XCELBIO IMPROVES AMMONIA REMOVAL

Abstract

Ammonia removal is an important aspect of biological nutrient removal in wastewater treatment processes. However, due to process constraints, inhibiting compounds or more stringent discharge standards the ammonia removal rate can be insufficient.

Subsequently, there is an increased need to optimize the functioning of existing treatment facilities.

Addition of Xcelbio to wastewater systems has been shown to increase ammonia removal. The impacts are increased oxygen utilization and higher microbial metabolic rates, which increase ammonia removal.

Study Objectives

This study has three objectives:

1. Briefly present the Xcelbio definition of increasing ammonia removal and the criteria we use to define successful treatment.
2. Review application experiences.
3. Examine the scientific basis for Xcelbio success in increasing ammonia removal.

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Increasing Ammonia Removal

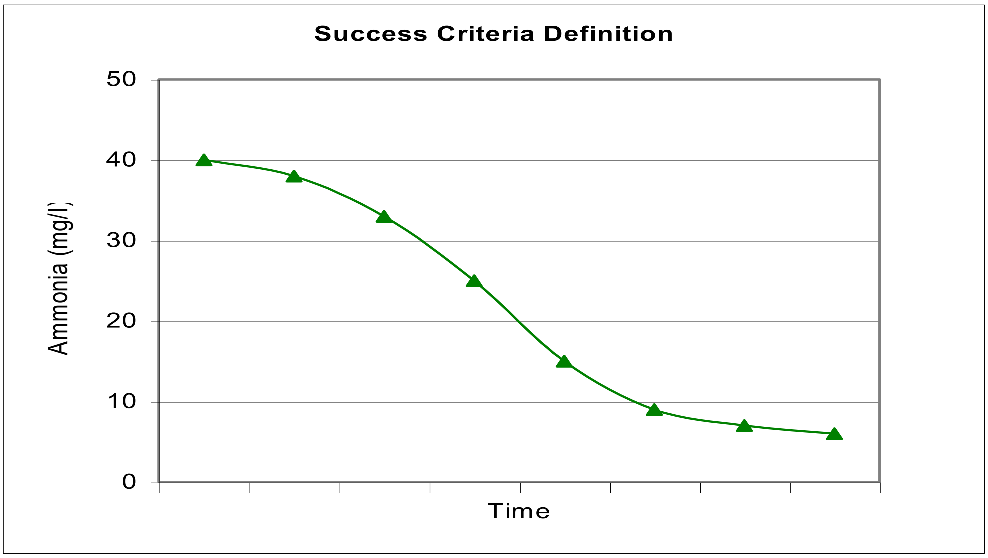
Ammonia is an essential nutrient and is consumed by organisms for the synthesis of new biomass. However, the main removal mechanism for ammonia removal is nitrification.

Nitrifier bacteria convert the excess ammonia to nitrate under oxygen sufficient conditions. When oxygen becomes limiting or residence time is too short they cannot survive and wash out of the system.

In order to overcome these constraints process modifications are typically required. Alternatively, the microbial population metabolism can be accelerated that effects ammonia removal.

Xcelbio defines the success in increasing ammonia removal as:

“The ability to continue efficiently improve ammonia removal. This is measured by graphing the actual data when Xcelbio is present compared to the historical data.”



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The addition of Xcelbio allows a wastewater treatment process to improve nutrient removal and simultaneously reducing sludge production while under overloaded conditions.

Because Xcelbio enhance the metabolism of the total biomass in waste treatment, it aligns itself to most processes.

Practical Application Experience

Xcelbio has practical experience in a variety of applications. The following data demonstrates full scale plant experiences where the addition of Xcelbio increased ammonia removal.

The following table presents data from overloaded domestic sewage treatment plants that were unable to reduce the ammonia concentration to discharge standards before Xcelbio treatment. The range of processes is oxidation pond to trickling filter to activated sludge.

Increasing Ammonia Removal

Parameter	Unit	Acceptable Range	Oxidation Pond	Trickling Filter	Activated Sludge
Capacity Analysis					
Designed Capacity	m^3/d		900	800	3,300
Actual Daily Flow	m^3/d		2,700	1,700	5,624
% Capacity	**%**		**300%**	**213%**	**170%**
Raw Sewage Concentration					
COD	mg/L		450	436	1,270
Ammonia	mg/L		21	23	45
Organic Loading					
Oxidation Pond	kg/ha/d		744		
Trickling Filter	$g/m^3/d$			945	
Activated Sludge	kg COD/kgMLSS/d				0.164
Effluent Quality (with Archaea bio-system treatment)					
COD	mg/L	50-100	42.6	36.4	44.8
Ammonia	mg/L	5-15	4.7	14.0	1.3
Nitrate	mg/L	20-25	0.2	0.3	0.0
Suspended Solids	mg/L	20-30	13.6	24.0	7.9

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All of these domestic sewage plants were operating beyond their design capacity (from 170% to 300%). In each case, the addition of Xcelbio resulted in a reduction of ammonia concentration to within specifications (see table effluent quality).

