Anaerobic phenol degradation via adsorption on conductive materials based on walnut shells

A.I Ntelopoulou[1], M. Alexandropoulou[2], C.A. Aggelopoulos[2], G. Antonopoulou[1]

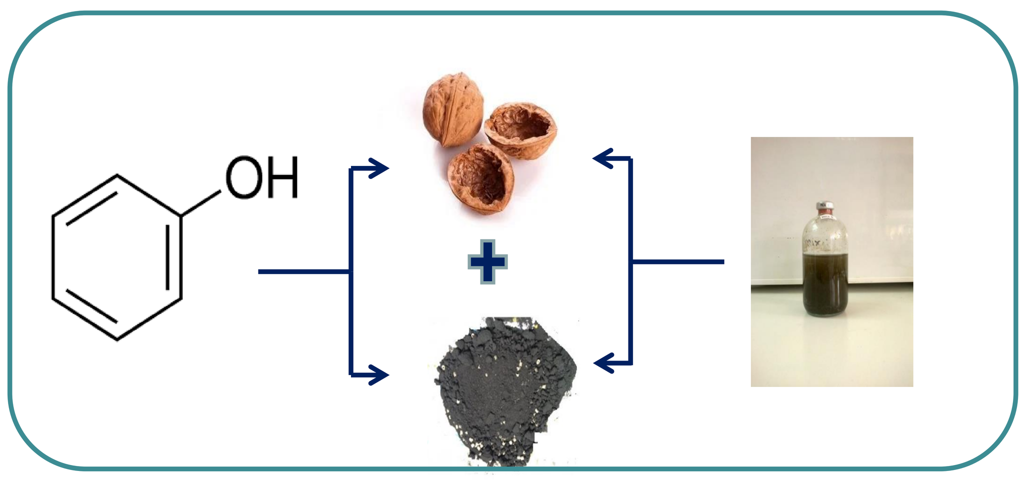
[1]Department of Sustainable Agriculture, University of Patras, 2 Georgiou Seferi str., GR 30100, Agrinio, Greece.
[2]Institute of Chemical Engineering Sciences, 11 Stadiou st., Platani, GR 26504, Patras, Greece.
geogant@upatras.gr

Introduction

Phenol is a toxic, intermediate chemical and common by-product in many industrial applications. During the last decades increasing attention has been paid to discovering alternative ways of removing phenols, establishing a wide range of different processes. Compared with other treatment technologies, anaerobic digestion (AD) is of considerable interest for its numerous advantages, such as lower energy consumption, lower biomass yield, and its ability to promote energy recovery in the form of methane. However, the high bio-toxicity of phenol to microbes and the low efficiency of hydrogen/formate interspecies electron transfer between syntrophic bacteria and methanogens limit the conversion of phenol to methane (He et al., 2019). Therefore, the addition of functional materials appears to provide a superior approach for enhancing anaerobic phenol degradation (Tian et al., 2020). Conductive materials, such as magnetite, carbon nanotubes and biochar have been used to enhance syntrophic methanogenesis by triggering direct interspecies electron transfer.

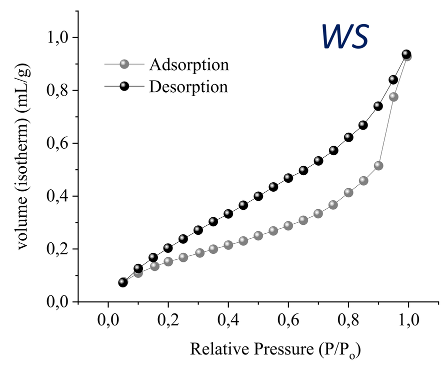
Objective

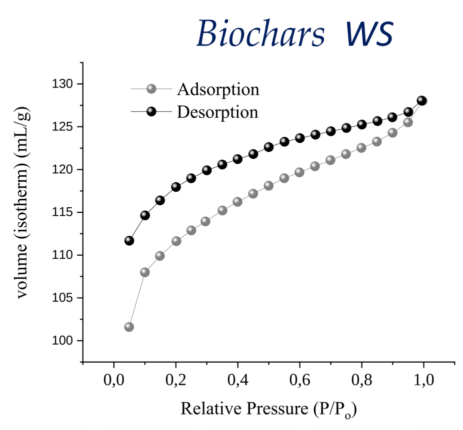
In this study, biochars, prepared by pyrolyzing walnut shells (WS) at 520 °C for 1 h under nitrogen atmosphere, as well as WS without any treatment were used in the AD of phenolic compounds, through biochemical methane potential (BMP) tests. Glucose at 2 g/L chemical oxygen demand (COD) supplemented with pure phenol or syringic acid at 0.5 g/L, was used as substrates.



