



Analysis of physical and biological degradation of PBDEs in historical limed biosolids and THP-AD treated biosolids

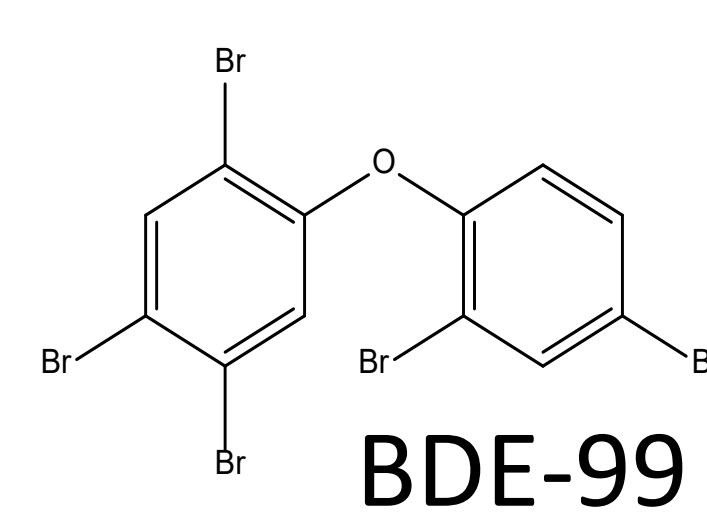
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Introduction



Biosolids are known to contain persistent organic pollutants, such as the flame retardant polybrominated diphenyl ethers (PBDEs). These chemicals were phased out of production and manufacturing in the U.S. by 2013, but are still ubiquitous in households and buildings. PBDEs are removed during the wastewater treatment process (WWTP) to varying extents and may persist in the environment.

During wastewater treatment process, solid sludge is separated from water and further treated in preparation for application as biosolids. In 2014, a Mid-Atlantic region WWTP plant implemented thermal hydrolysis process (THP) and anaerobic digestion (AD) in an effort to produce Class A biosolids. This THP-AD system replaces the production of Class B biosolids by lime stabilization previously produced at this WWTP.



THP: Heats sludge to 180 °C
55 - 138 PSI for 30+ minutes

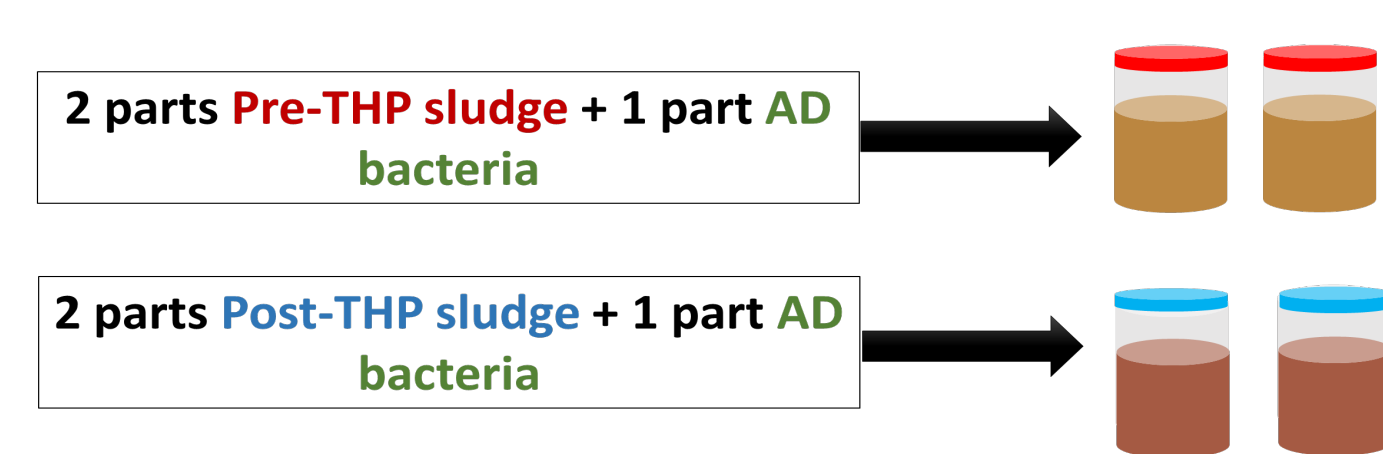
PBDEs can be degraded physically during the THP process. PBDEs can also be degraded biologically by obligate halo-respiring anaerobic bacteria. While it has been shown that methanogenic bacteria benefit from THP treatment, it is unknown if THP system also supports the growth of dehalogenating bacteria in AD.