OXIDATION POND

An oxidation pond system treating poultry abattoir effluent was supplemented with Xcelbio.

The system comprises of 2 anaerobic ponds in series followed by 3 facultative lagoons in series for a total residence time of 30 days. The average raw effluent concentration is tabled as follows:

Compound	Raw Effluent (mg/l)
Chemical oxygen demand (COD)	4360
Total Kjeldahl Nitrogen (TKN)	468

Due to the blood content in the effluent the ammonia concentration is exceptionally high.

As can be seen from the graph on the following page the ammonia concentration dropped over time with over 95% being removed.

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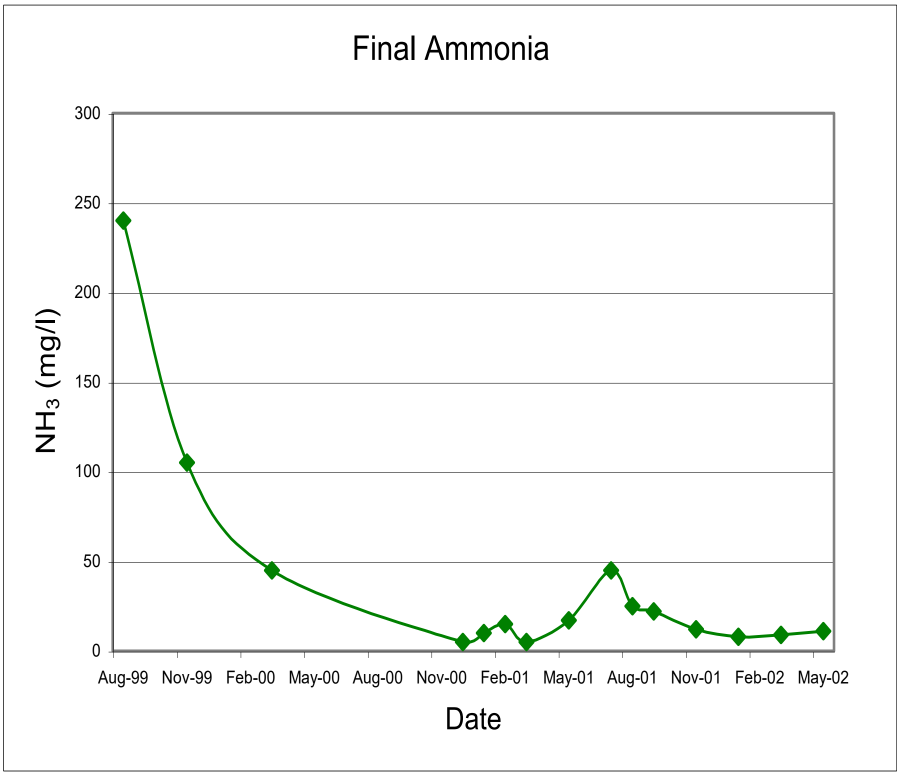

These results are significant considering that the TKN loading on the lagoon is extremely high.

Trickling Filter

Simultaneous carbon removal and nitrification on a single trickling filter is governed by the organic loading. When the organic loading increases oxygen becomes limited. This causes nitrification to decrease as the organic loading increases.

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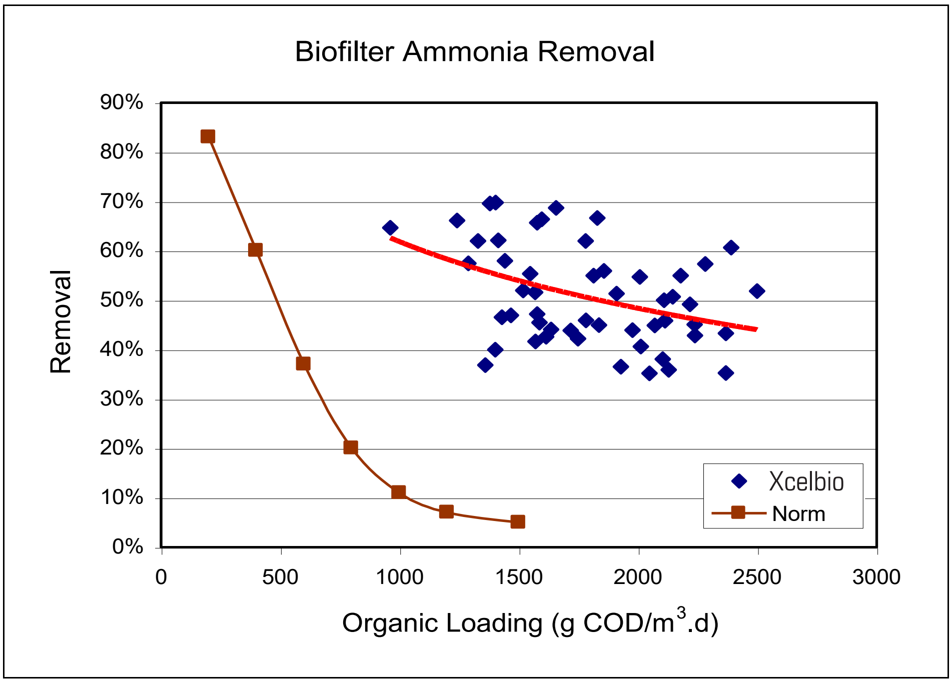
The following graph demonstrates the ammonia removal efficiency in an organically overloaded trickling filter plant.