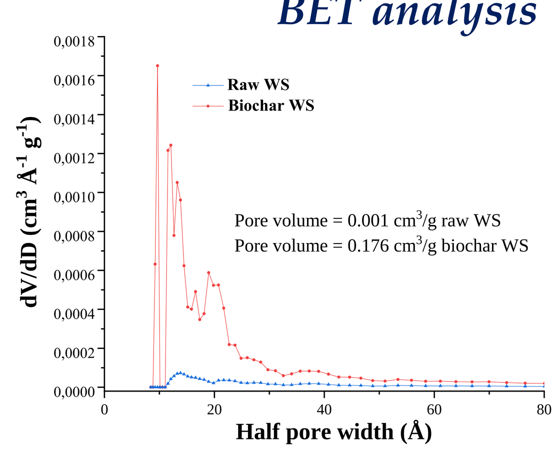
Preparation and Characterization of materials

Biochars: pyrolysis of WS, 520 °C, 1h, heating rate 10 °C/min. N_2 atmosphere, flow rate 2.4 L/min.



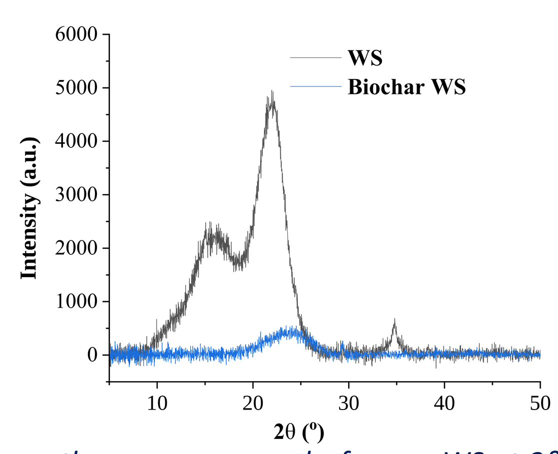


BET analysis



Sample	BET Surface Area (m^2/g)
WS	0.617
Biochars WS	317.1

XRD analysis



✓ There were three common peaks for raw WS at 2θ angles of 16.0°, 22.0° and 34.6° which are dependent on (110), (002) and (004) and all of them are related to cellulose type I. The broad peak in the XRD of raw WS sample and derived biochars at 2θ angle of 22.0° revealed the presence of an amorphous phase mainly consisting of cellulose, hemicelluloses, and lignin.

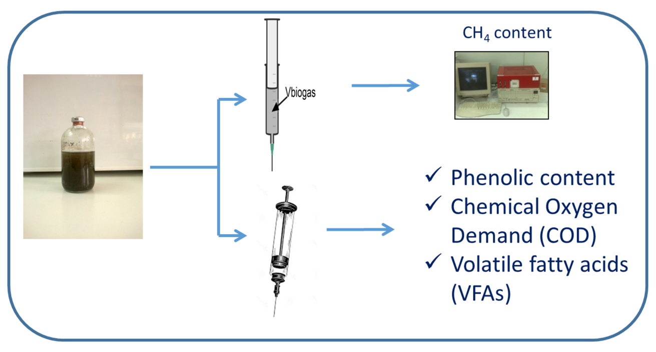
Materials and Methods

BMP experiments

Substrate: 2 different types of phenolic compounds (Syringic acid + pure phenol) + glucose at 2 gCOD/L

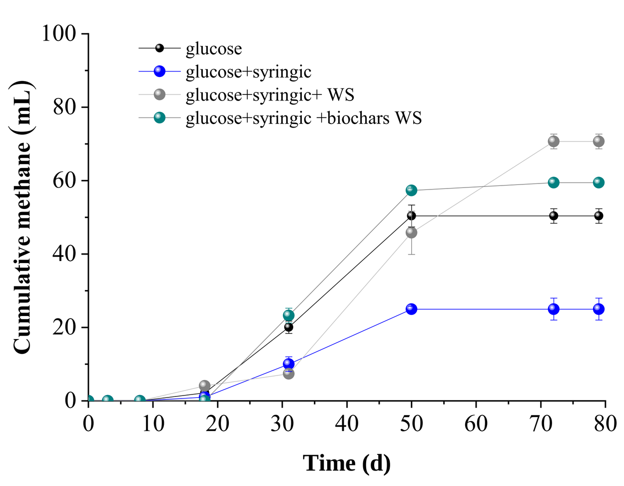
Inoculum: 20 % v/v of anaerobic sludge from wastewater treatment plant

