CONTROLLED PHOSPHATE REMOVAL IN BNR PLANTS – PRODUCING A SELLABLE FERTILISER

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ABSTRACT

Treatment plants with enhanced biological phosphorous removal provide a stable, high quality effluent for safe environmental discharge. Some downsides of this process include high phosphorous levels in recycle loads post digestion, reduced dewaterability of biosolids and the formation of struvite, which causes mechanical issues within pipework, pumps and sludge treatment systems.

It is possible to precipitate the struvite under a controlled reaction using a magnesium based chemical, and to produce struvite as a by-product, that can be sold as an enriched fertilizer. Furthermore, there is a reduction in phosphorous within recycle loads by 80% and an increase of 2 – 4% dry solids in dewatered biosolids. The removal of phosphate from the biosolids results in a drier cake with less polymer demand.

This paper discusses a process for controlled phosphate removal, and the benefits of applying this technology at a full scale installation in Germany. Savings in operational costs due to the process are presented.

1.0 INTRODUCTION

The drive for enhanced nutrient removal in wastewater treatment plants has led to the extension of biological treatment plants, to include process steps to removal nitrogen and phosphorous. These additional steps allows the treatment plants to produce a high grade effluent, that when discharged to the environment pose minimum dispution to background nutrient loads, and thus managing eutrophication within river and similar water bodies.

In the case of phosphorous, this nutrient is stored within the activated sludge and removed from the process within the biosolid stream. Under anaerobic conditions, phosphates are released to the liquid phase. This release results in the recycling of phosphorous and also causes the precipitation of struvite within pipelines and mechanical equipment associated with mechanical sludge dewatering.

The phosphates also reduce the dewaterability of the sludge, as the water retaining capability is increased in the aerobic sludge phase.

Utilisation of the phosphates is becoming a global concern, as stocks of phoshpate minerals are depleting, and new alternative sources, including recovery, are becoming a sustainable alternative.

2.0 DISCUSSION

The formation of struvite in digested sludge is a chemical process. Struvite is magnesium ammomium phoshate, and is approximately 38% phosphate, therefore making it a rich source of phosphorous when considering its use as a fertiliser. Struvite leads to a number of maintenance issues within a sewage treatment plant, typically in the pipework and pumping systems associated with sludge dewatering.

Removal of this compound is costly, and can cause significant damage to pump internals.

Figure 1: ***Struvite Formation in Pipework***

The presence of phosphates in sludge also reduces the dewaterability of the sludge, as shown in the chart below.

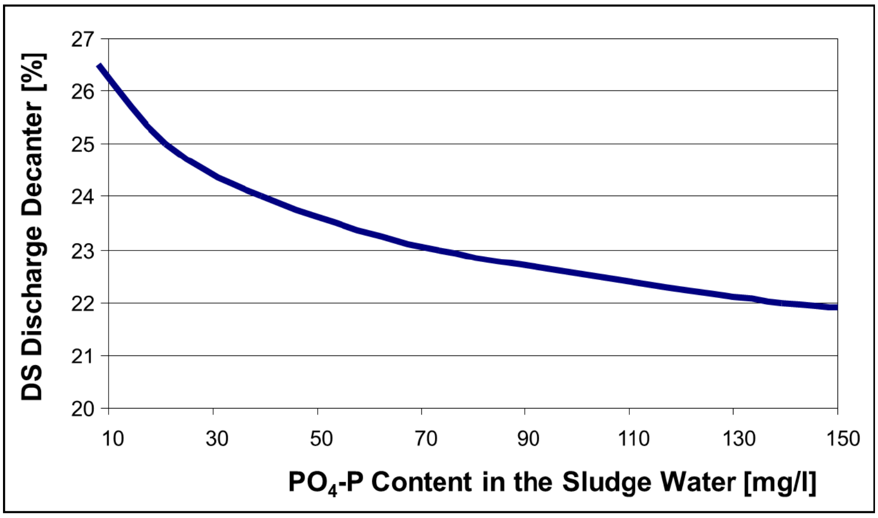

Figure 2: ***Relationship Between Cake Solids and Phosphate Levels***

2.1 Struvite Removal Processes

A number of processes are available on the market that remove struvite via various methods. In general, the systems produce a final struvite product that can be sold as a fertiliser, and the return phosphate load to the head of the biological process is reduced.

