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### WP 2.B Subsurface Contamination

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# Degradation of selected endocrine disruptors during sewage sludge composting

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# Background

- Sewage sludge
  - Source of organic carbon and other nutrients → use as a fertilizer
  - Residual amounts of (micro)pollutants → potential source of environmental contamination

Černá, T., Ezechiáš, M., Semerád, J., Grasserová, A. and Cajthaml, T. (2021) Evaluation of estrogenic and antiestrogenic activity in sludge and explanation of individual compound contributions. J. Hazard. Mater. **423**, 127108.
http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do (Sewage sludge production and disposal, eurostat)

# Background

- Sewage sludge
  - Source of organic carbon and other nutrients → use as a fertilizer
  - Residual amounts of (micro)pollutants → potential source of environmental contamination
- Composting of sewage sludge
  - One of the most common sludge stabilization and sanitation processes

Černá, T., Ezechiáš, M., Semerád, J., Grasserová, A. and Cajthaml, T. (2021) Evaluation of estrogenic and antiestrogenic activity in sludge and explanation of individual compound contributions. J. Hazard. Mater. **423**, 127108.
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# Background

- Endocrine-disrupting chemicals (EDCs)
  - Exogenous substance or mixture that alters function(s) of the endocrine system and consequently causes adverse health effects in an intact organism, or its progeny, or (sub)populations

→ Potentially hazardous at low levels

Vieira, W. T., De Farias, M. B., Spaolonzi, M. P., Da Silva, M. G. C. and Vieira, M. G. A. (2021) Endocrine-disrupting compounds: Occurrence, detection methods, effects and promising treatment pathways—A critical review. J. Environ. Chem. Eng., Elsevier **9**, 104558.

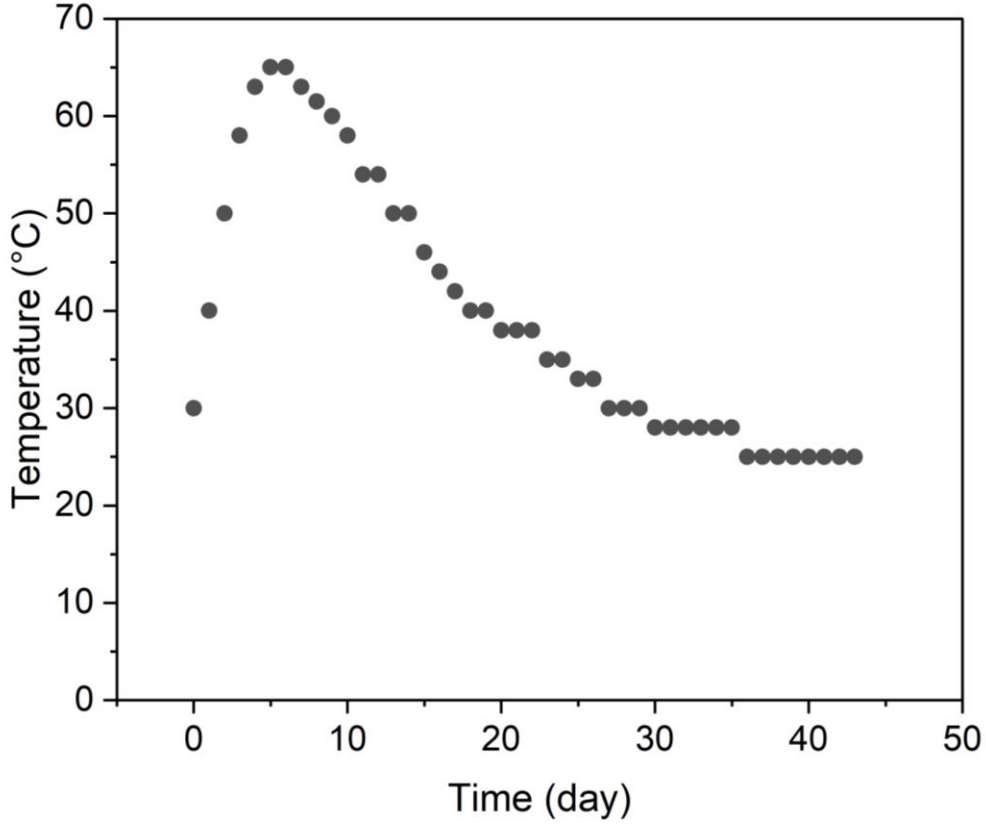
# Aims of the study

- Monitoring of the concentrations of selected EDCs during 100 days of thermophilic composting of sewage sludge
- Simultaneous assessment of estrogenic activity