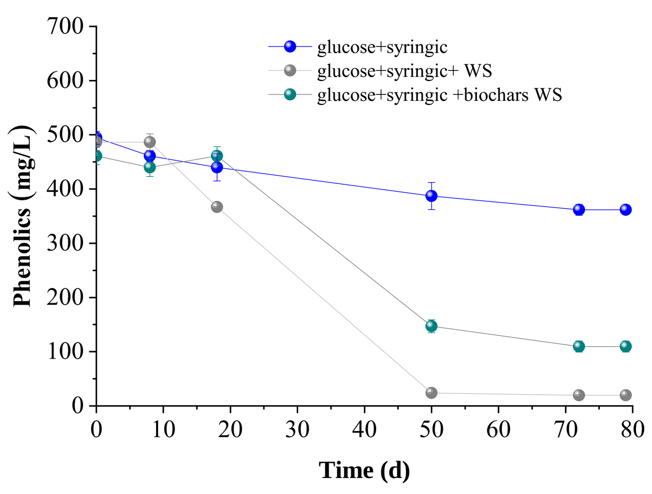
Materials: WS or biochars of WS (1 g/L)

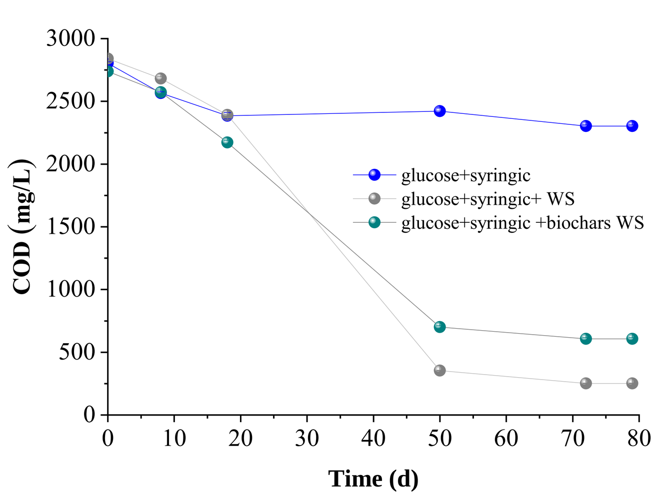


Results and discussion

Syringic acid





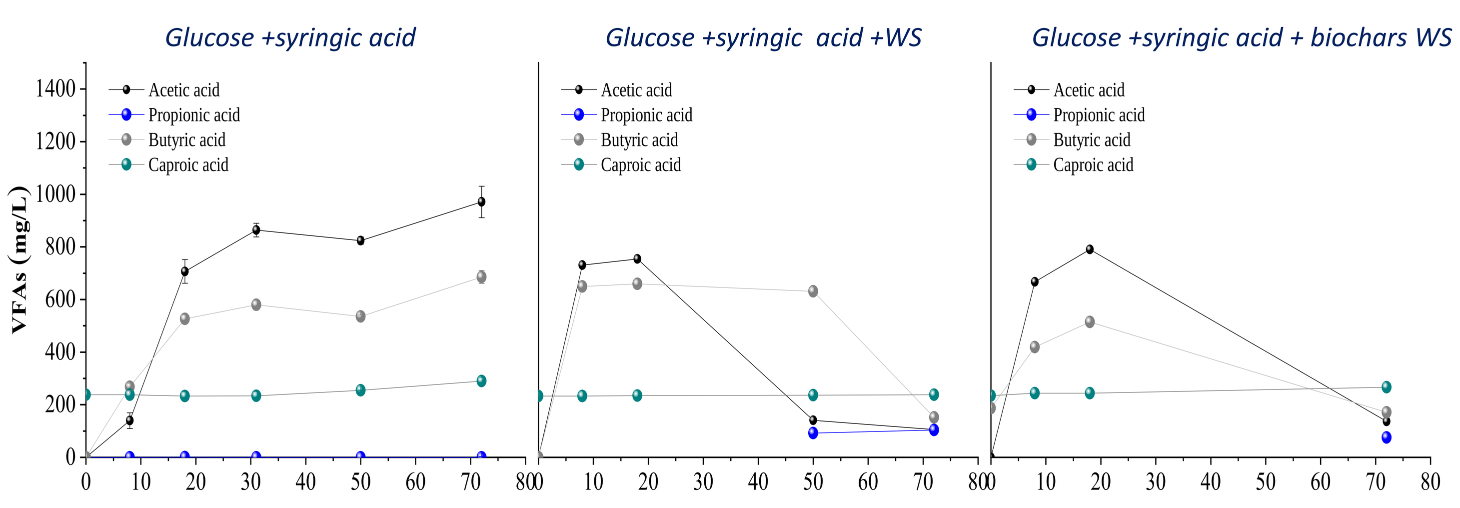


✓ Addition of raw WS as well as biochars in the experiments of glucose with syringic acid, enhanced methane generation.

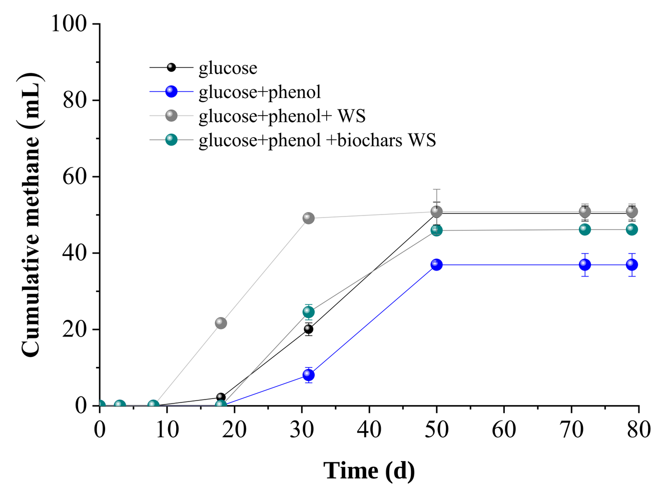
