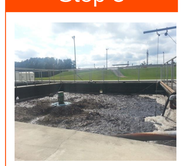
Analyze aerobically digested sludge from study locations

Step 2



Model struvite formation

Step 3



Optimize operational methods to increase struvite formation

Step 4

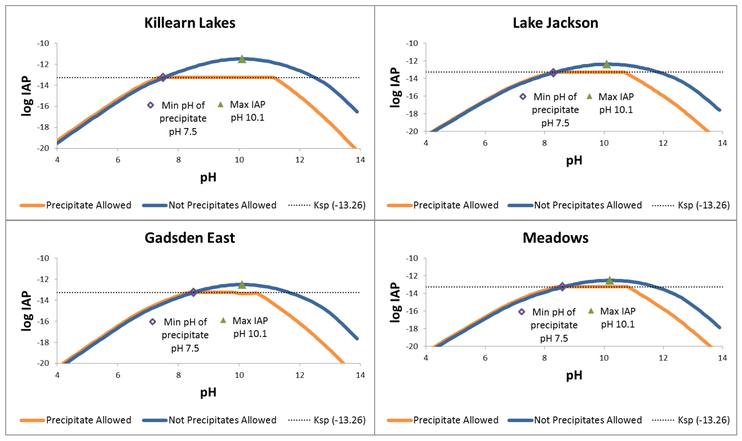
Determine economic and environmental impact

Data / Observations

Aerobic digestates were analyzed for chemical properties affecting struvite formation.

WWTP	pH	mmol/L						log(Ps)
		TP	Ortho P	TN	NH_4	Mg	Ca	
Killearn Lakes	7.3	2.06	1.56	33.8	9.08	1.47	0.73	-7.68
Lake Jackson	7.24	0.52	0.38	20.9	4.95	0.91	1.27	-8.77
Gadsden East	7.2	0.75	0.24	18.7	4.22	1.49	1.13	-8.82
Meadows	7.35	0.67	0.28	11.2	9.48	0.35	1.05	-9.03

Using Visual MINTEQ 3.1, the activities of Mg_2^+, NH_4^+, PO_4^{3-} were calculated. The Ksp used was 13.26[7]. Ion Activity Products (IAPs) were calculated varying the pH from 4.0 to 14. First , in MINTEQ, precipitates allowed to determine the minimum pH struvite would form. Then precipitates were not allowed to find the level of supesaturation attainable. IAP values exceeding the Ksp predicted the pH ranges where struvite will form.



Conclusions

- Initial analysis of the aerobic digestates from 4 different WWTPs indicate that concentrations of Mg_2^+, NH_4^+, PO_4^{3-} are adequate for struvite formation.
- The next step will be to form struvite using the actual aerobic digestates from 4 different WWTPs.

Works Cited

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