Impact of Food Waste Diversion on Landfill Emissions

United States Environmental Protection Agency

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Introduction

Food waste is rapidly-decaying, nutrient-dense material that contributes about 15% to the total municipal solid waste (MSW) stream. In 2017, 75% of food waste generated was landfilled, 19% was incinerated at waste to energy facilities, and 6% was composted or recycled (Figure 1, EPA, 2017). Food waste has high moisture content (60-80%) which adds significant weight and contributes to landfill leachate and gas generation. States and municipalities are enacting landfill bans on food waste, which could have long-term implications for landfill leachate and gas generation. This research analyzes landfill lysimeter gas and leachate to identify and quantify the impact of food waste diversion on landfill emissions. Approximately 40 kg of synthetic mixed municipal solid waste was distributed in six chlorinated polyvinyl chloride (CPVC) lysimeters (Figure 2). Below are images of the lysimeter vessels and sampling mechanisms in an environmental chamber held at 37° C (Figures 3 and 4). The food waste was collected from a post-consumer food waste stream from a cafeteria at the University of Louisville.

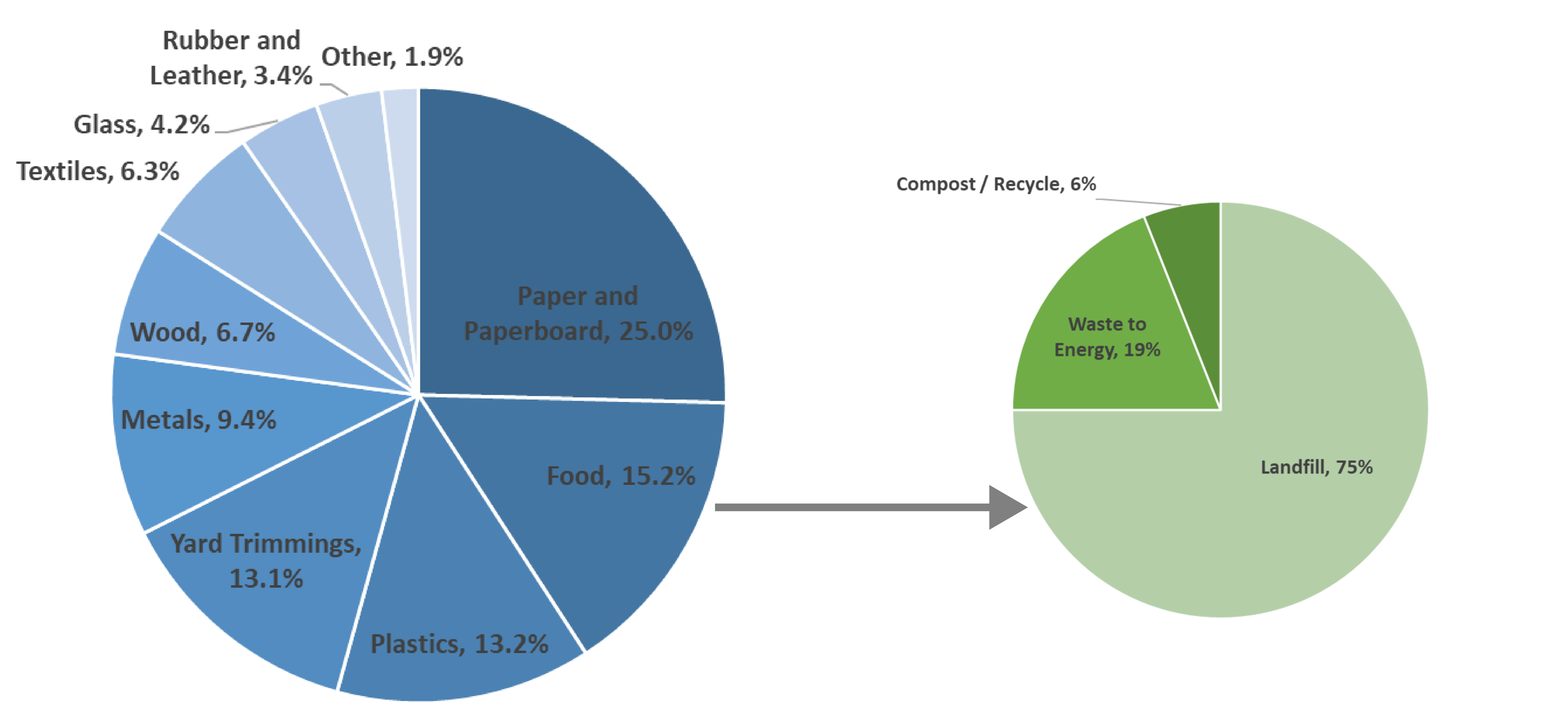

Figure 1. Composition of 267.8 million tons of MSW generated in the United States for 2017. Food waste accounted for 40,705,600 tons or 81,411,200,000 pounds. 30,529,200 tons of the total food waste generated was landfilled (EPA, 2017).