Typically, the ammonia removal drops dramatically with an increase in organic loading (see squares). With Xcelbio, however, the ammonia removal is very consistent over a wide range of organic loadings.

Based on the organic loading the removal efficiency was increased by 500%.

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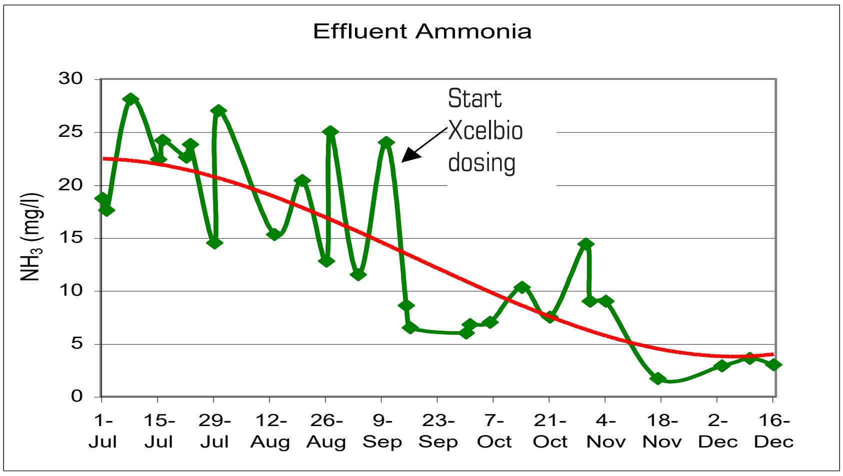
Under overloaded conditions nitrification often suffers. This plant receives mainly domestic sewage with some industrial effluent. Due to sludge disposal difficulty there was a build up of to 10,000 mg/l biomass in the aeration basin.

This caused the aeration capabilities to be exceeded with dissolved oxygen concentrations in the basin never exceeding 0.5 mg/l. This resulted in a concomitant deterioration in ammonia removal.

The following graph shows the improvement in effluent quality with regard to ammonia prior to and after Xcelbio treatment.



This consistent ability of Xcelbio augmentation of waste treatment to improve ammonia removal at high loading rates is unique and makes Xcelbio a valuable tool in managing effluent quality.

Scientific Basis for Xcelbio Ammonia Removal

Ammonia removal is regarded as a 2 stage process where nitrifiers oxidize the ammonia to nitrate via nitrite under oxic conditions 1. Recently new microbial processes, e.g. aerobic denitrification and heterotrophic nitrification, have been reported.

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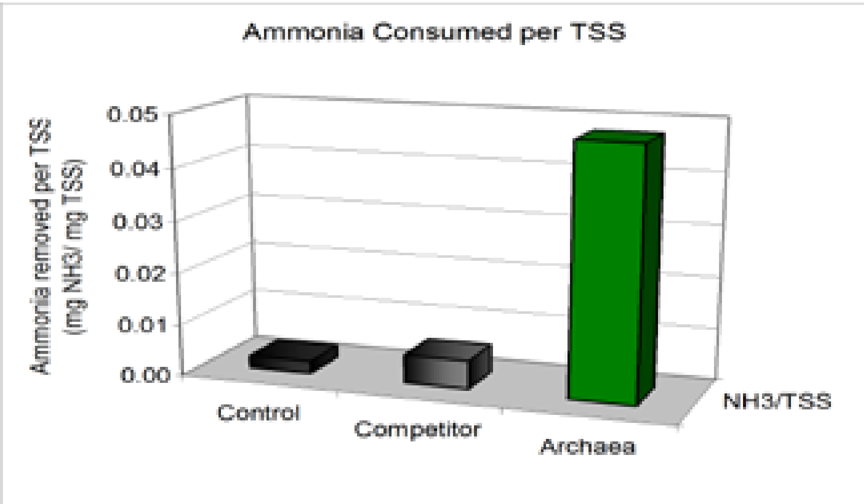
Thiospaera pantotropha have demonstrated the ability to simultaneously nitrify heterotrophically and denitrify aerobically with dissolved oxygen concentration as low as 0.3 mg/l 2.