This research aims to assess the combination of physical and biological PBDE degradation occurring at this WWTP plant by:
(i) Quantifying dehalogenating bacteria across the treatment system, and **(ii)** quantifying PBDEs in Class A and historical Class B biosolids.

Experimental Methods

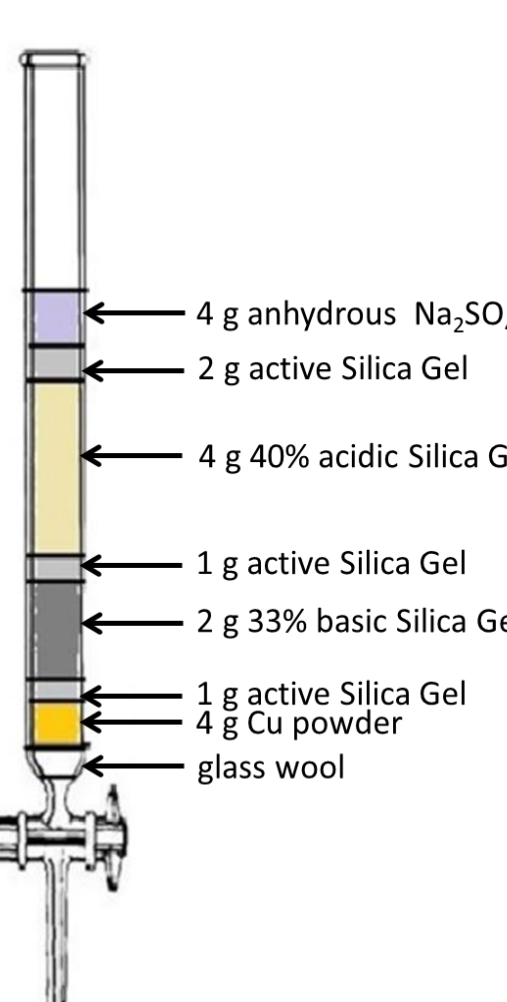
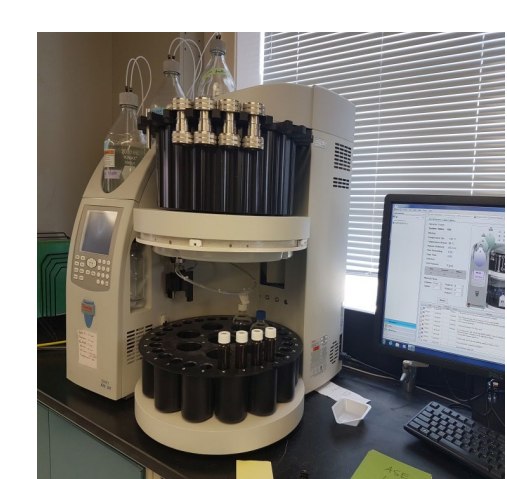
Biological Degradation:

- 1) Samples collected
- 2) DNA Extraction
- 3) PCR
- 4) Gel Electrophoresis
- 5) qPCR



