

# Archaea Improves Ammonia Removal

**ArchaeaSolutions, Inc.**

R. Ambachtsheer, Pr Eng. and E. Childs, Ph.D

100 Lloyd Ave, Suite D

Tyrone, GA 30290

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## 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 Archaea bio-systems 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.

## Presentation Objectives

This presentation has three objectives:

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

## 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.

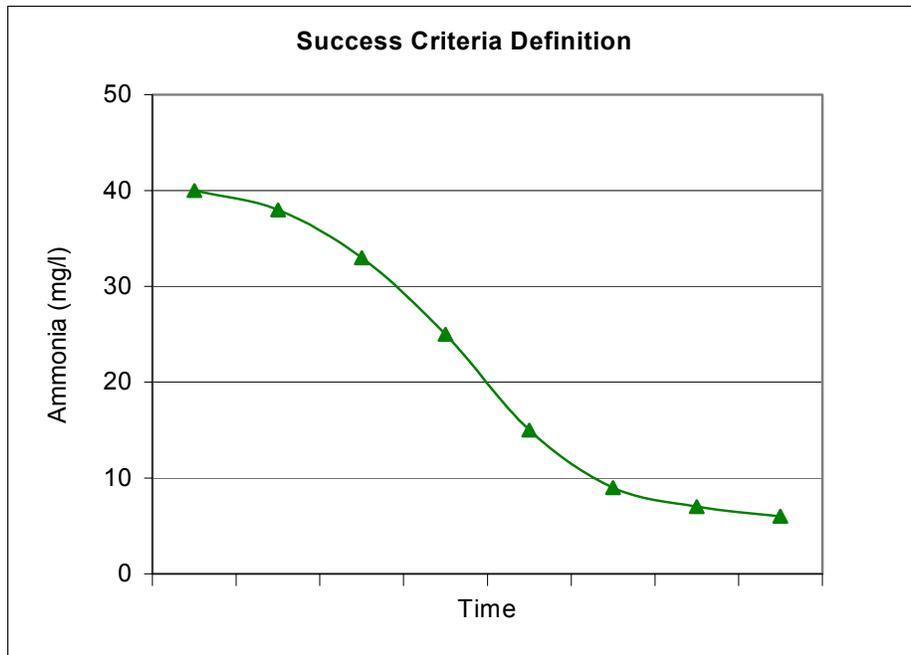
Nitrifier bacteria convert the excess ammonia to nitrate under oxygen sufficient conditions. When oxygen becomes limiting or residence time is too short they cannot survive and wash out of the system.

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

ArchaeaSolutions, Inc. defines success in increasing ammonia removal as:

“The ability to continue to efficiently improve ammonia removal. This is measured by graphing the actual data when Archaea bio-systems are present compared to the historical data.”

The graph below illustrates the criteria for success.



The Archaea bio-system allows a wastewater treatment process to improve nutrient removal and simultaneously reducing sludge production while under overloaded conditions.

Because Archaea bio-systems enhance the metabolism of the total biomass in waste treatment, it aligns itself to most any process.

### **Practical Application Experience**

ArchaeaSolutions, Inc. has practical experience in a variety of applications. The following data demonstrates full-scale plant experiences where the presence of an Archaea bio-system increased ammonia removal.

► **Increasing 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 Archaea bio-system treatment. The range of processes is oxidation pond to trickling filter to activated sludge.

Parameter	Unit	Acceptable Range	Oxidation Pond	Trickling Filter	Activated Sludge
<b>Capacity Analysis</b>					
Designed Capacity	m <sup>3</sup> /d		900	800	3,300
Actual Daily Flow	m <sup>3</sup> /d		2,700	1,700	5,624
<b>% Capacity</b>	%		<b>300%</b>	<b>213%</b>	<b>170%</b>
<b>Raw Sewage Concentration</b>					
COD	mg/L		450	436	1,270
Ammonia	mg/L		21	23	45
<b>Organic Loading</b>					
Oxidation Pond	kg/ha/d		744		
Trickling Filter	g/m <sup>3</sup> /d			945	
Activated Sludge	kg COD/kgMLSS/d				0.164
<b>Effluent Quality (with Archaea bio-system treatment)</b>					
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

All of these domestic sewage plants were operating beyond their design capacity (from 170% to 300%). In each case, the presence of Archaea bio-systems caused them to reduce ammonia concentration to within specifications (see table effluent quality).

