ANAEROBIC METHANE PRODUCTION STUDY TO EVALUATE THE FULL-SCALE EFICACY OF TWO BIOCHEMICALS USED TO NEUTRALIZE THE IMPACT OF QUATERNARY AMMONIUM COMPOUNDS IN A PORK PROCESSING WASTE STREAM

SCOPE OF THE STUDY:

Quaternary ammonium compounds can negatively affect the performance of anaerobic wastewater treatment. This study was conducted to evaluate two quaternary ammonium neutralizing biochemicals in a bench-scale setting utilizing a Respirometer Systems and Applications (RSA) PF-8000 Pulse-Flow Respirometer to measure gas production in test reactors that were impacted by known amounts of a quaternary ammonium compound.

OVERVIEW:

Anaerobic biomass from the processor's wastewater treatment system and a quaternary ammonium compound utilized for disinfection at the pork processing plant were shipped to Respirometer Systems and Applications (RSA) in Fayetteville, AR. Under the direction of Dr. James Young the bench-scale gas production study was performed utilizing a Respirometer Systems and Applications (RSA) PF-8000 Pulse-Flow Respirometer.

Eight discrete anaerobic reactors were utilized in the study. Each reactor received identical amounts of anaerobic biomass and was periodically fed 2400 mg of acetate. Two "Control" reactors were ran to better assess the final test results. Six "Test" Reactors were used in the study and were amended with either 7.5 or 15 mg/l of the provided quaternary ammonium compound. Of the six Test Reactors two were amended with Quat Lock™ and two were amended with NeutraQuat™. A two stage study was performed. The 1st Stage ran for 72 hours and the 2nd stage ran for 84 hours.

METHODS: TEST SETUP

The anaerobic sludge was mixed and the following reactors were set up for the Methane Production Study:

1. REACTOR 1 - 500ml Anaerobic Sludge – Control (w/ 2400 mg acetate added @ Time 0 & Time 24 hr.)

2. REACTOR 2 - 500ml Anaerobic Sludge – 7.5 mg/l Quat (7.5 mg/l Quat and 2400 mg acetate added @ Time 0 & Time 24 hr.)

3. REACTOR 3 - 500ml Anaerobic Sludge – 15 mg/l Quat (15 mg/l Quat and 2400 mg acetate added @ Time 0 & Time 24 hr.)

4. REACTOR 4 - 500ml Anaerobic Sludge – 7.5 mg/l Quat & 7.5 mg/l Quat Lock™ (7.5 mg/l Quat – 7.5 mg/l Quat Lock™ and 2400 mg acetate added @ Time 0 & Time 24 hr.)

5. REACTOR 5 - 500ml Anaerobic Sludge – 7.5 mg/l Quat & 7.5 mg/l NeutraQuat™ (7.5 mg/l Quat – 7.5 mg/l NeutraQuat™ and 2400 mg acetate added @ Time 0 & Time 24 hr.)

6. REACTOR 6 - 500ml Anaerobic Sludge – 15 mg/l Quat & 15 mg/l Quat Lock™ (15 mg/l Quat – 15 mg/l Quat Lock™ and 2400 mg acetate added @ Time 0 & Time 24 hr.)