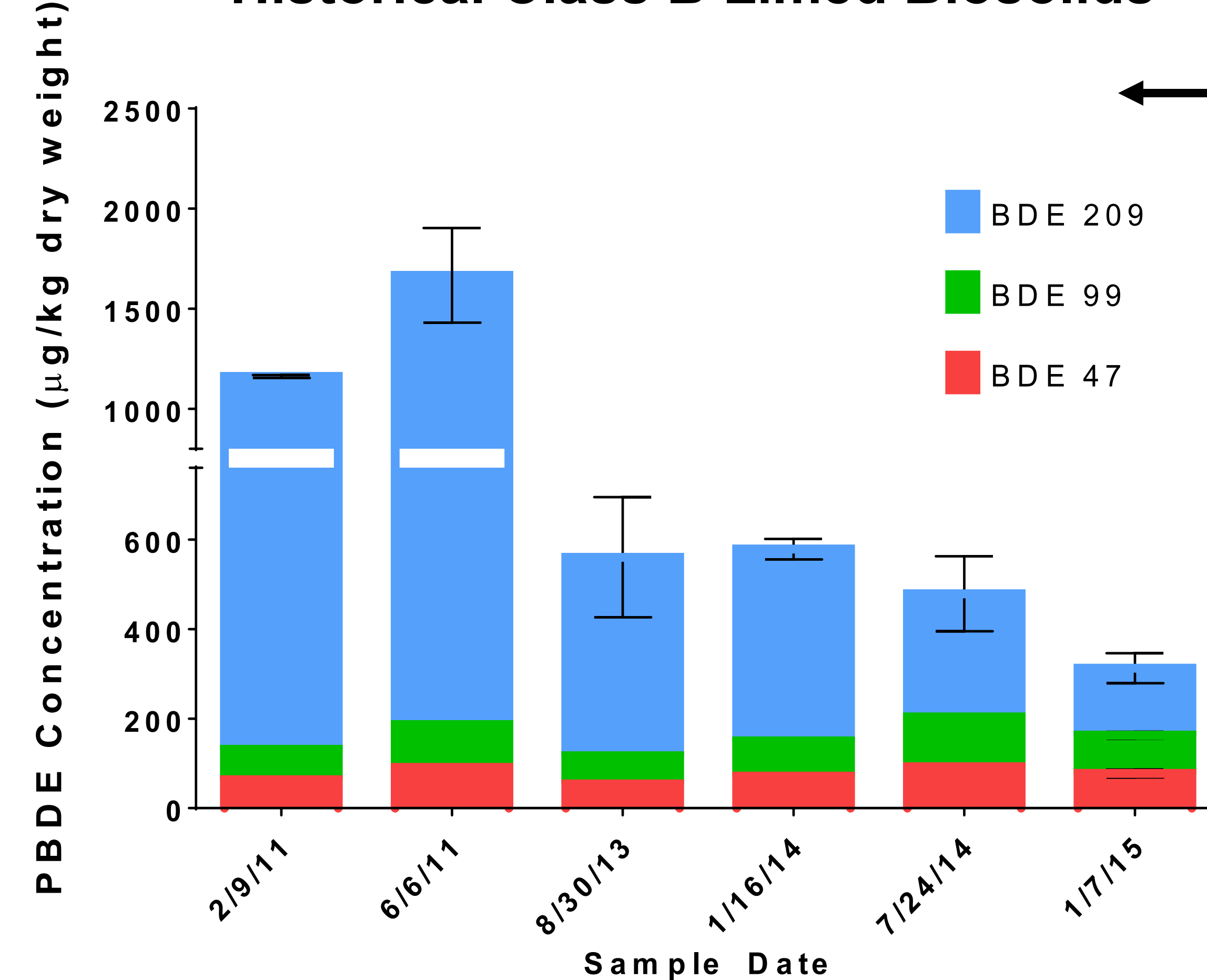
PBDEs in Biosolids:

- 1) Samples collected from final biosolids
- 2) Accelerated Solvent Extraction
- 3) Extract Cleanup using column
- 4) Zymark TurboVap to dry samples
- 5) GC-MS Analysis