# Methods

- Small-scale thermophilic composting
- Glass reactors ($V$ = 4 L), controlled temperature, aeration conditions and moisture content (60% w/w)

temperature profile



**Co-substrate**
(wheat straw, poultry manure, gypsum)

**Sewage sludge**
(anaerobically digested sludge from municipal wastewater treatment plant)

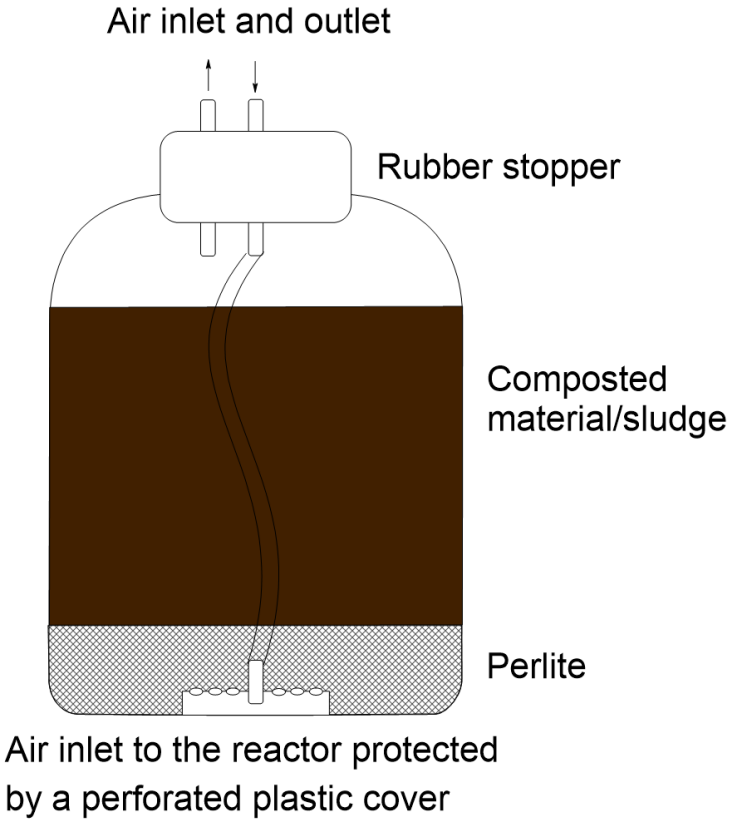
**Starting mixture**
40% (dw) sludge content

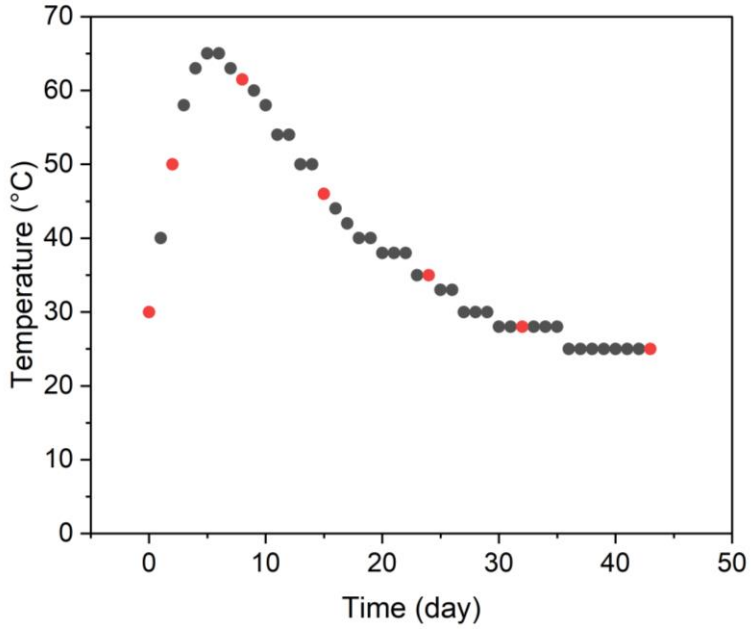
**Incubation sludge control**

**Sludge control** (25 °C, no aeration)

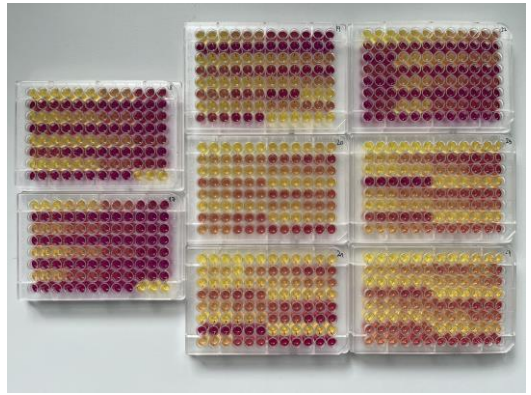
Reactors in
a modified incubator
with external aeration