✓ Methane generation was highest in the experiments with raw WS addition, accompanied by the highest phenols degradation and COD reduction.

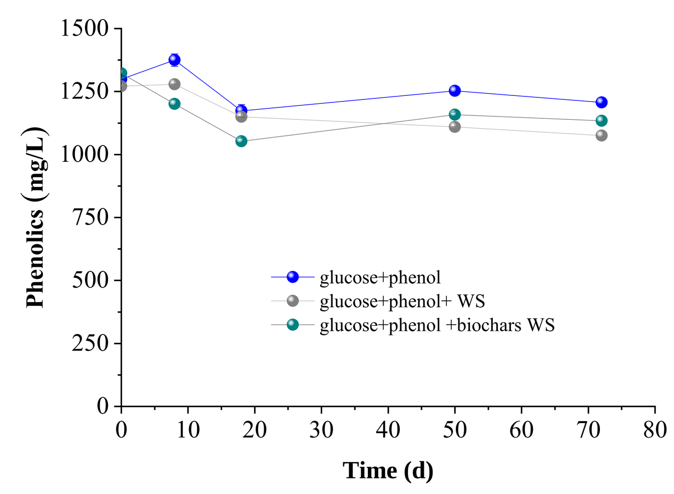
✓ COD reduction was due to the consumption of VFAs produced, during the experiment.

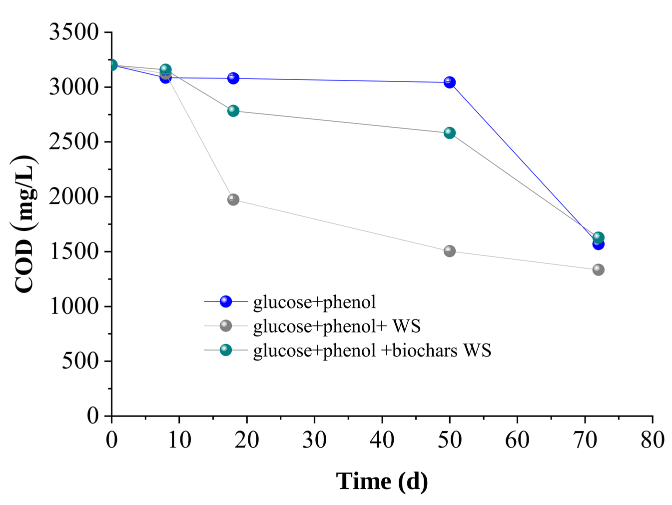
✓ In the case of biochars, their higher surface area compared to the raw WS, did not promote methanogenesis