Materials and Methods

Based on EPA's 2015 waste composition study, each lysimeter was loaded with different amounts of food waste, ranging from 100% to 0% of the total food waste present in the waste stream (Figure 2). All other components from the compositional study were kept constant for this study. The bladders are filled biweekly with 1200 mL of Deionized (DI) water to simulate precipitation and generate leachate for analysis (Figure 3). On opposite weeks, a valve on the bottom of each lysimeter is opened, allowing leachate to drain into beakers and be analyzed for pH, conductivity, dissolved oxygen (DO), chemical oxygen demand (COD), ammonia (NH3-N), metals and total volume. Gas is collected into 10 L Tedlar® bags and analyzed for composition and volume (Figure 4).

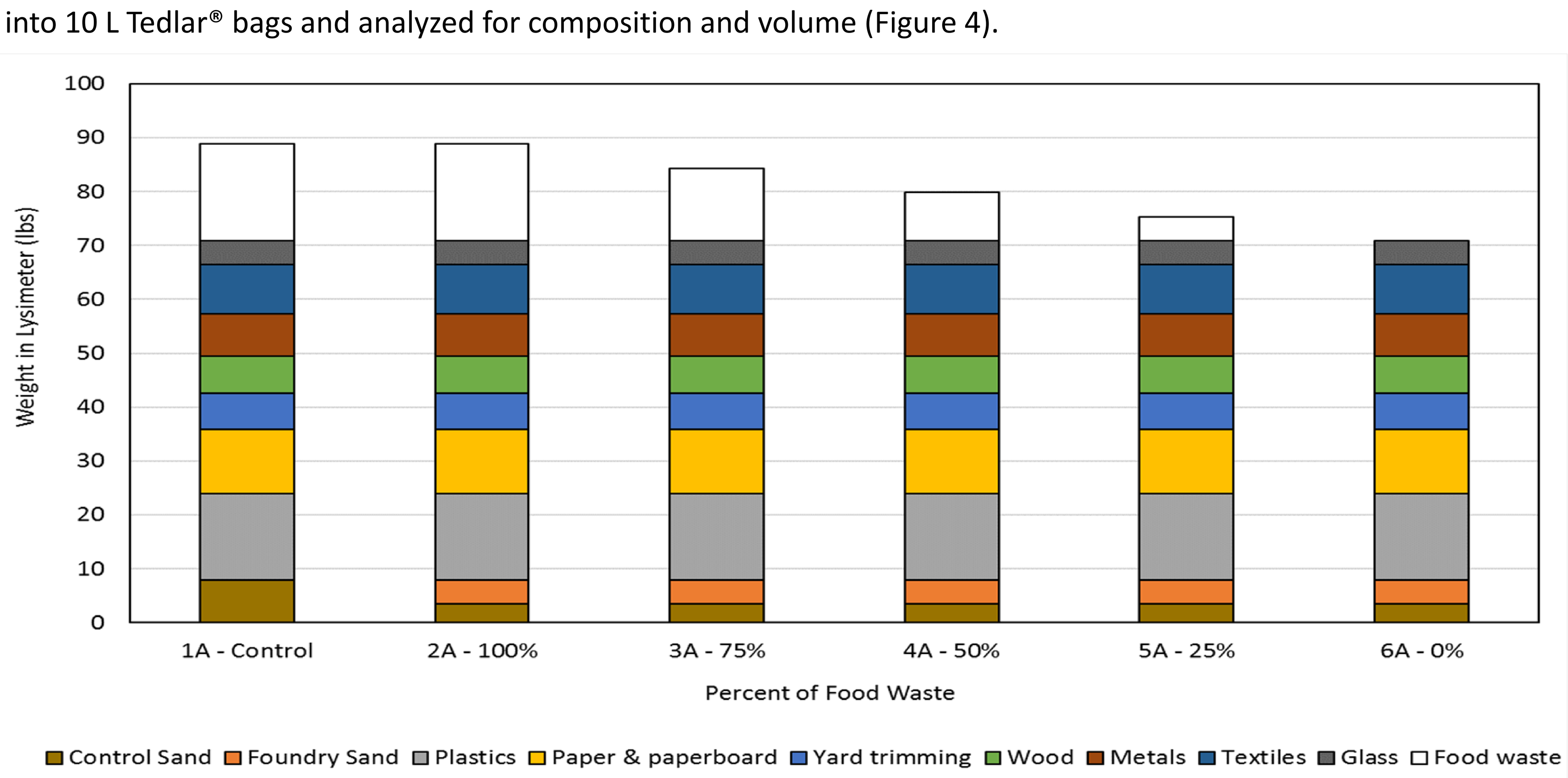

Figure 2. Illustration of composition of waste in lysimeters used for this study. Food waste (white) is independent variable being tested.

Figure 3. Photo of lysimeters in environmental chamber.

Figure 4. Top of lysimeter with precipitation bladder (top) and gas collection (bottom).

Results and Discussion

Cumulative methane generation of 1A is 497 L whereas 6A is only 224 L, which averages to be 0.89 L/day and 0.32 L/day, respectively. There is a significant reduction in methane emissions with a waste stream containing 0% food waste (Figure 5). This suggests food waste provides macro and micronutrients for anaerobic decomposition. In 5A and 6A where there is little to no food waste, it appears gas generation begins earlier, likely because there is a shorter acid-forming phase. Initially, food waste may adversely impact landfill decomposition by delaying methanogenesis with the volatile fatty acids and high protein content present in the waste, keeping the pH more acidic for longer (Figure 6). COD remains similar regardless of amount of food waste and appears to be influenced more by pH (Figure 7). Generally, Ammonia (NH3-N) is also lower with less food waste (Figure 8). The decay rates vary dramatically from 0.0041 to 0.0016 yr^{-1}, resulting in very different half lives (Table 1). The half live is the number of days it takes for half the carbon to leave the system.

Acknowledgements

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Implications and Future Research

Gas is generated earlier but at a slower rate from landfills with less and without food waste (i.e., lag-time is less, decay constant (k) is lower and half life is longer). NH3-N is generally less for decreasing amounts of food waste. Considering leachate treatment costs are partially dependent on COD and NH3-N concentrations, removing food waste from the waste stream could reduce overall treatment costs. Removing food waste also reduces cumulative emissions, which results in less contribution of greenhouse gases. Food waste is also a viable alternative energy source in some applications further avoiding or reducing methane emissions. These lysimeters are expected to continue producing gas for at least another year, which during that time the same sampling and analysis will occur.