# Experimental design




Sampling on days 0, 2, 8, 15, 24, 32, 43, and 100



**Yeast estrogen screen** (Routledge and Sumpter, 1996)

Accelerated solvent extraction of samples

**Chemical analysis** of selected endocrine disruptors (LC-MS/MS)

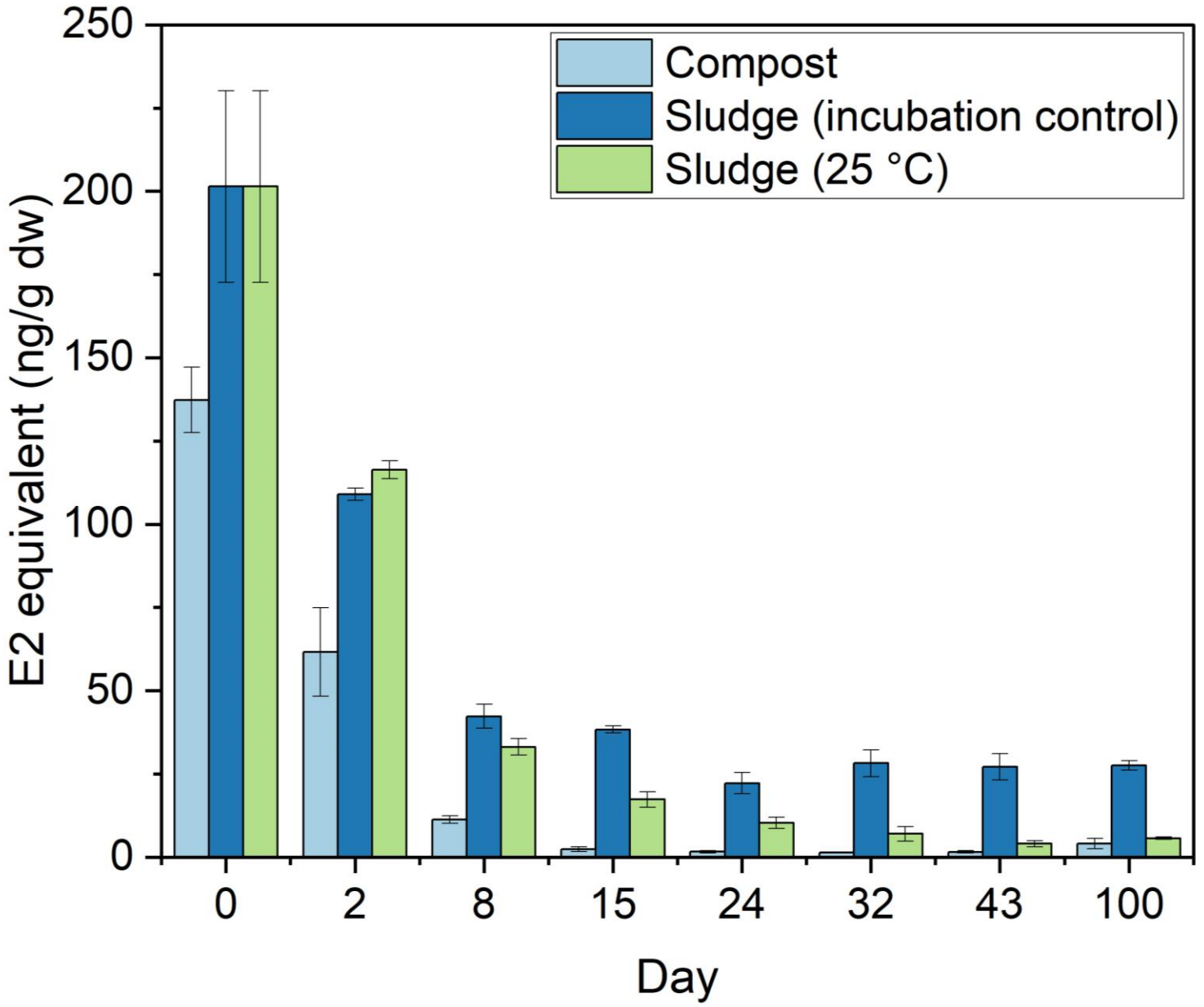
# Sampling and further analysis

# Results

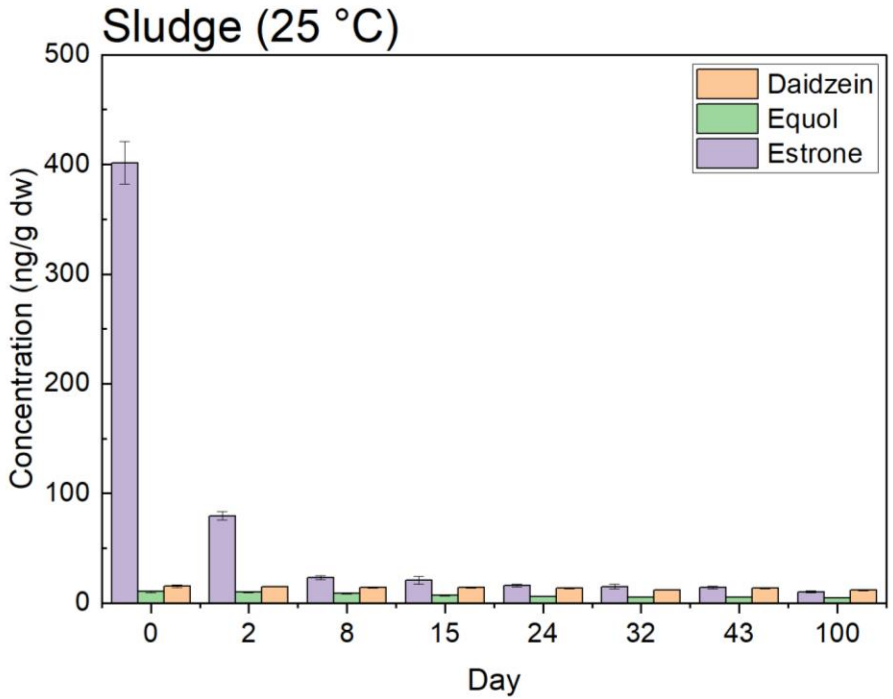
- Only some of the 17 selected EDCs were **detected** in sludge or compost
  - Natural EDCs: 17$\alpha$-estradiol, 17$\beta$-estradiol, estriol, **estrone**, $\alpha$-zearalenol, equilin, **equol**, **daidzein**, **genistein**, **testosterone**
  - Synthetic EDCs: **bisphenol A**, **bisphenol F**, **bisphenol S**, 17$\alpha$-ethinylestradiol, norethindrone, norgestrel, **triclosan**