PBDEs in Biosolids

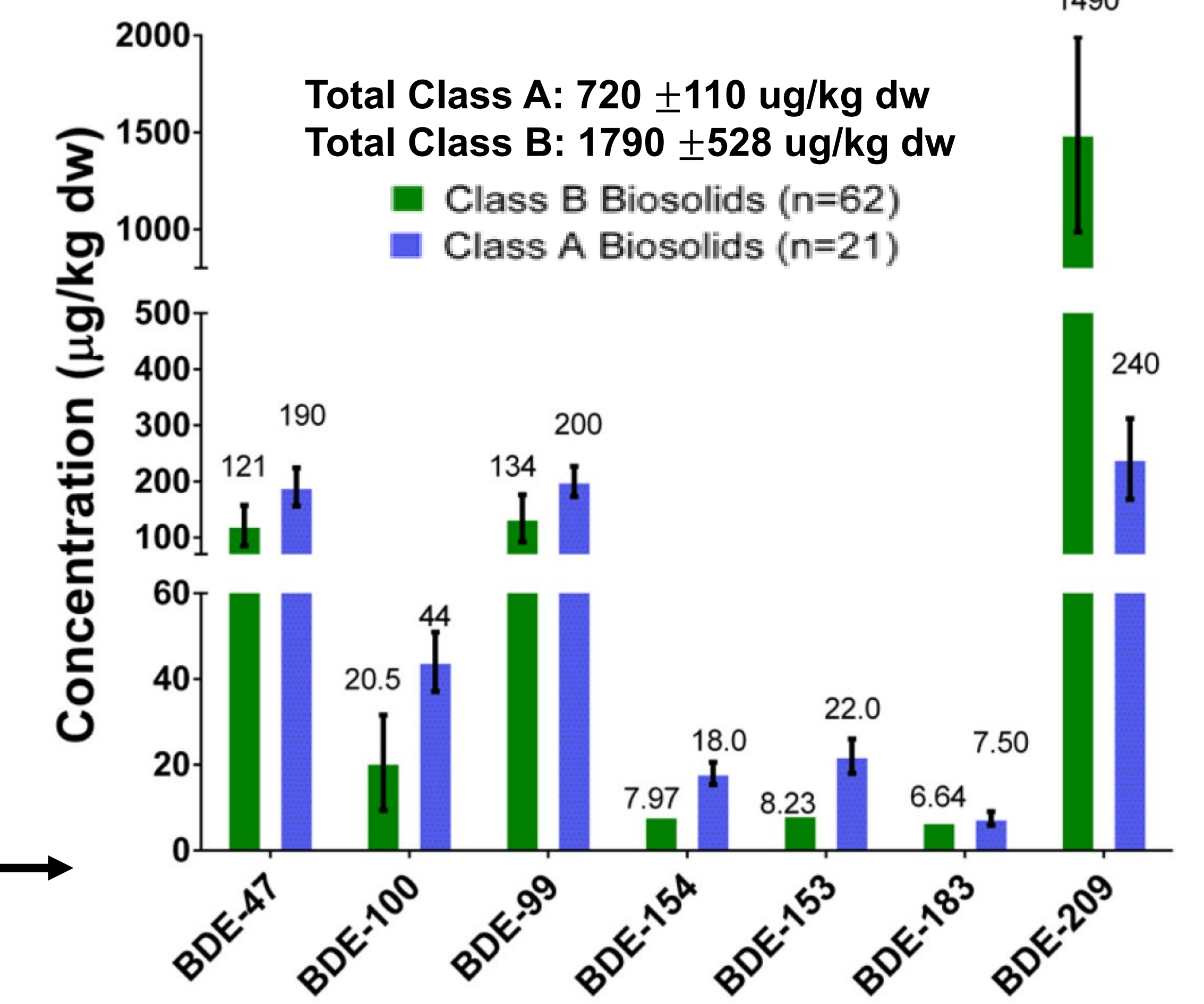
Historical Class B Limed Biosolids



- Decrease in concentration of total PBDEs in limed biosolids from 2011 to 2015
- Concurrent with phase out of PBDEs by US producers and importers by 2013