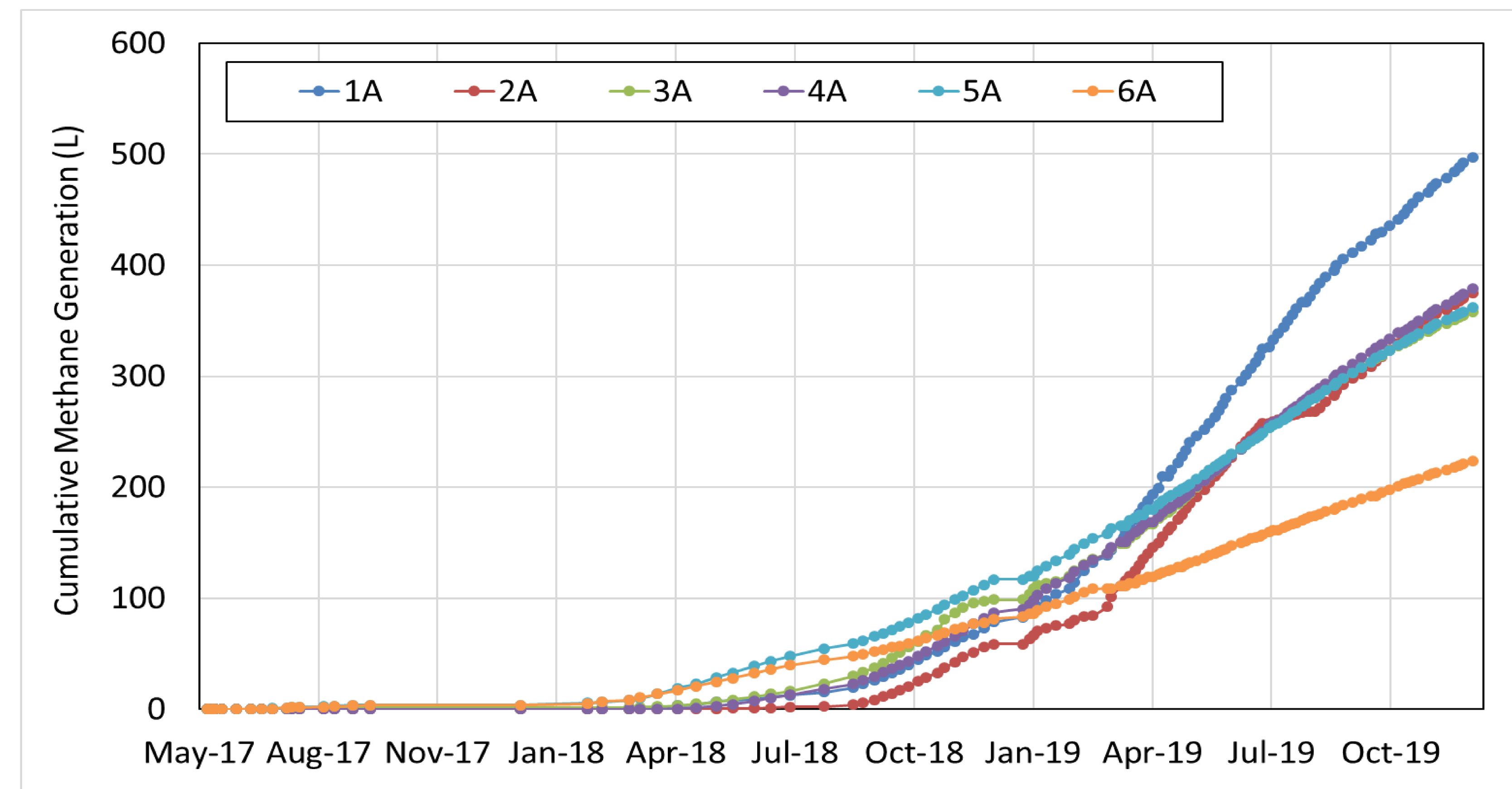

Figure 5. Cumulative methane generation observed from each lysimeter with 1A generating the most and 6A generating the least amounts of methane.

Lysimeter	1A	2A	3A	4A	5A	6A
k (day^{-1})	0.0041	0.0028	0.0027	0.0028	0.0031	0.0016
$t_{1/2}$(days)	169	248	257	248	224	433

Table 1. Linear regression used to calculate decay rates and half lives of the carbon observed leaving each lysimeter. 1A decays 2.5 times faster than 6A.