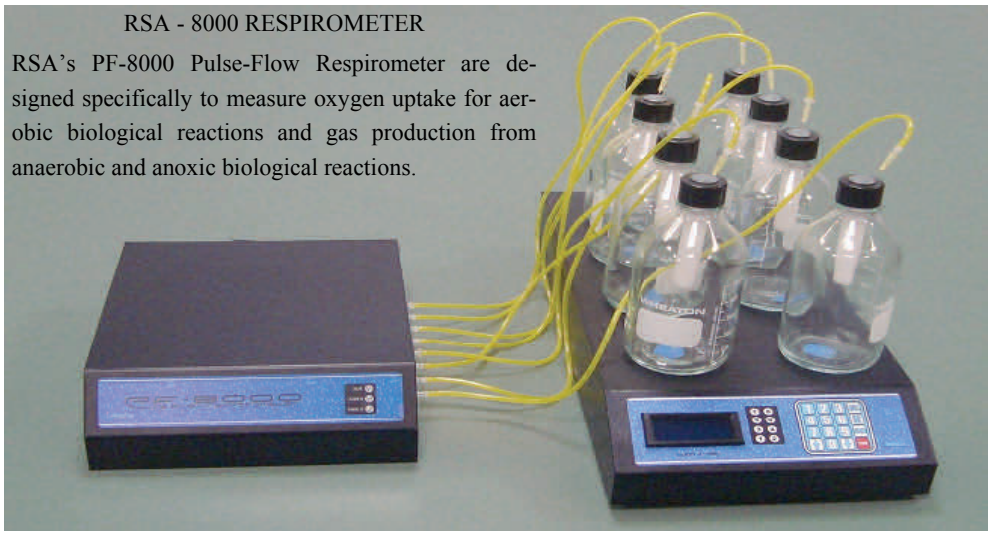
7. REACTOR 7 - 500ml Anaerobic Sludge – 15 mg/l Quat & 15 mg/ NeutraQuat™ (15 mg/l Quat – 15 mg/l NeutraQuat™ and 2400 mg acetate added @ Time 0 & Time 24 hr.)

STAGE 1 – Ran for 72 hours. The Test Reactors were amended with the components listed above at Time 0 and Time : 24 hrs.

STAGE 2 - Ran for 84 hours. The Test Reactors were amended with the components listed above at Time 0. 2400 mg of acetate was reintroduced at Time: 18 hours & Time : 36 hours.

RSA - 8000 RESPIROMETER

RSA's PF-8000 Pulse-Flow Respirometer are designed specifically to measure oxygen uptake for aerobic biological reactions and gas production from anaerobic and anoxic biological reactions.



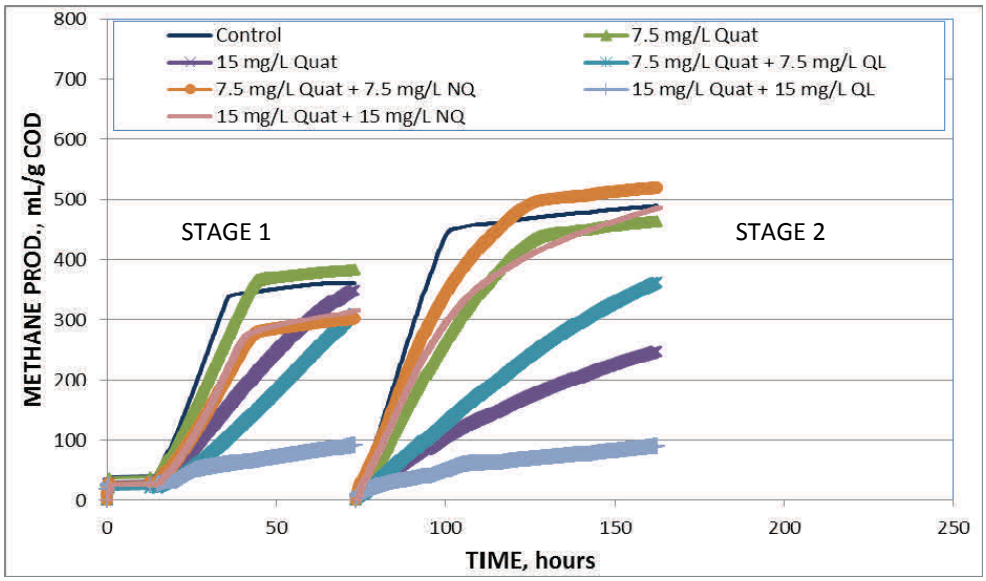
DESCRIPTION OF STUDY:

The ANAEROBIC METHANE PRODUCTION Study performed consisted of dosing an anaerobic culture (with a known solids concentration) with a supplied industrial disinfection agent [quaternary ammonium compound (Quat)] at concentrations of 7.5 mg/l and 15 mg/l, an anaerobic food source (acetate) introduced at 2400 mg/l and then adding the quaternary ammonium neutralizing agents Quat Lock™ or NeutraQuat™. The study examined the methane production of the six test reactors and one control reactor via a respirometric measurement of methane production utilizing Respirometer Systems and Applications PF-8000 Pulse-Flow Respirometer.