Phenol



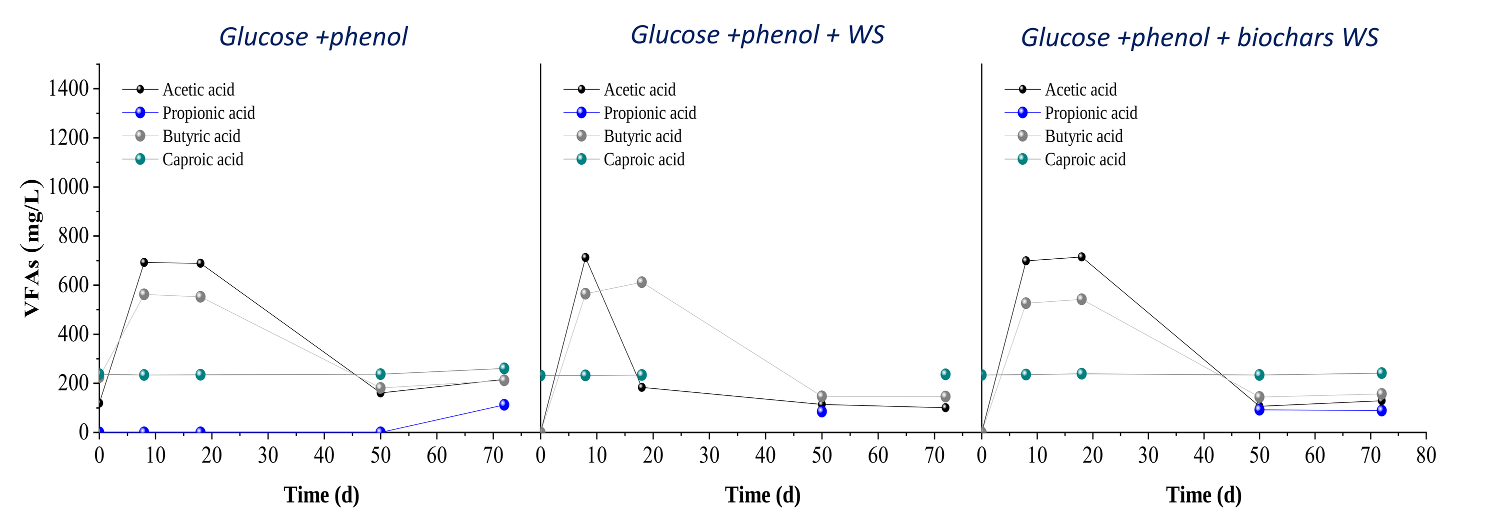




✓ In the case of phenol, addition of raw WS as well as biochars did not enhance cumulative methane generation, as in the case of syringic acid.

✓ Addition of WS enhanced the rate of methane production.

✓ Addition of WS or biochars did not promote the degradation of phenolics.Only glucose was degraded, as also confirmed by COD and VFAs measurements.



Conclusions

✓ Syringic acid degradation was promoted by the addition of WS or biochars WS.

✓ In the case of phenol, addition of raw WS or biochars did not enhance cumulative methane generation. Addition of WS enhanced only the rate of methane production.

✓ In the case of syringic acid, methane generation was highest in the experiments with raw WS addition, accompanied by the highest phenols degradation as well as VFAs and COD reduction.

➢ Tian, X., Song, Y., Shen, Z., Zhou, Y., Wang, K., Jin, X., Han, Z., Liu, T., 2020. A comprehensive review on toxic petrochemical wastewater pretreatment and advanced treatment. J. Clean. Prod. 245, 118692.

➢ He, C., Lin, W., Zheng, X., Wang, C., Hu, Z., Wang, W., 2019. Synergistic effect of magnetite and zero-valent iron on anaerobic degradation and methanogenesis of phenol. Bioresour. Technol. 291, 121874.

This paper has been financed by the funding programme "MEDICUS", of the University of Patras.