► **Oxidation Pond**

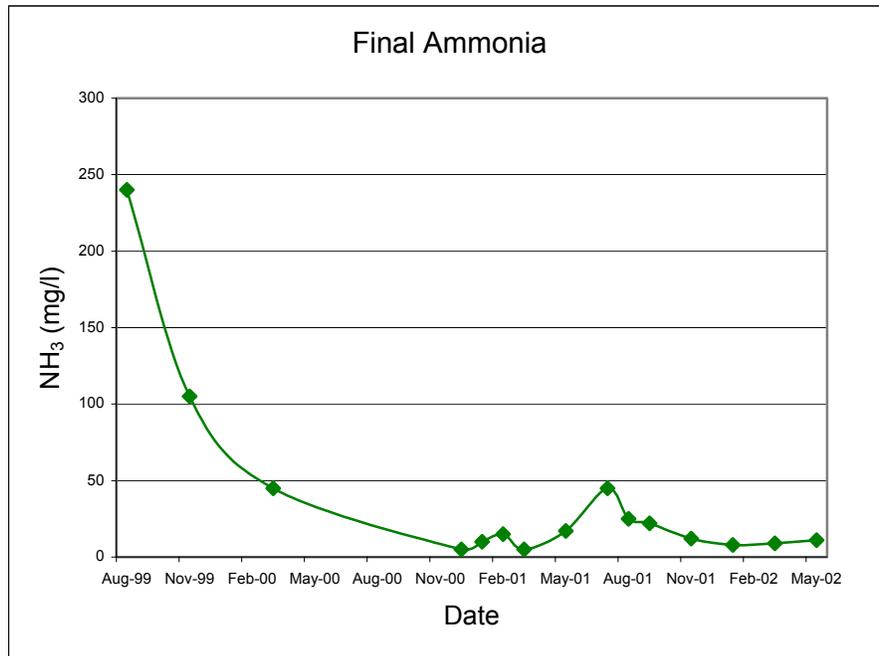
An oxidation pond system treating poultry abattoir effluent was supplemented with an Archaea Bio-system.

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
Ammonia (NH <sub>3</sub> )	174
Suspended Solids	1518