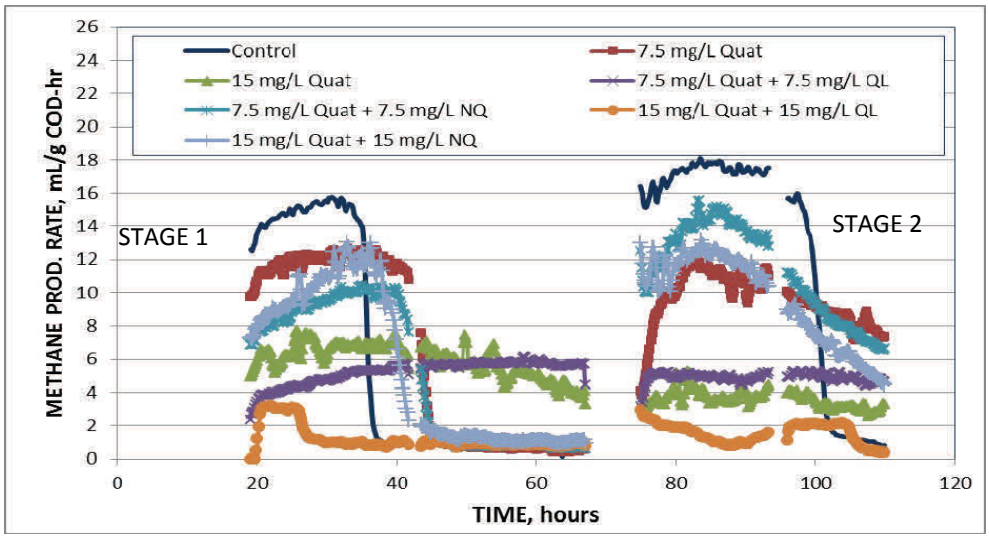
The Anaerobic Methane Production Study involved the addition of the quaternary ammonium neutralizing agents Quat Lock™ or NeutraQuat™ (at known concentrations) to Test Reactors containing anaerobic cultures, a quaternary ammonium compound (Quat) at concentrations of 7.5 mg/l and 15 mg/l, and an anaerobic food source (acetate) at 2400 mg/l. These components are combined per the testing protocol and then sealed within the Test Reactors following an oxygen purge to remove head space oxygen contained within the vessels.

Methane production was measured over the study duration (Stage 1 = 72 hours and Stage 2 = 84 hours). In the study, substrate (acetate), quaternary ammonium and the quaternary ammonium neutralizing agents Quat Lock™ or NeutraQuat™ injections were made at the start of Stage 1 and again at 24 hours.

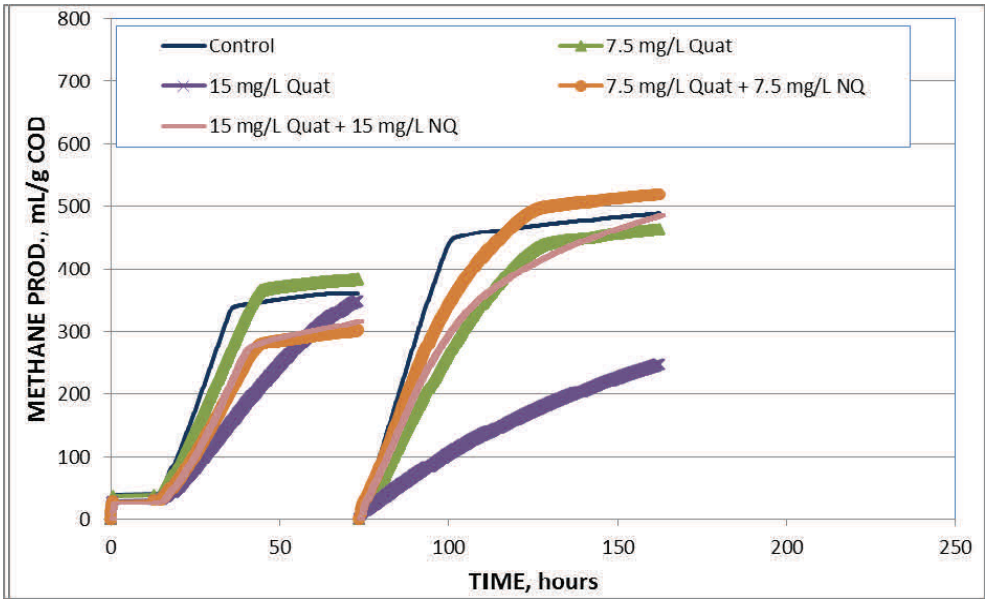
1A) TOTAL COMBINED METHANE PRODUCTION TESTS (Total Methane Production)