In general these processes rely on the controlled removal of struvite.

2.2 AirPrex Reactor Configuration

The AirPrex system consists of one or several reactors, that is fitted with aeration sparges. A magnesium based compound, such as magnesium chloride, is dosed into the reactor. The air flow to the sparges is controlled via the pH in the reactors. This controls the precipitation of struvite, and the residence time in the reactor is such that the struvite crystals grow.

The crystals are then removed from the process using a solids classifier.

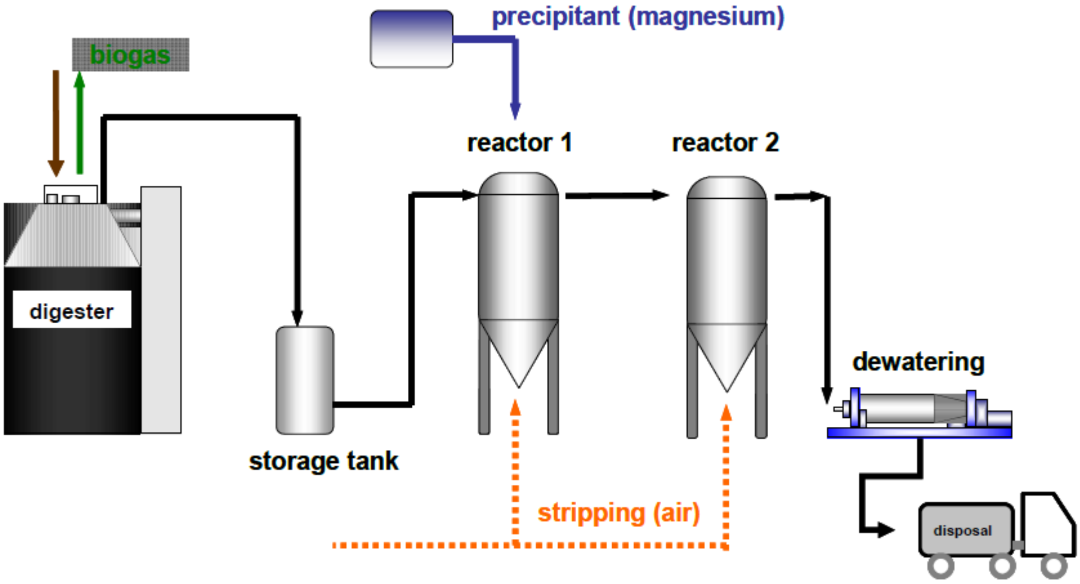

Figure 3: *The AirPrex Process*

2.3 Plant Operating Data

Full scale operating plants using the AirPrex process have been in operation for over five years. There are a total of 6 operating sites in Europe with a further 6 under construction.

The following table highlights some of the installations:

Table 1: *AirPrex System – Sample Installations*

Plant	Capacity	Location	Year
Moenchengladbach STP	360 ML/d	Germany	2009
Wassmandorf STP	430 ML/d	Germany	2010
Echten STP	70 ML/d	Netherlands	2011
Amsterdam West STP	360 ML/d	Netherlands	2013

The technology can be applied to any size of treatment plant, from 10 through to 1000 ML/d. The return on investment is generally more attractive beyond 5 ML/d.

Data outlining the struvite production rates are summarised below, again sludge load and reactor size.

