**Circular Economy implications of microalgal-based wastewater treatment: materials and energy recovery pathways**

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Abstract

Combined activated sludge (AS)-microalgae systems have been proposed to simultaneously remove both carbon and nutrients from wastewaters, as alternative to conventional technologies such as those based on denitrification and chemical phosphorus precipitation. Although this combined process could be efficient from the point of view of components removal from effluents, it generates potential issues to solid residue disposal practices, as algae normally respond poorly to traditional, mechanical drying processes.

In addition to gasification, a possible process for sustainable resource recovery from this residue is transformation into biochar, achieved by post-processing through pyrolysis. Biochar obtained from sewage sludge is considered one of the most interesting final products in a wastewater-based circular economy, as proven by the multitude of its possible uses tested so far.

In this study, a residuals disposal solution was investigated, consisting of pyrolysation of a mixed biological sludge/bioalgae matrix under different conditions: in such way, not only landfilled residuals are practically eliminated, but a material with multiple potential end uses is recovered. Process feedstock (algae, sludge and combinations thereof) and end-products (biochar and bio-oil) were characterised before and after pyrolysis, respectively.

Algae were also subject to preliminary solvent oil extraction to assess whether increased biochar production would result from such process (which it did, increasing biochar production by 25–33%). A comprehensive discussion on properties of end products as function of process design, possible applications in a circular economy cycle and advantages of co-pyrolysis follows.