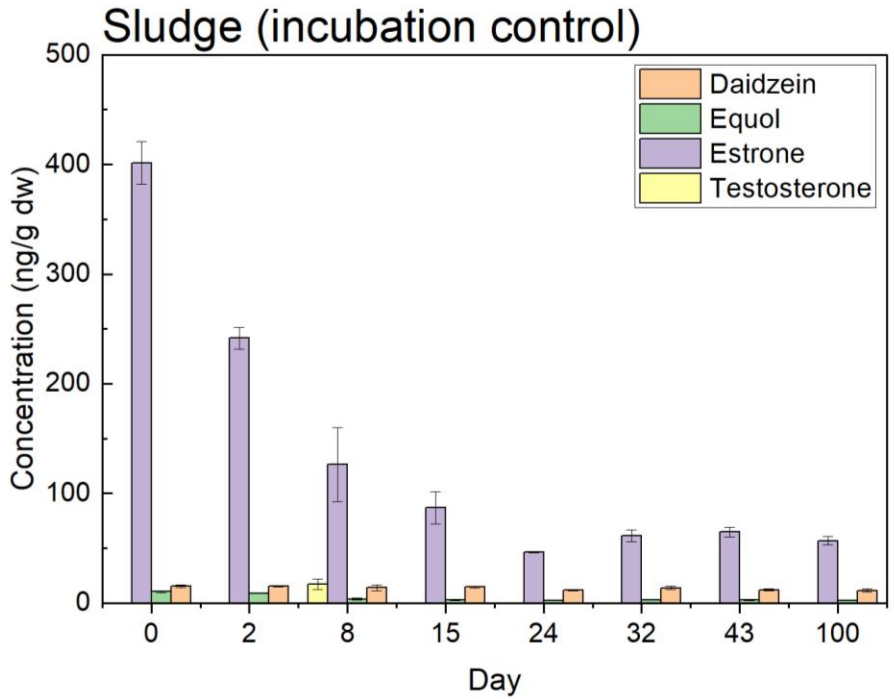
# Evaluation of estrogenic activity in compost and sludge samples

- More rapid decrease of estrogenic activity was observed in the compost compared to both sludge controls
- The highest residual activity was in the incubation control