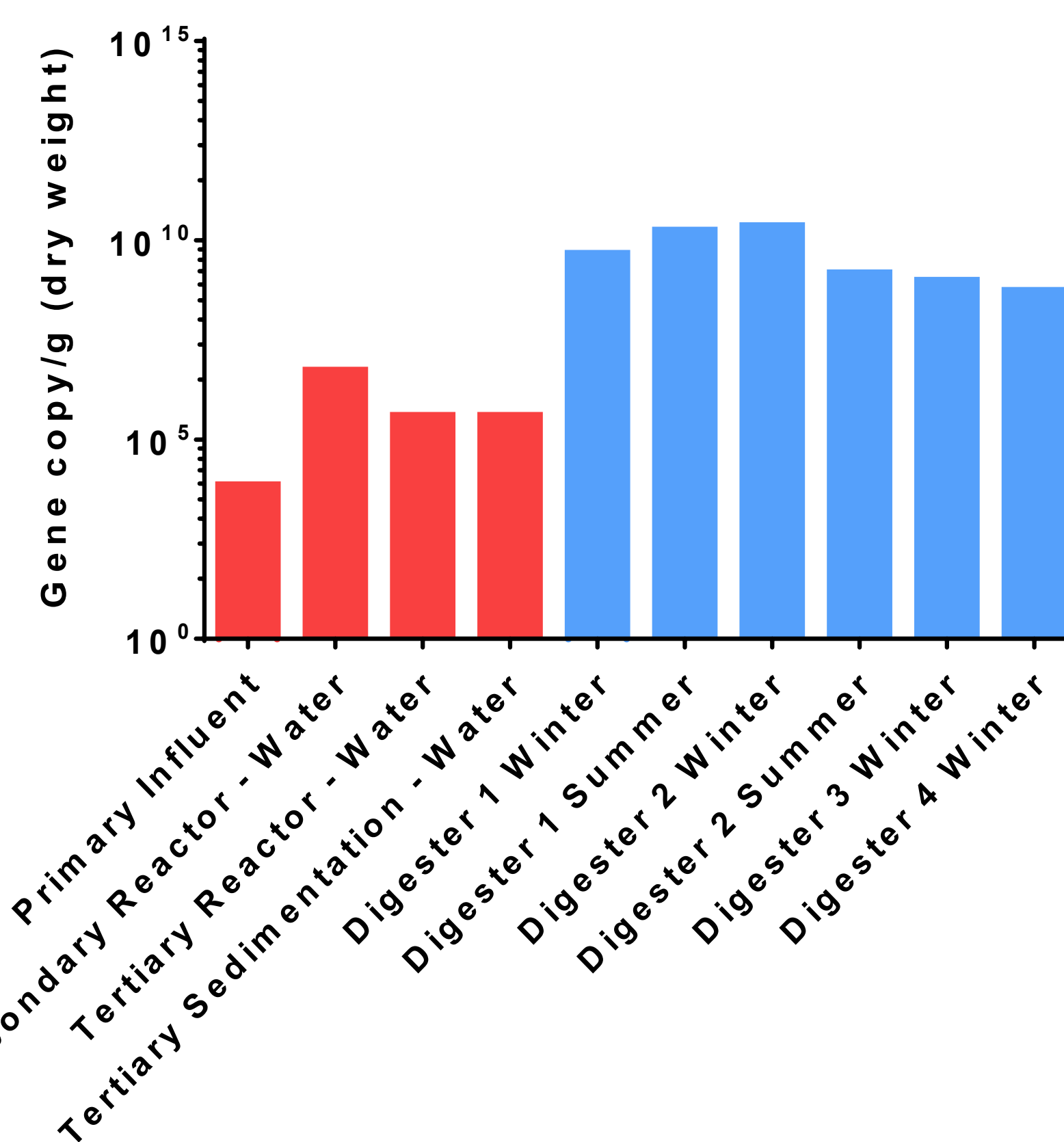
- Class B biosolids sampled between 2005-2011
- Class A biosolids sampled between 2014-2016

PBDEs in Treated Biosolids

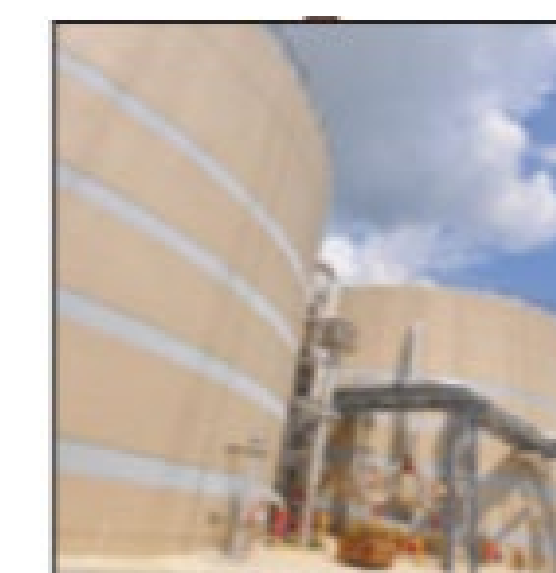


Biological Degradation: WWTP

Chloroflexi Dehalogenamonas across WWTP



Secondary Reactors



Anaerobic Digesters

Conclusions and Future Work

Biological Degradation:

