Sustainable Management of Organic Waste: Evaluating the Potential of Hydrothermal Carbonization in the North Aegean Region, Greece

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Global climate change poses significant challenges, driven primarily by human activities such as the burning of fossil fuels and unsustainable waste management practices. Addressing this issue requires multifaceted approaches, including reducing greenhouse gas emissions, utilizing sustainable biomass sources, and enhancing carbon sequestration (European Commission, 2023). Global climate is projected to continue to change over the 21st century and beyond (Walsh *et al*., 2014). This study focuses on developing a system for the assessment of the feasibility of implementing hydrothermal carbonization as a waste treatment method. A Strengths, Weaknesses, Opportunities, and Threats (S.W.O.T.) analysis is carried out, and the developed system for the utilization of hydrothermal carbonization process in Greece is applied in the North Aegean Region, where 7 organic waste treatment facilities are mentioned in the regional planning.

Every day, a large amount of food waste is directed to landfills, causing financial loss and additional environmental degradation, highlighting the urgency of finding a suitable approach to treating organic waste. As moisture content makes up 75% of the food waste, hydrothermal carbonization is a beneficial process for the treatment of organic waste since it does not require extensive drying. Hydrothermal carbonization of food waste as a sustainable energy conversion path was studied by Le *et al.* (2022). The implementation of a hydrothermal carbonization process appeared viable for the treatment of organic fraction of municipal solid waste, both from an environmental and economic point of view (Tradler *et al.* 2018). Furthermore, anaerobic digestion with the hydrothermal carbonization process proved to be an acceptable alternative (Mayer *et al.,* 2021).

A comprehensive methodology was developed in order to evaluate three organic waste treatment scenarios, integrating anaerobic digestion and hydrothermal carbonization. Quantitative and qualitative data on organic production, treatment facility capacities, energy recovery potential and operational costs, were gathered from national and regional urban solid waste management plans, scientific literature, and manufacturer specifications. Furthermore, linear functions were derived to model various parameters, including energy recovery, collection vehicle requirements, emissions' reduction and treatment costs. Three treatment scenarios were explored: (a) anaerobic digestion with landfill disposal of residue, (b) anaerobic digestion with composting of residue, and (c) anaerobic digestion with hydrothermal carbonization of residue.

The analysis revealed substantial potential for energy recovery through anaerobic digestion and hydrothermal carbonization of organic waste in the North Aegean Region. The calculated energy recovery, emissions reduction, and treatment costs varied across municipalities, reflecting local waste generation rates and infrastructure capacities. Specifically, hydrothermal carbonization demonstrated significant and competitive advantages in energy recovery and operational costs compared to traditional anaerobic digestion methods.

Table 1. Annual reduction of emissions ($t_{CO2\text{-}eq}$) as they were calculated from the 3 organic waste treatment scenarios in the N.A. Region.

Municipality	1st scenario ($t_{CO2\text{-}eq}$)	2nd scenario ($t_{CO2\text{-}eq}$)	3rd scenario ($t_{CO2\text{-}eq}$)
Lesvos	-312.84	-700.56	-958.24
Chios	-364.98	-817.32	-1,117.96
Ikaria (Raches)	-32.33	-72.39	-99.02
Ikaria (Agios Kirikos)	-23.12	-51.76	-70.80
Samos	-260.70	-583.80	-798.54

Lemnos	-199.87	-447.58	-612.21
Thimaina (Fournoi)	-9.56	-21.41	-29.28
Total	-1,203.39	-2,694.82	-3,686.01

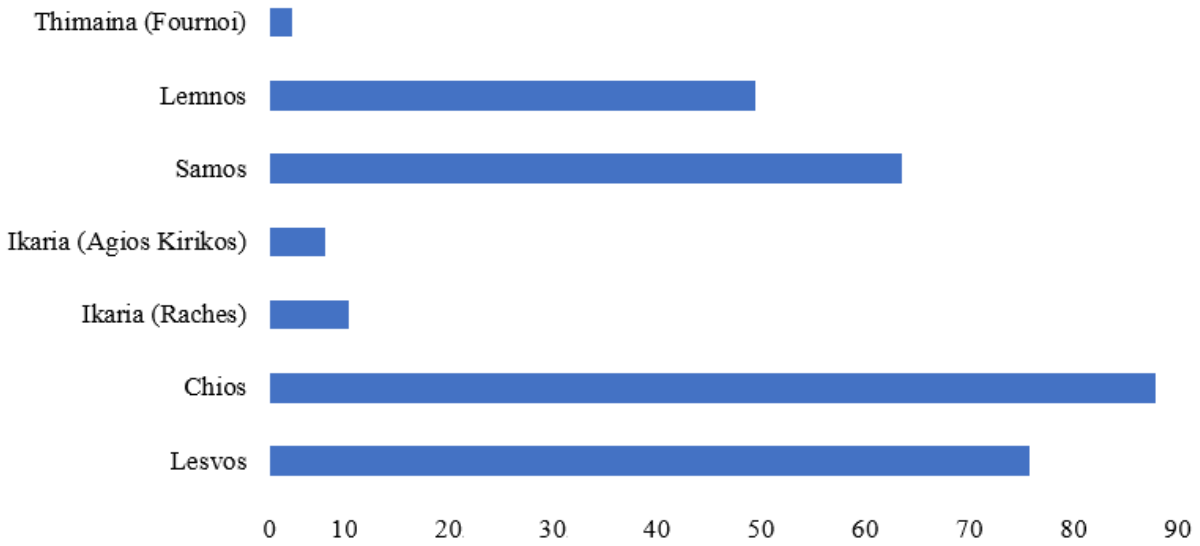

Figure 1. Annual potential revenue from the sale of hydrochar (k€) resulted from the proposed implementation of hydrothermal carbonization in the 7 projected organic waste treatment facilities in the regional planning for the year 2030.

This study highlights the viability of integrating hydrothermal carbonization into regional waste management strategies to enhance energy recovery and reduce greenhouse gas emissions. The proposed treatment scenarios offer valuable insights for decision-makers in optimizing organic waste management policies and practices. Furthermore, the resulting findings underscore the importance of adopting sustainable organic waste treatment technologies to address environmental challenges effectively.

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