Table 2: *Struvite Production Rates*

Plant	Sludge Load (m^3/d)	Struvite Production (t/y)	Reactor Size (m^3)
Moenchengladbach STP	1500	900	910
Wassmandorf STP	2000	700	800
Echten STP	600	150	205
Amsterdam West STP	2400	1100	1100

2.4 Observations from Operating Sites

Analysis of the operating costs shows that the bulk of the cost savings is associated with the higher cake solids generated in the dewatering system, between 3 and 4% Dry Solids. There is also a benefit in reduced polymer demand in the dewatering process by approximately 20%. The return P-levels in recycle lines was reduced by 80%.

Typical return on investment has been demonstrated to be between three and five years, depending on the plant size. A chart summarising the split in OPEX is shown below in figure 4.

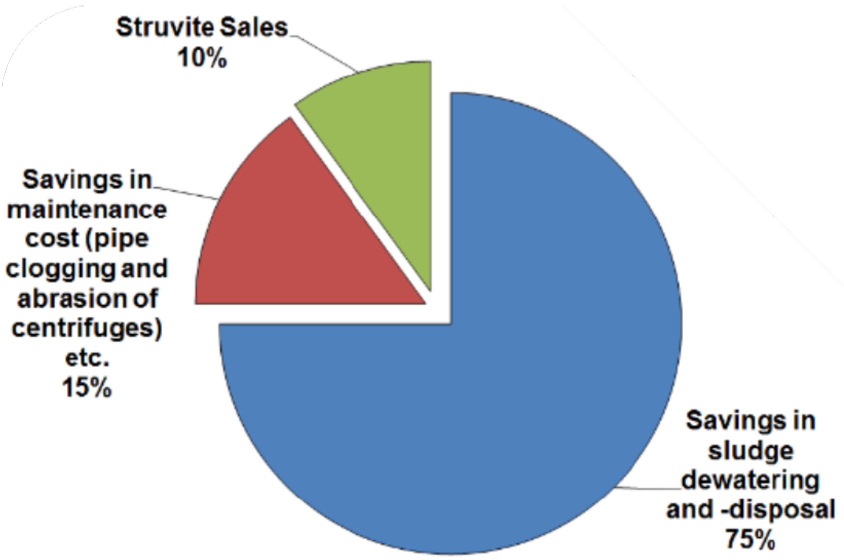

Figure 4: ***OPEX Savings due to the process***

2.5 Selling the Fertiliser

The operating sites in Europe all sell their struvite to local groups, mainly farmers. The sell price ranges from A$80 to A$120 per ton. Chemical analysis has shown that the struvute is suitable for fertiliser use under EU regulations.

Recovery of struvite has provided the water authorities a positive footprint within the local community, and some of the authorities market the product under their own brandname.

Figure 5: ***Fertisliser Marketed by Berlin Water***

3.0 CONCLUSION

Biological phoshorous removal provides a cost effective means for the removal of phosphorous from sewage. When activated sludge from such a plant is anaerobically digested, the release of phosphates in the water phase leads to the uncontrolled formation of struvite, that leads to a number of maintenance issues and the return of a high phosphate load to the head of the biological reactors.

The controlled removal of phoshorous from the digested sludge provides a number of operational advantages, including:

- Removal of struvite, leading to reductions in mainteance costs
- Formation of a sellable fertiliser
- Increased cake solids by 4%DS, leading to significant savings
- 80% reduction phosphate loads in return lines to the biological process
- 20% reduction in polymer demand in the sludge dewatering plant

The fertiliser can be sold to local farming groups and is a rich source of phosphate. Should the biolsolids be reused, then the struvite formation step can be removed, and the process still yields a drier cake and reductions in OPEX associated with less solids disposals.

Full scale references in Europe have demonstrated the potential of this process, and confirmed the OPEX benefit and return on investment.

4.0 REFERENCES

Ewert. *Controlled Phosphate Precipitation – Significant Optimisation Potential in Enchanced Biological Phoshorous Removal*

Bogner. *MAP Recovery Process*