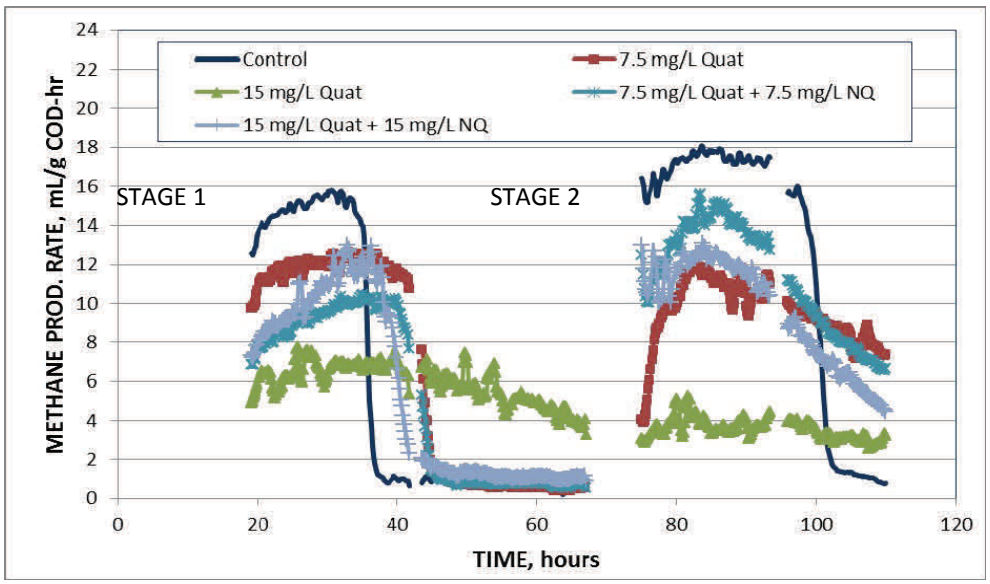
1B) TOTAL COMBINED METHANE PRODUCTION TESTS (Methane Production Rate)



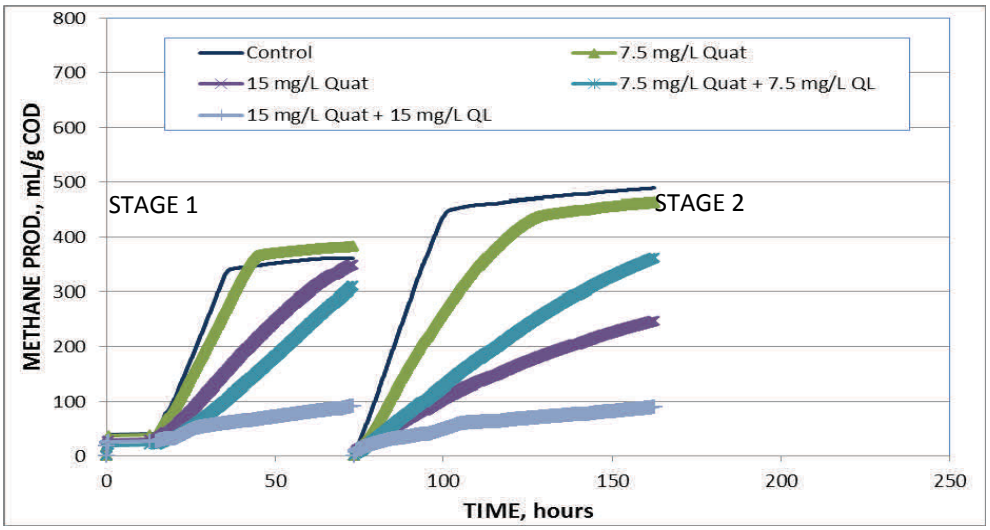
2A) NeutraQuat™ METHANE PRODUCTION TESTS (Total Methane Production)