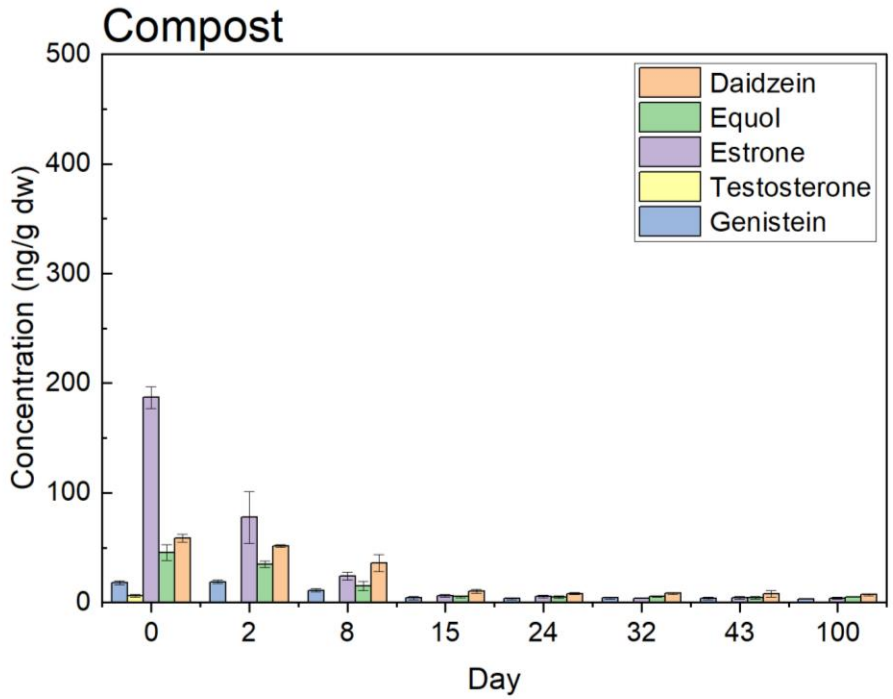


# Mean concentrations of natural EDCs

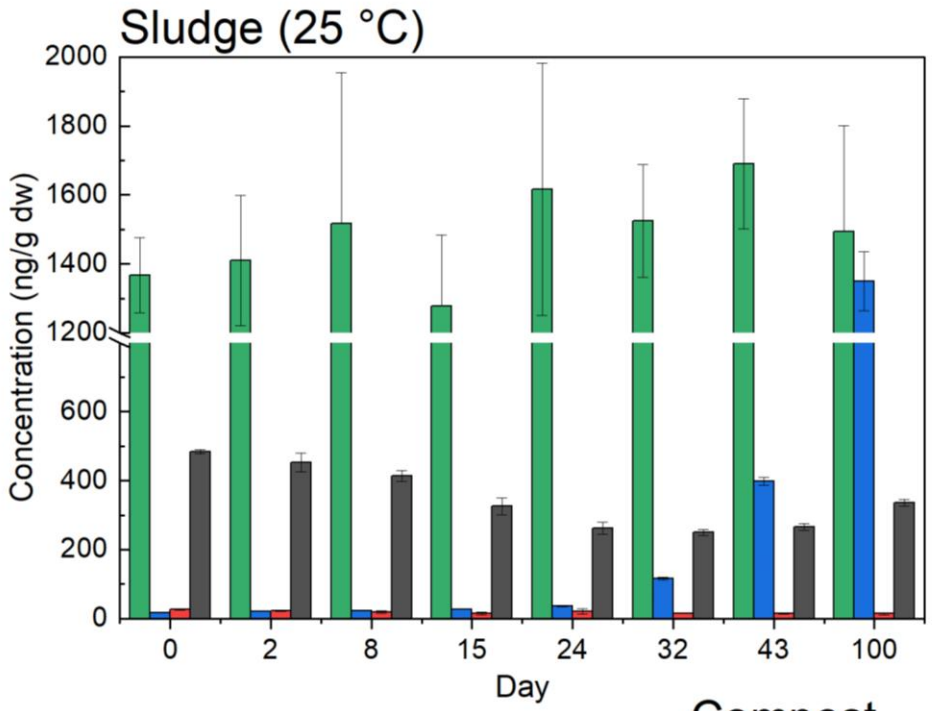


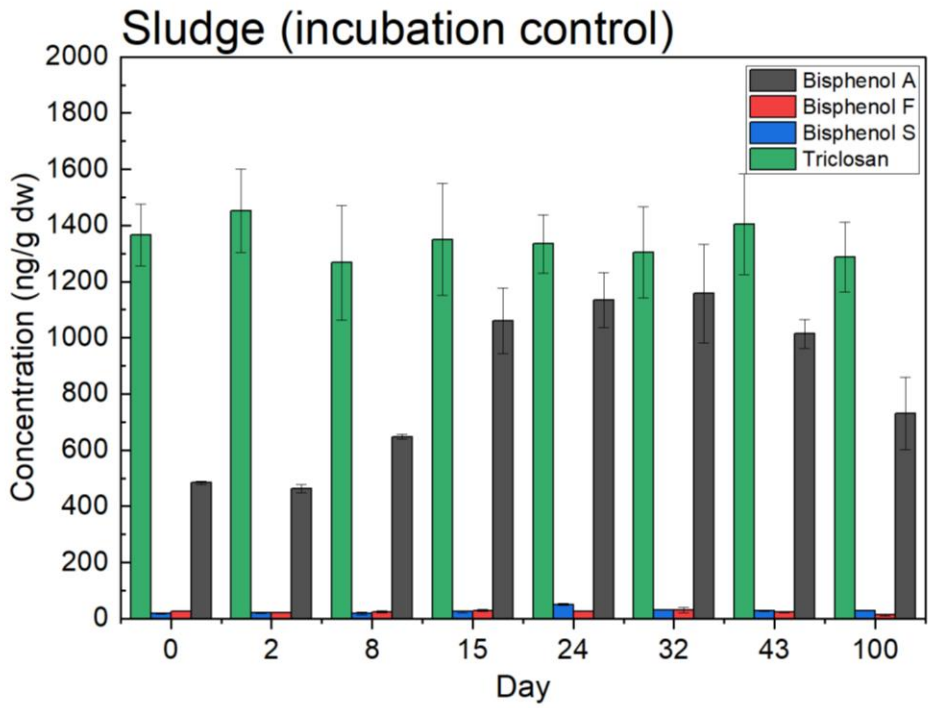




- A decrease in the concentration of estrone corresponds with a decrease in the estrogenic activity