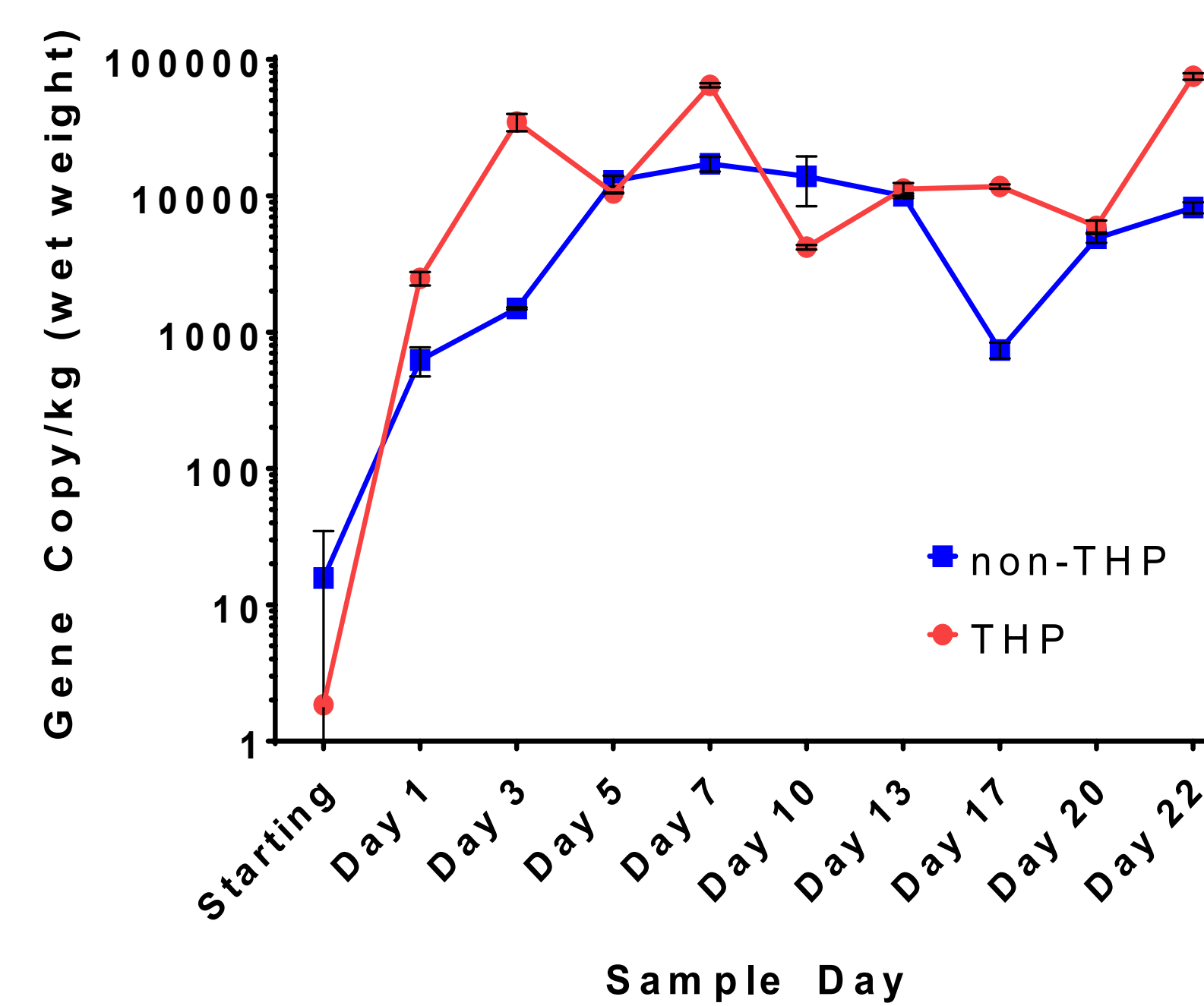
Among the biological reactors at this WWTP plant, the anaerobic digesters have the **greatest potential** to biologically degrade PBDEs. The addition of the THP system supports this potential. **Future work** will quantify PBDE concentrations (i) across the solids treatment train, and (ii) in mesocosm samples to further understand the combination of physical and biological degradation of PBDEs at this WWTP plant.

PBDEs in Biosolids:

There was a **significant decrease** in the total concentration of PBDEs in Class A biosolids compared to historical Class B biosolids produced at the same WWTP. THP-AD treatment may lead to **higher levels of degradation** of PBDE congeners than did lime stabilization. This may be of environmental concern, since smaller congeners are more toxic and mobile. **Future work** will further examine PBDE concentrations in historical Class B limed biosolids to investigate the possible effect of the US PBDE phase out on biosolids contamination at this WWTP plant.

Biological Degradation: THP-AD

Dehalobacter in AD Mesocosms



qPCR shows growth of *Dehalobacter* in both THP and non-THP treated samples

Both environments have the potential to biologically degrade PBDEs