Development of Algal-Bacterial Wastewater Treatment Systems that are Effective in the Presence of Antimicrobial Processing Aids Used in the Poultry Processing Industry

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Poultry processing plants utilize a range of antimicrobial processing aids to sanitize plant equipment and bird carcasses to meet stringent food safety standards. Recently, the U.S. Poultry and Egg Association recognized that these processing aids could present problems for their existing wastewater treatment approaches. While effective at killing pathogens, antimicrobials have the unfortunate side effect of harming the "good" bacteria, particularly nitrifiers, that are critical to wastewater treatment. Past research on anaerobic digestate has shown that adding algae to wastewater treatment processes can help bacteria more effectively carry out nitrification, even in a toxic environment. It is unknown if algae can help nitrifying bacteria overcome the adverse effects of antimicrobial aids in the treatment of poultry processing wastewater. The research objective of this study was to compare the effectiveness of an algal-bacterial process to a bacteria-only wastewater treatment process in the presence of an antimicrobial aid commonly used in the poultry industry: peracetic acid (PAA).

The first step in this project was to determine the concentration of PAA at which the growth of *Chlorella sorokiniana* algae is inhibited. The result from this dose-response study showed that *C. sorokiniana* has a similar sensitivity to PAA as nitrifying bacteria, with an EC50 of about 7.5 mg/L PAA.

To understand the effect of PAA on an algal-bacterial wastewater treatment process, we performed a batch microcosm study by adding algae to a bacterial consortium treating poultry processing wastewater in the presence and absence of 7 mg/L of PAA. PAA was spiked into the culture daily over 120 hours. Subsequently, ion chromatography was used to measure the change in water quality by analyzing ammonium, nitrite, and nitrate concentrations. Additionally, quantitative polymerase chain reaction (qPCR) was performed on the final biomass samples to evaluate the effect of PAA by quantifying the genes for ammonia (AmoA) and nitrite (nxrb1-F) oxidizing bacteria. Figure 1 includes the results for ion chromatography and qPCR.

The ion chromatography results show that 7 mg/L of PAA suppresses nitrification; however, the results show the suppression of nitrification is reduced when algae are present in the system, therefore allowing for nitrification to occur. This is seen by the conversion of ammonium to nitrite/nitrate by the bacteria present in the algal-bacteria system. The ammonium levels dropped significantly in the algae cultures due to the improved algal uptake and bacterial utilization of ammonium. The qPCR analysis indicated that PAA suppressed the ammonia and nitrite oxidizers; however, algae clearly supported these oxidizers in both the presence and absence of PAA. These results indicate the possibility of using an algal-bacterial process to effectively treat poultry processing wastewater, even in the presence of PAA.

Statement of Research Advisor

The results from this project constituted a significant advance in our understanding of how algae can increase nitrification capacity of bacteria when treating poultry processing wastewater. To our knowledge, this is the first report showing that algae can support ammonia-oxidizing and nitrite-oxidizing bacteria in the presence of PAA.

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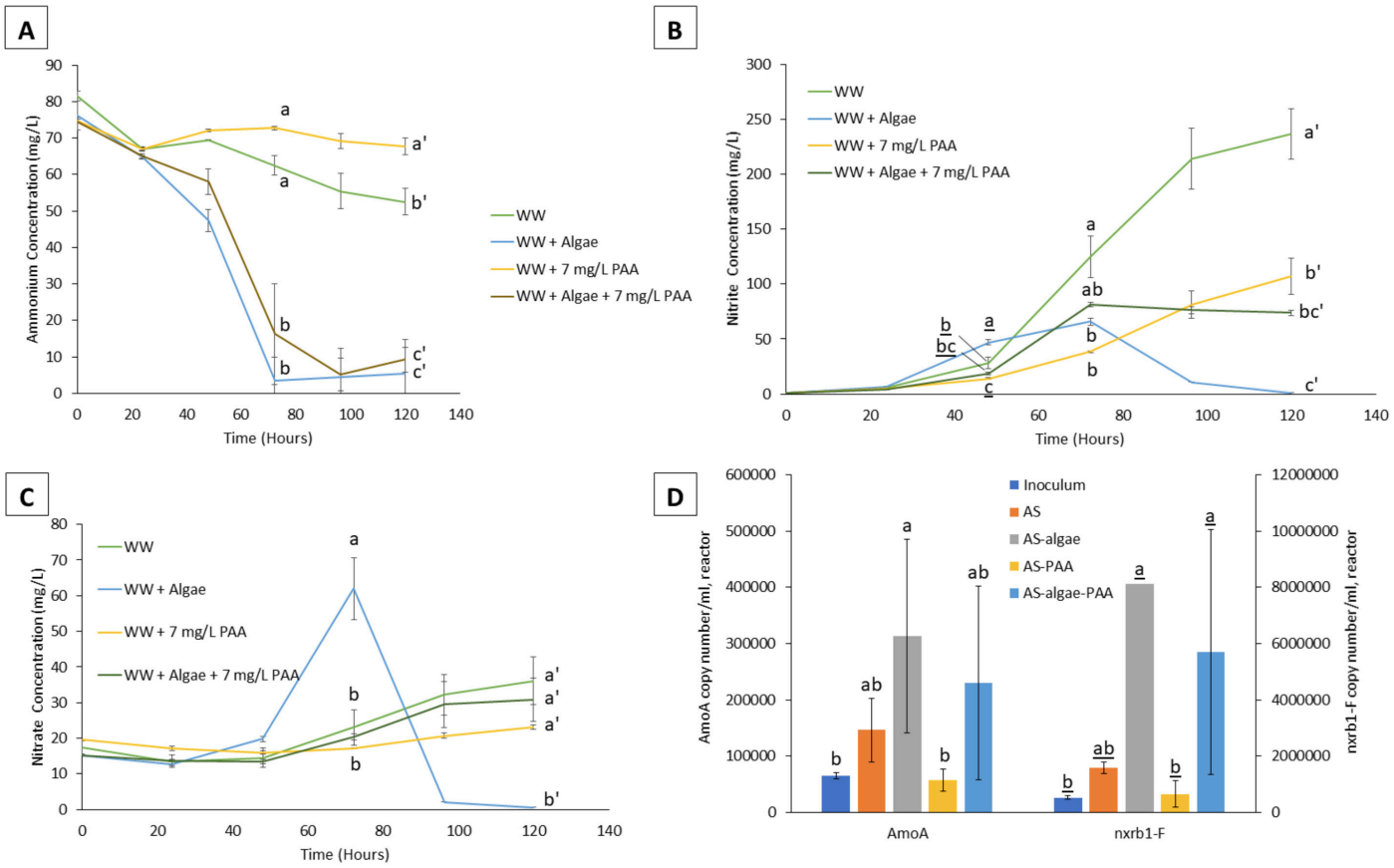

Figure 1. Effects of PAA and algae on nitrification and oxidizing bacteria in poultry processing wastewater. Ammonium removal (A), nitrite production and consumption (B), nitrate production and consumption (C), and gene copy number for oxidizing bacteria (D) during the wastewater treatment process. For a given time point or gene, points with the same letter are not significantly different based on Tukey's HSD test (n = 3).