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

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

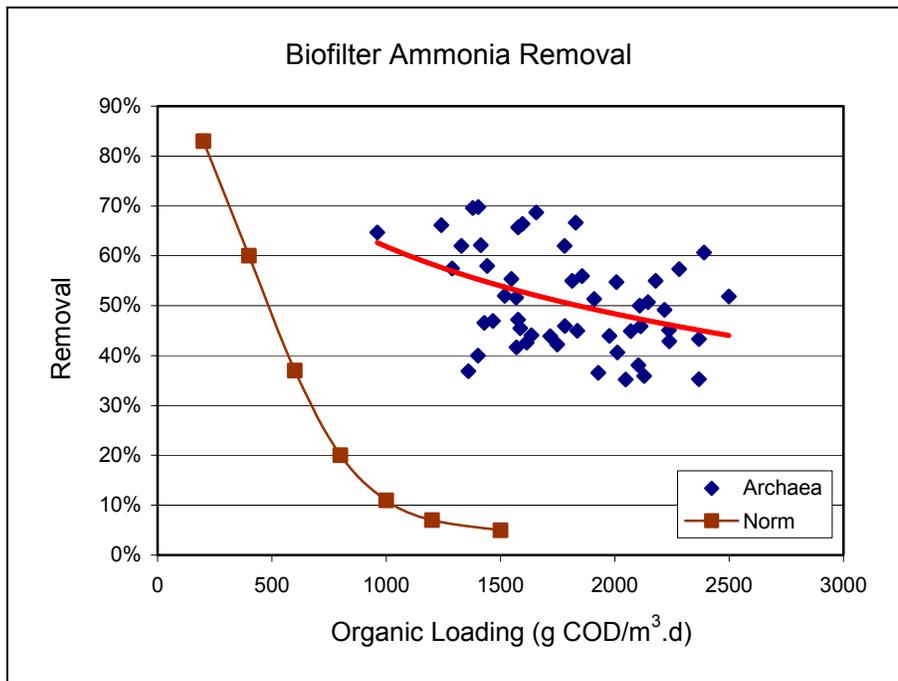


These results are significant considering that the TKN loading on the lagoon is extremely high.

► **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.

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 Archaea, however, the ammonia removal is very consistent over a wide range of organic loadings.

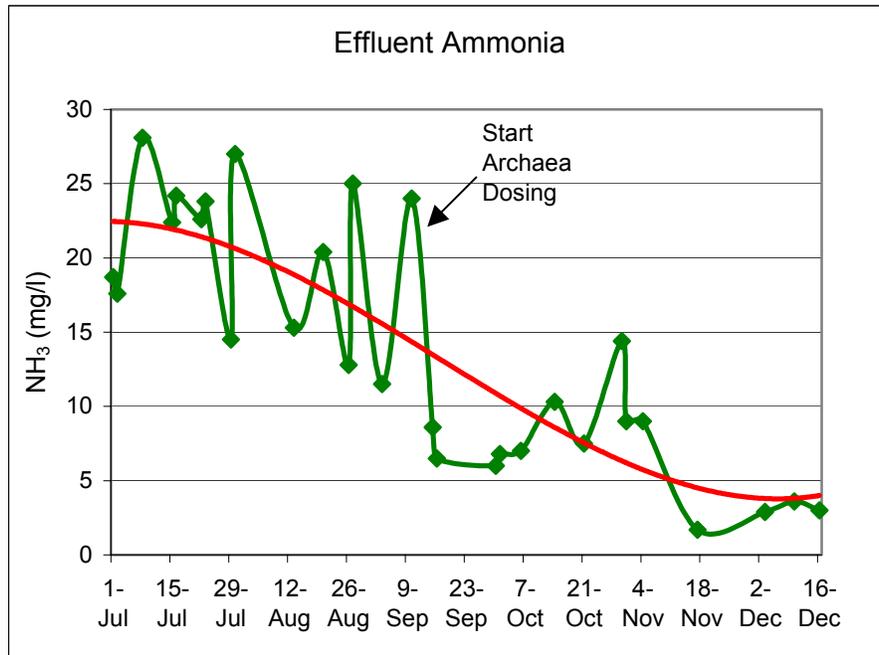
Based on the organic loading the removal efficiency was increased by 500%.

► **Activated Sludge**

Under overloaded conditions nitrification often suffer. 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 Archaea treatment.



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

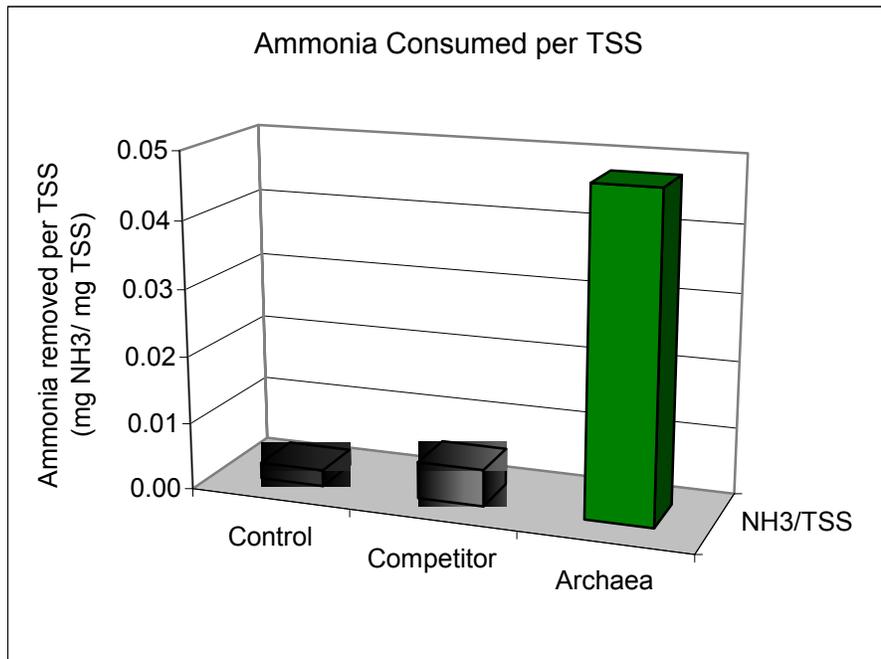
**Scientific Basis for Archaea Ammonia Removal**