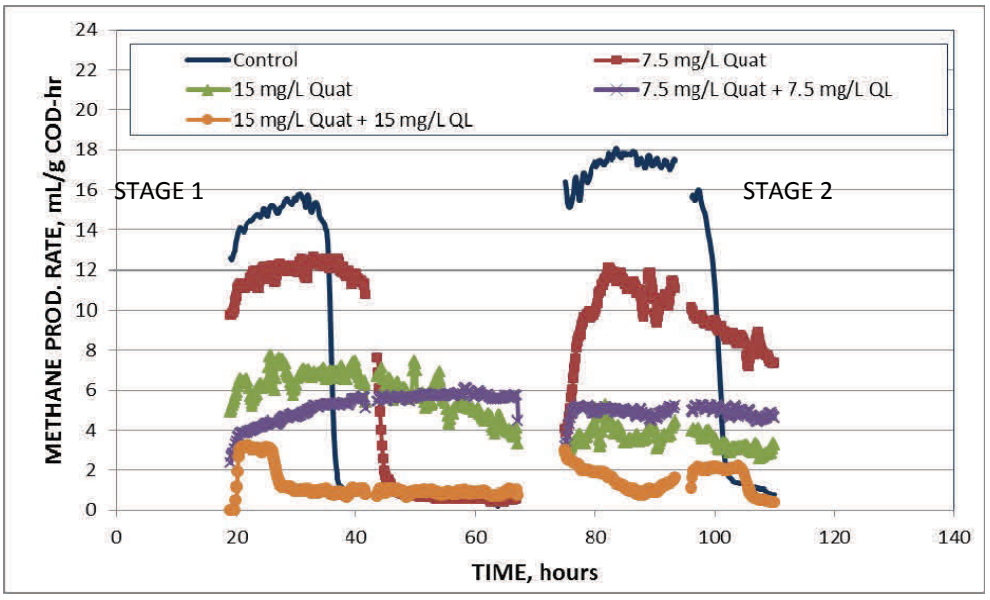
2B) NeutraQuat™ METHANE PRODUCTION TESTS (Methane Production Rate)



3A) Quat Lock™ METHANE PRODUCTION TESTS (Total Methane Production)



3B) Quat Lock™ METHANE PRODUCTION TESTS (Methane Production Rate)



During Stage 2 acetate, quaternary ammonium and the quaternary ammonium neutralizing agents Quat Lock™ or NeutraQuat™ were introduced at Time = 0 and then acetate was introduced at 18 hours and 36 hours by injecting acetate into the Test Reactors. The methane production was expressed as mL/g COD added. The performance of each test reactor in this anaerobic treatment study was based on the Specific Methanogen Production (SMP) of the biomass contained within each Test Reactor.

DISCUSSION:

STAGE 1

The 15 mg/l Quat + 15 mg/l Quat Lock™ produced the least amount of methane as compared to all of the other Test Reactors (91.95 ml of methane per gram COD). This was significantly less than the other Test Reactors. The 7.5 mg/l Quat + 7.5 mg/l Quat Lock™ Test Reactor produced the second lowest amount of methane (301.22 ml methane per gram COD).

The Quat Lock™ amended Test Reactors actually showed increased toxicity over the Quat only amended tests in both the 7.5 mg/l Test Reactors and in the 15 mg/l Test Reactors. In this anaerobic study, methane production was positively influenced with the addition of NeutraQuat™, whereas the methane production was decreased with the addition of Quat Lock™.