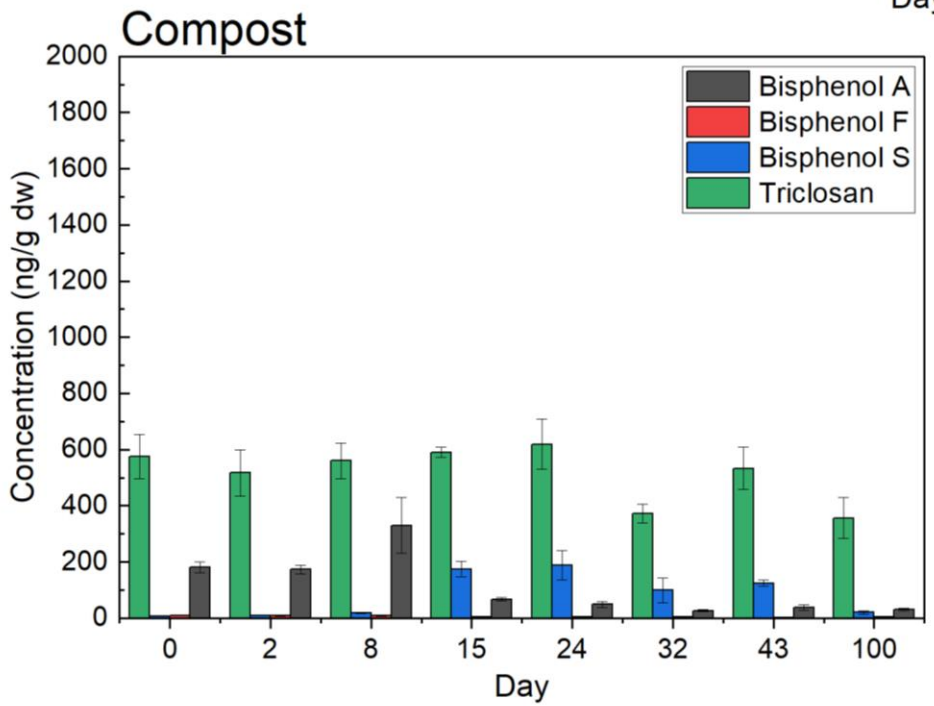


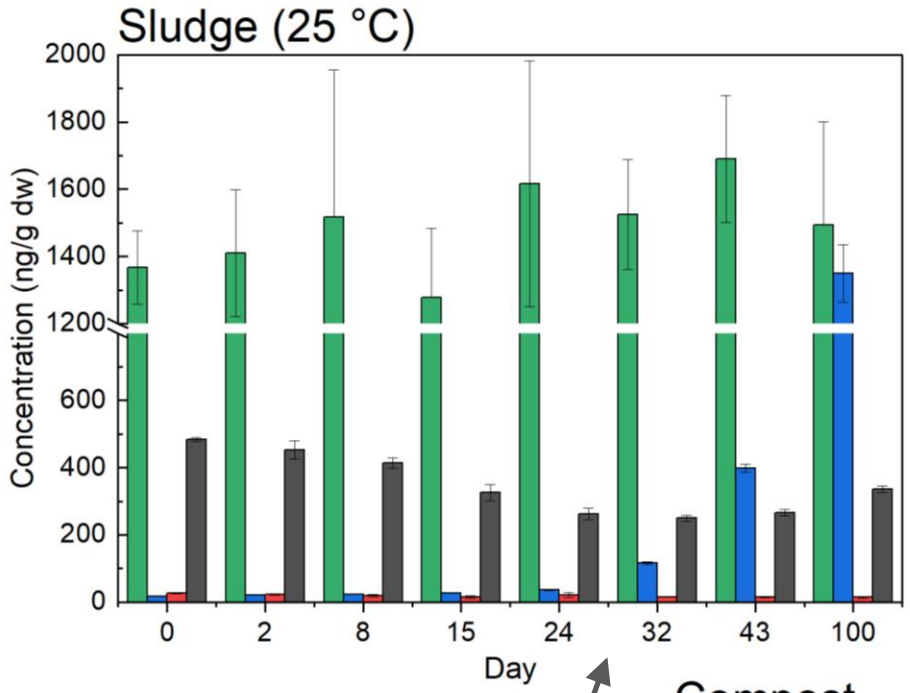
# Mean concentrations of synthetic EDCs

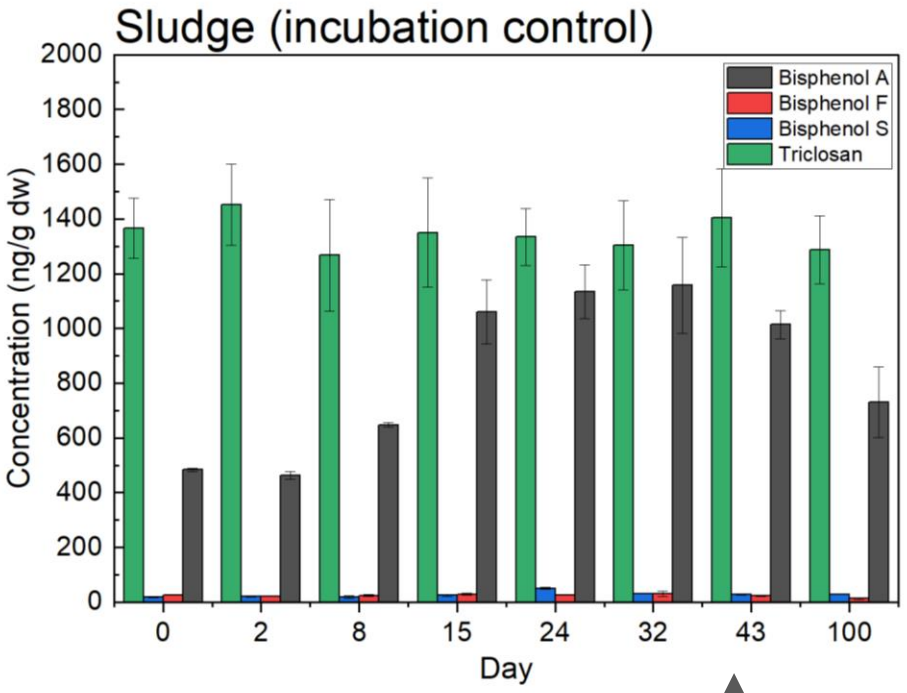