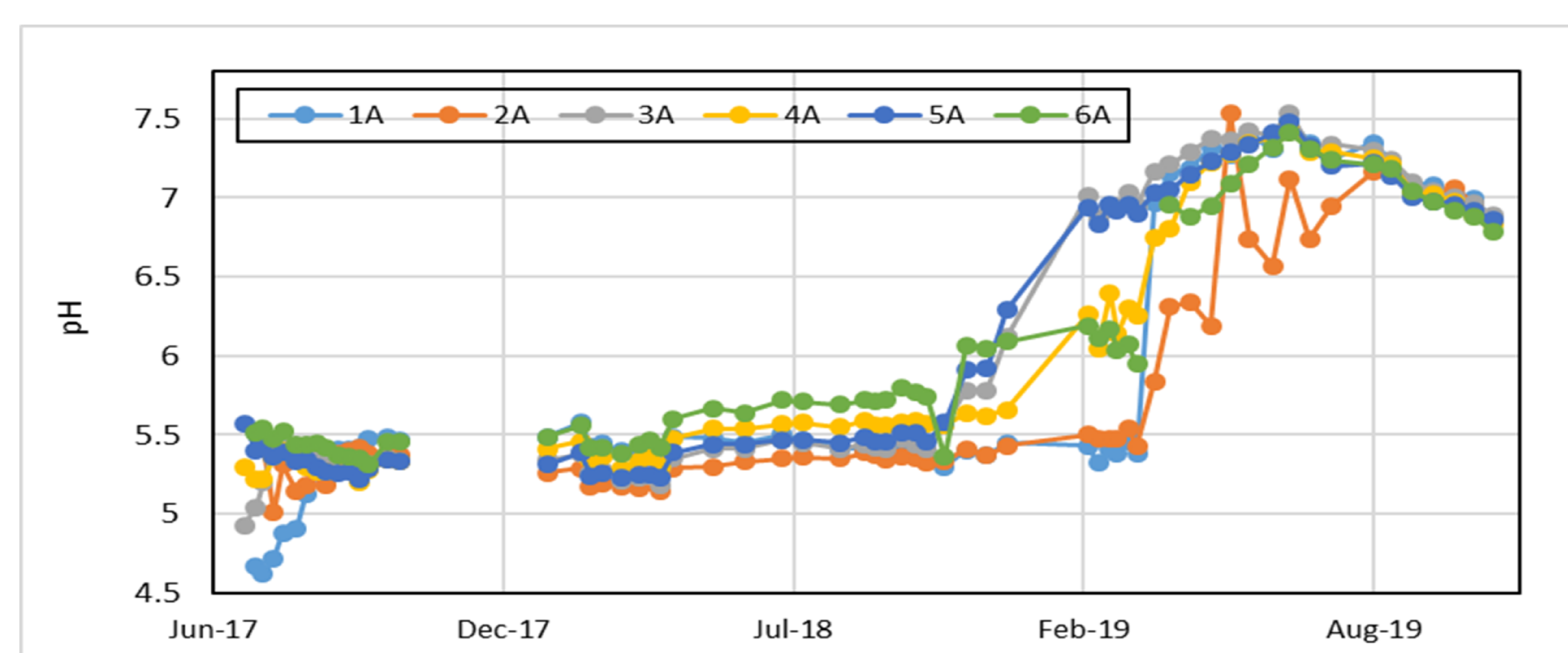

Figure 6. pH neutralization occurred more quickly for 5A and 3A suggesting a