The analysis of the rate of methane production graphs revealed "toxic" fingerprints in both of the Quat + Quat Lock™ Test Reactors (and were similar to the "toxic" fingerprints in the Quat only amended Test Reactors). Of significance in the methane production rate graphs are the similar fingerprints of the Control Test Reactor and the NeutraQuat™ Test Reactors (steep methane production rate increase followed by a decrease as the supplied acetate was consumed).

When comparing the NeutraQuat™ tests to the Quat Lock™ Tests, the NeutraQuat™ Tests produced greater quantities of methane. The 15 mg/l Quat + 15 mg/l Quat Lock™ produced only 91.95 ml methane as compared to the 315.19 ml of methane produced by the 15 mg/l Quat + 15 mg/l NeutraQuat™ Test Reactor. The 15 mg/l Quat with equal amounts of the quaternary ammonium neutralizing material revealed an increase in methane production by the NeutraQuat™ Test Reactor that was more than 3 times the amount of methane produced in the Quat Lock™ test reactor.

The analysis of the rate of methane production graphs revealed "toxic" fingerprints in both of the Quat + Quat Lock™ Test Reactors (and were similar to the "toxic" fingerprints in the Quat only amended Test Reactors). Of significance in the methane production rate graphs are the similar fingerprints of the Control Test Reactor and the NeutraQuat™ Test Reactors (steep methane production rate increase followed by a decrease as the supplied acetate was consumed).

In this anaerobic study, methane production was positively influenced with the addition of NeutraQuat™, whereas the methane production was decreased with the addition of Quat Lock™.

STAGE 2

The 7.5 mg/l Quat + 7.5 mg/l NeutraQuat™ Test Reactor exhibited the greatest methane production of all test reactors (518.43 ml Methane produced per gram COD) and even outperformed the Control Test (488.90 ml Methane produced per gram COD) which received no quaternary ammonium.

The 15 mg/l Quat + 15 mg/l Quat Lock™ produced the least amount of methane as compared to all of the other Test Reactors (89.56 ml of methane per gram COD). This was significantly less than the other Test Reactors.

When comparing the NeutraQuat™ Tests to the Quat Lock™ Tests, the NeutraQuat™ Tests produced greater quantities of methane. The 15 mg/l Quat + 15 mg/l Quat Lock™ produced only 89.56 ml methane as compared to the 484.86 ml of methane produced by the 15 mg/l Quat + 15 mg/l NeutraQuat™ Test Reactor. The 15 mg/l Quat with equal amounts of the quaternary ammonium neutralizing material revealed an increase in methane production by the NeutraQuat™ Test Reactor that was more than 5 times the amount of methane produced in the Quat Lock™ test reactor. During Stage 2 of the study the NeutraQuat™ Test Reactors produced more gas than during Stage 1 and the difference in methane production was greater in the Test Reactors in which NeutraQuat™ was introduced in comparison to both of the Quat only reactors and the Quat + Quat Lock™ Test Reactors

The analysis of the rate of methane production graphs revealed "toxic" finger prints in both of the Quat + Quat Lock™ Test Reactors (and were similar to the "toxic" fingerprints in the Quat only amended Test Reactors). In Stage 2 the NeutraQuat™ Test Reactors methane production rate graphs are even more similar to the methane production rate fingerprint of the Control Test Reactor (once again notice the steep methane production rate increase followed by a decrease as the supplied acetate was consumed).

The Quat Lock™ amended Test Reactors once again showed increased toxicity over the Quat only amended tests (in both the 7.5 mg/l Test Reactors and in the 15 mg/l Test Reactors).

In Stage 2 of this anaerobic study, methane production was positively influenced with the addition of NeutraQuat™, whereas the methane production was decreased with the addition of Quat Lock™.

CONCLUSION:

NeutraQuat™ amended Test Reactors showed significantly greater methane production than Quat Lock™ amended Test Reactors for all levels of quaternary ammonium or acetate additions.

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