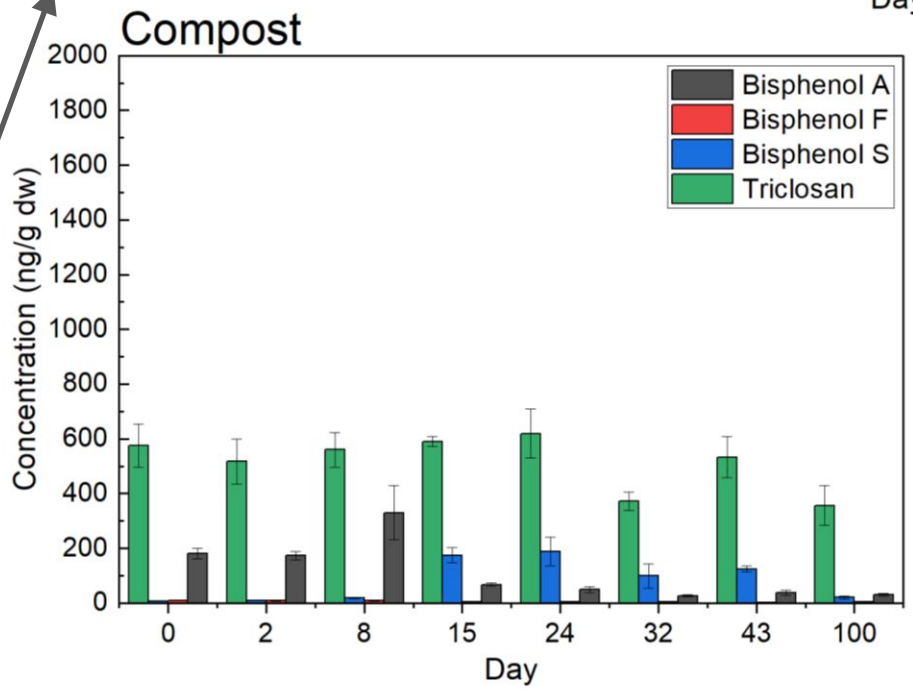




- No observed degradation of triclosan
- Significant changes in concentrations of bisphenol A and bisphenol S