Typically, Crenarchaeota (Xcelbio) are two orders of magnitude smaller than bacteria. This will increase the amount of ammonia required for cellular growth. It is postulated that due to Crenrchaeota's different cell structure and increased surface area more ammonia is required.

In our own studies, we have found increased ammonia consumption. During respirometry tests it was demonstrated that ammonia was removed at an accelerated rate. The data is shown in the following graph.



These results are more significant when taking into consideration that less sludge was being produced.

Said another way, in aerobic systems the presence of Xcelbio increases ammonia removal in stressed conditions that would include overloaded conditions. The question that remains is the expected end-point of this enhanced ability.

Another experiment with petrochemical waste was performed to answer this question. Side by side tests were done in identical activated sludge pilot plants. Initially the the D.O. was lowered to 0.7-0.9 mg/L to simulate overloaded conditions.

It was found that the Xcelbio treated process used less air to maintain the desired oxygen concentration. This reflects better oxygen utilization. At the same time more ammonia was removed, which indicates even higher oxygen utilization.

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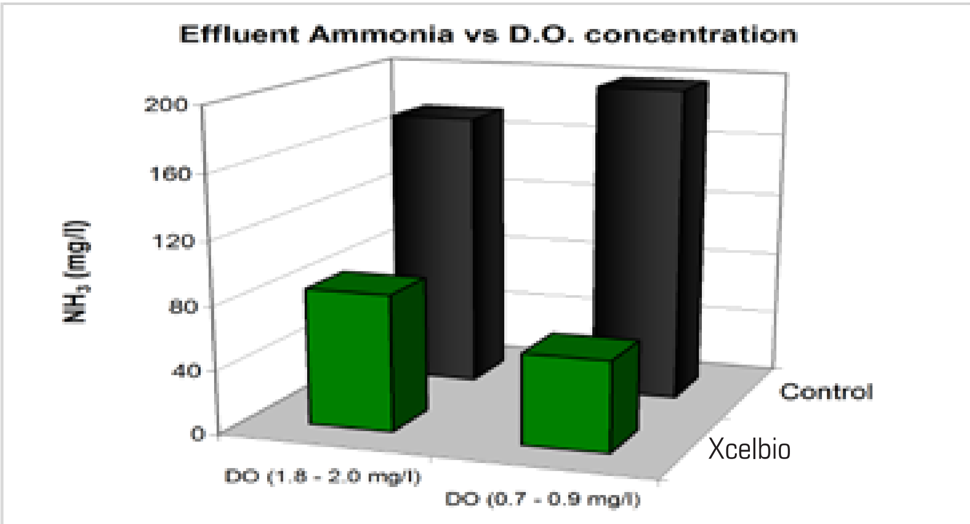
Eventually the D.O. was lowered to 0.7-0.9 mg/L to simulate overloaded conditions.

It was found that the Xcelbio treated process used less air to maintain the desired oxygen concentration. This reflects better oxygen utilization. At the same time more ammonia was removed, which indicates even higher oxygen utilization.

It was also found that Xcelbio improved sludge settleability and less foaming occurred on the basin compared to the control.



Under normal conditions the Xcelbio treated system improved ammonia removal by 50%. As is typical, the control ammonia removal deteriorated under low dissolved oxygen concentrations. While the Xcelbio system actually improved its ammonia removal.

This clearly demonstrates that the presence of the Xcelbio not only enhances oxygen uptake, but also results in superior effluent quality.

In 2000, Xcelbio discovered how to concentrate and activate Crenarchaeota (Xcelbio) in the presence of oxygen. This is the base of our economic position and unique technology.

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Conclusion

By utilizing Xcelbio in wastewater treatment plants ammonia removal can be increased. This is due to the following:

1. Increased oxygen utilization.
2. Increased biomass respiration rate and improved biomass viability due to accelerated microbial metabolism.
3. Reduced treatment required to achieve organic material breakdown.
4. Reduced oxygen- and energy requirement.
5. Improved capability to cope with hydraulic- and organic shock loads making the process less susceptible to process upsets.
6. Increased process performance improving nutrient removal and effluent quality.

Science is beginning to define the roles Archaea organisms play in waste breakdown. The syntrophy of Crenarchaea with other microbes and the ability of Archaea to live and divide in aerobic systems have recently been published 3, 4.

The technology base rests on concentrating and activating
Crenarchaeota (Xcelbio) from natural sources. As such, the microbes with which they have syntrophy are present.

References

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