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

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

Typically, Archaea 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 Archaea'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 Archaea increases ammonia removal in stressed conditions that would include overloaded conditions. The question that remains is the expected end-point of this enhanced ability.

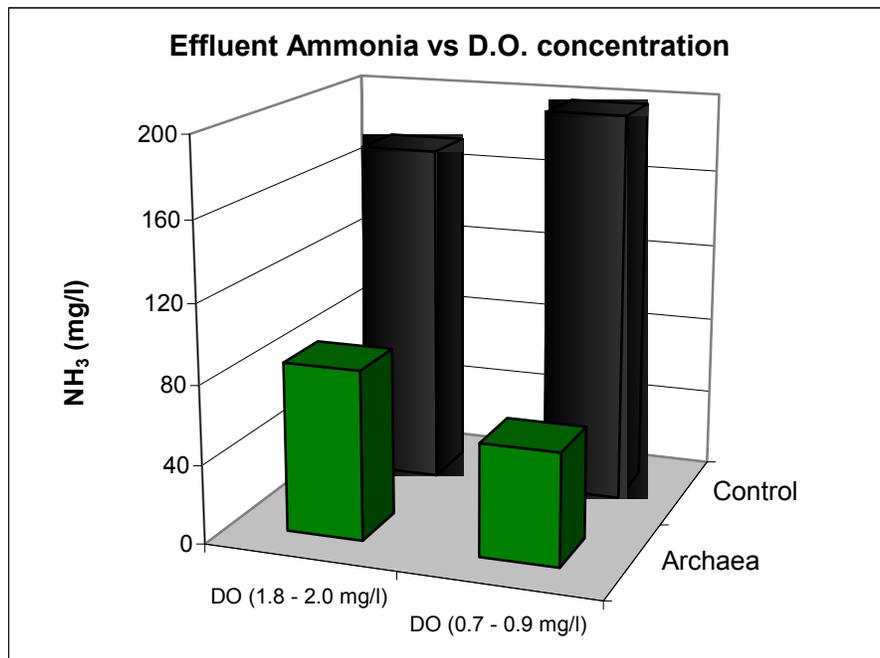
Another experiment with petrochemical waste was performed to answer this question. Side by side tests were done in identical activated sludge pilot plants. Initially the dissolved oxygen (D.O.) was maintained between 1.8-2.0 mg/L.

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

It was found that the Archaea 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 the Archaea bio-system improved sludge settleability and less foaming occurred on the basin compared to the control.

The graphs below illustrate the results for NH<sub>3</sub> removal at normal dissolved oxygen concentrations and at low (stressed) concentrations.



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

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

In 2000, ArchaeaSolutions, Inc. discovered how to concentrate and activate Archaea in the presence of oxygen. This is the base of our economic position and technology.

## **Conclusion**

By utilizing Archaea bio-system 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 Archaea with other microbes and the ability of Archaea to live and divide in aerobic systems have recently been published<sup>3,4</sup>.

The technology base of ArchaeaSolutions, Inc. rests on concentrating and activating Archaea from natural sources. As such, the microbes with which they have syntrophy are present.

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