co-digestion benefit.

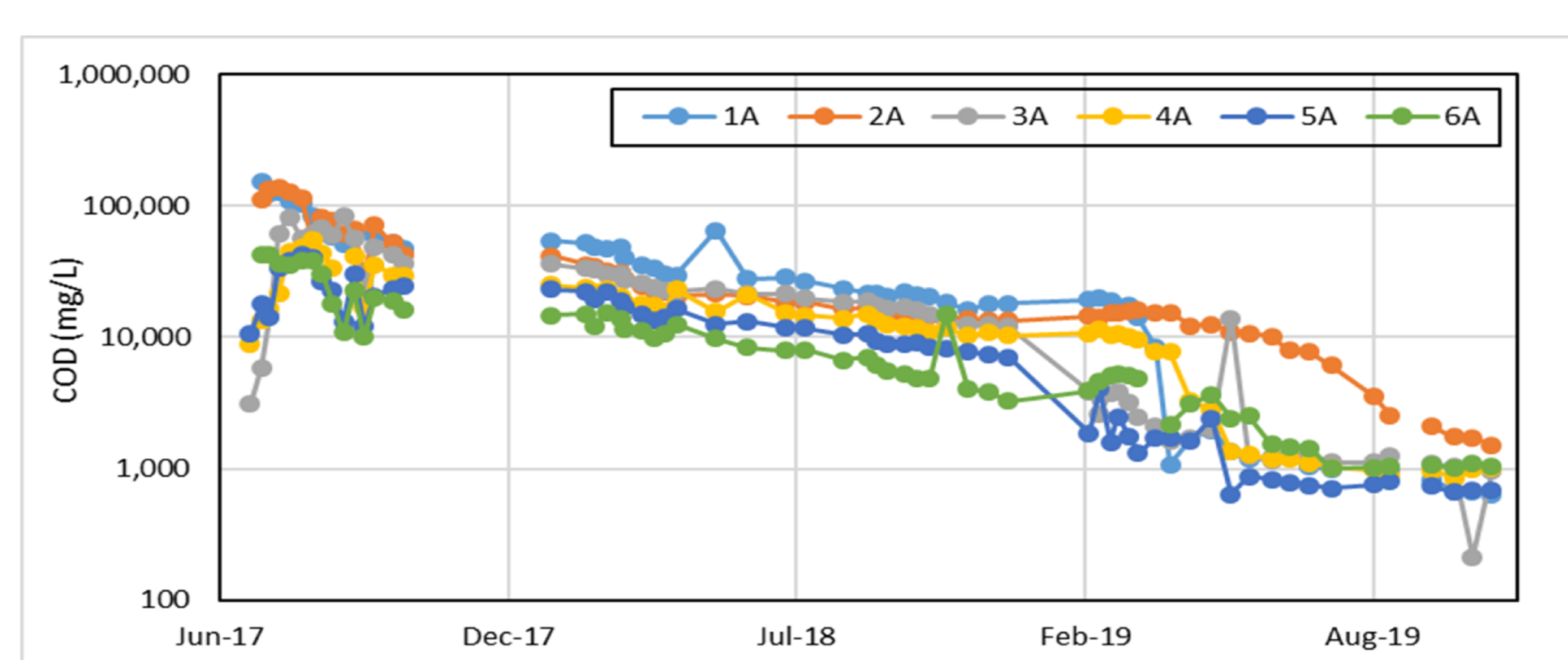

Figure 7. As pH neutralizes, COD significantly decreases.