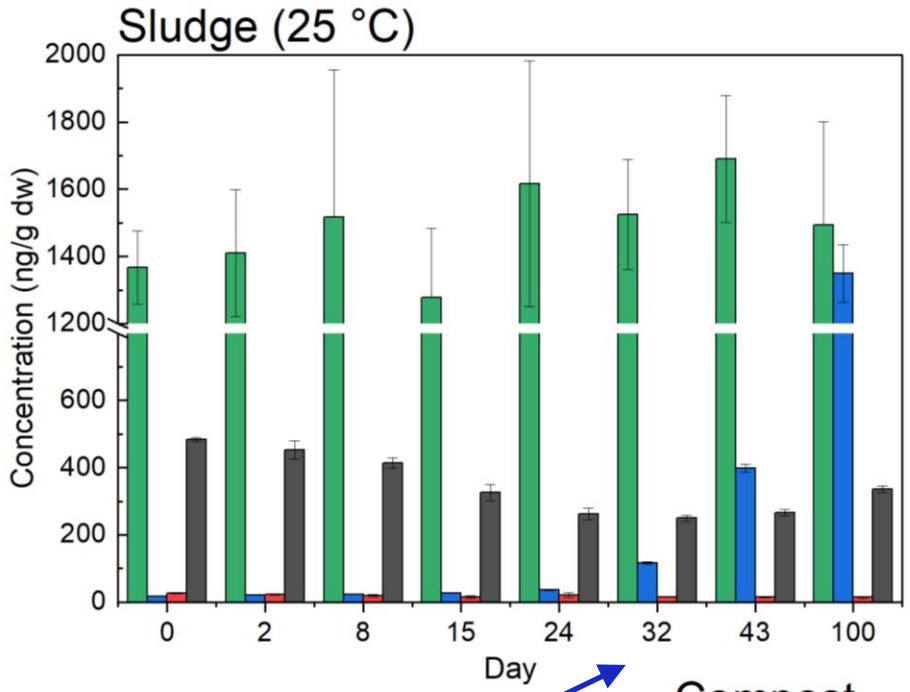



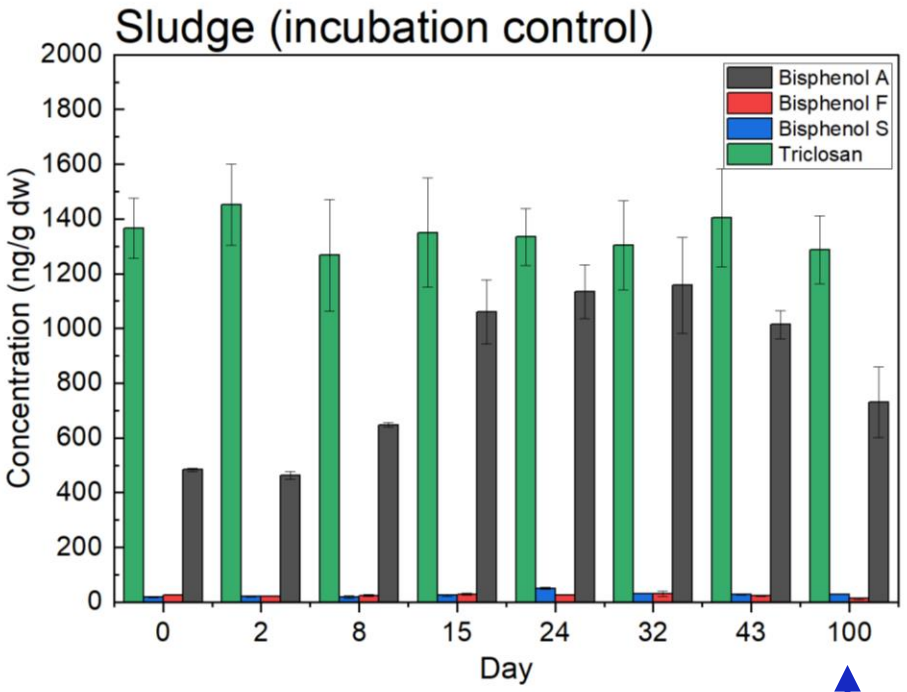




## Bisphenol A

- Residual amount (compared to day 0)
  - sludge control: 69%
  - **compost: 17%**

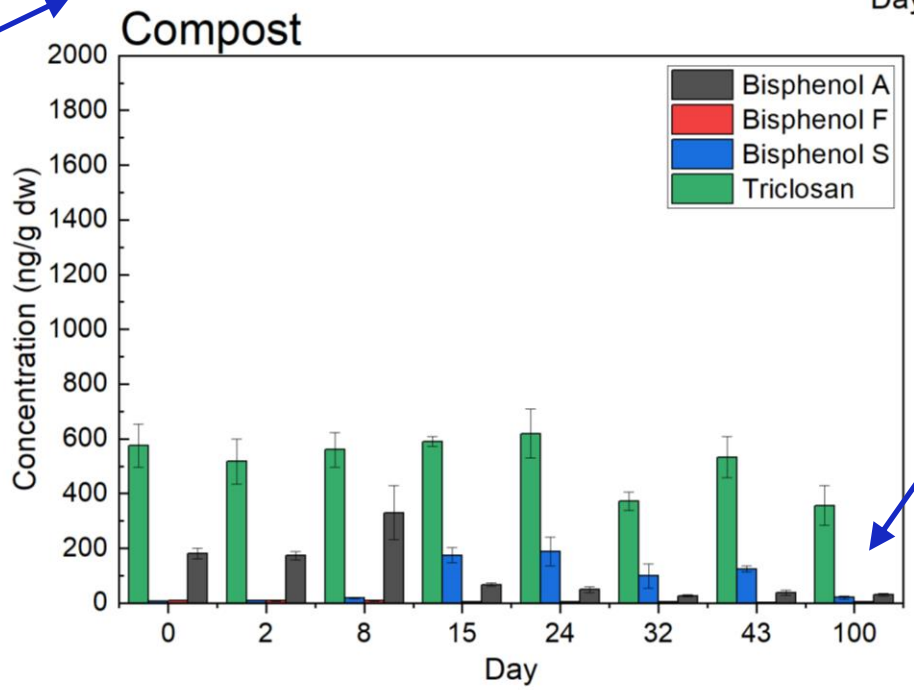
- The initial and final concentrations of bisphenol A were comparable despite a temporary increase (incubation control)




# Bisphenol S

- **The final concentration was almost a hundred times as high as the initial concentration (sludge control)**




- The initial and final concentrations of bisphenol S were comparable (compost and incubation control)

# Conclusions and future prospects…

- Changes in bisphenol concentrations occurred probably due to the presence and hydrolysis of their conjugated forms (e.g. glucuronide conjugates)

# Conclusion and future prospect…

- Changes in bisphenol concentrations occurred probably due to the presence and hydrolysis of their conjugated forms (e.g. glucuronide conjugates)
- Options of conjugate analysis
  - Direct analysis of conjugates (targeted or non-targeted)
  - Analysis of parent EDCs before and after hydrolysis/solvolysis treatment

# Acknowledgements

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Thank you for your attention!

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