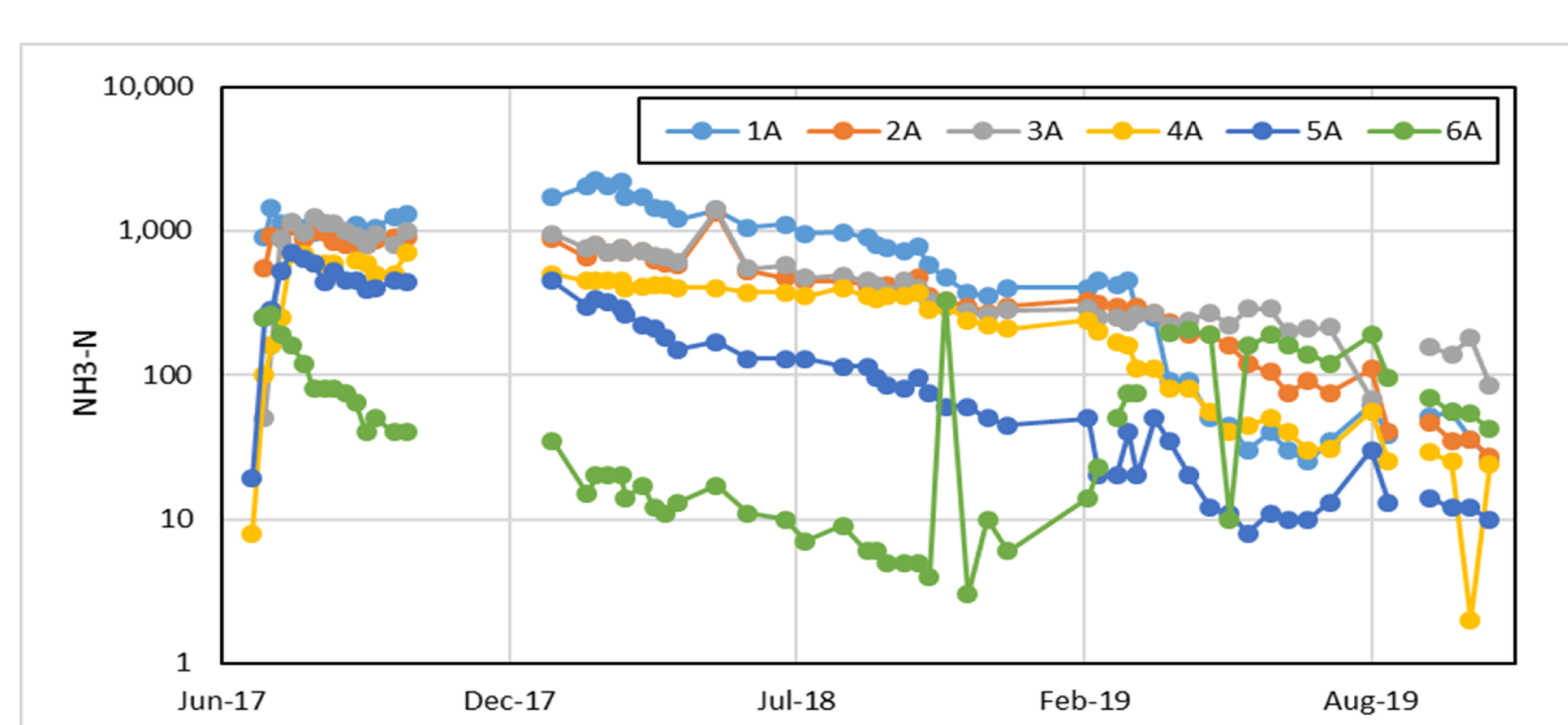

Figure 8. Ammonia concentration was well-correlated to food waste content in each of the lysimeters, until a spike in 6A was observed.