Solid Fibrous Digestate Pyrolysis

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Pyrolysis is a well-known established process used for the treatment of residual biomass in order to convert it in high-value products (biochar, bio-oil and syngas) (Stefanidis et al., 2014). Thermochemical processes (pyrolysis) convert feedstock material to bio-based products under various temperature conditions and absence of oxygen. This process results in irreversible changes in chemical composition and physical state of feedstock. Changes originate from a series of reactions that involve cross-linking, depolymerization and fragmentation. These reactions lead to formation of biochar, condensable liquid (bio-oil) and non-condensable gases (syngas) (Lappas et al., 2002).

In anaerobic digestion (AD) plants, waste biomass is utilized to produce biogas and subsequently heat and electricity. The output streams of the latter are gaseous streams (like CO_2, H_2O and impurities SO_x, NO_x, arising from combustion in a CHP plant) and whole digestate (WD) which is the residual biomass after AD. Whole digestate is finally used as it is (field fertilization) or after mechanical separation (usually a screw press) as liquid digestate (LD) and solid fibrous digestate, (SFD). The liquid fraction is then used as fertilizer whilst the solid fraction is further treated to produce compost. SFD is another potential source of pyrolysed products, since it is reach in lignin, cellulose and semi-cellulose which are suitable for pyrolysis according to European Biochar Certification (EBC, 2020). Qlab research team investigates SFD pyrolysis to biochar, with the purpose to increase digestate valorization and enhance circular economy and profitability in AD plants. Specifically, the produced biochar will be used to increase soil health, improve biogas quality and increase anaerobic digestion stability as it is illustrated in the following figure (Figure 1).

The digestate used in this project was collected from biogas plants of Central Macedonia. A summary of the obtained results regarding its characteristics is presented in table 1. The pyrolysis protocol involves drying of solid digestate at 103ºC overnight, followed by pyrolysis at 500ºC, 600ºC and 700ºC for 30, 60 and 120 minutes. The results obtained from solid digestate are presented in table 2.

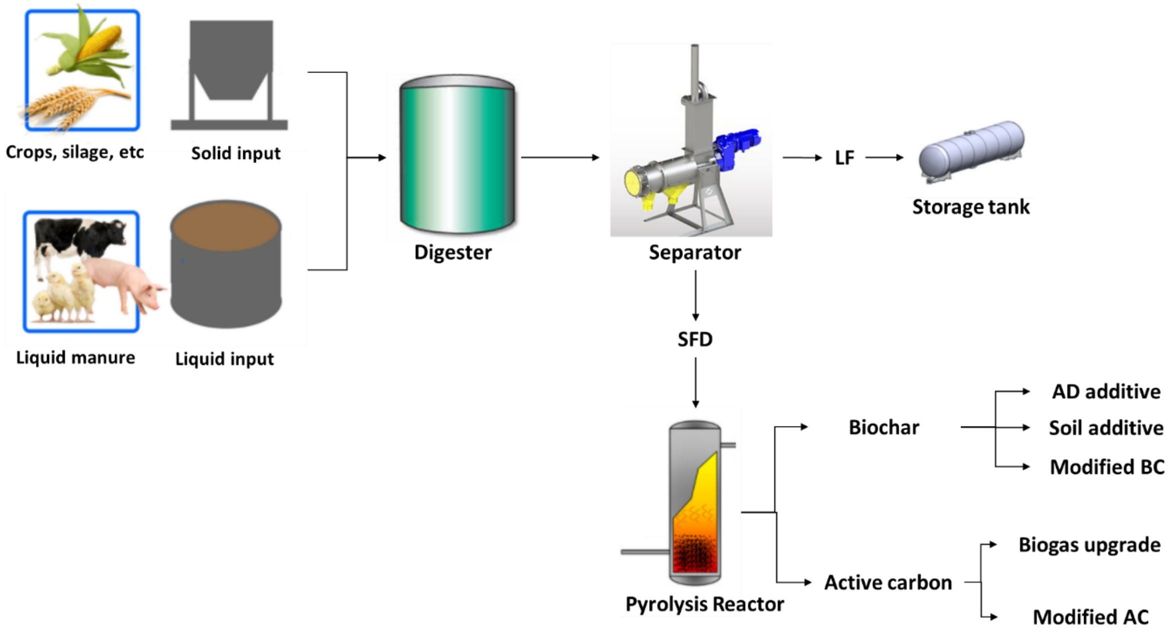

Figure 1: Graphical abstract of new solid digestate management path.

Table 1: Comparison of whole digestate (WD) vs solid fibrous digestate (SFD)			
Parameter	**Units**	**Whole digestate**	**Solid digestate**
Dry Matter	**%**	5,6	22,5
Moisture	**%**	94,3	78,2
pH	**-**	8,1	8,3
Conductivity	**mS/m**	957	104
Salinity	**‰**	6,2	1,9
Organic Matter	**%**	3,78	29
Total Nitrogen	**%**	0,5	1,3
N-NO_3^-	**%**	0,008	0,006
N-NH_4^+	**%**	0,3	0,4
Total Phosphorus	**%**	0,16	0,9

Table 2: Biochar yield at different pyrolysis temperatures and pyrolysis time.		
Pyrolysis Temperature	**Pyrolysis Time**	**Biochar yield (% DM of solid digestate)**
500^0C	30 min	41.4%
500^0C	60 min	41%
500^0C	120 min	40.5%
600^0C	30 min	39.3%
600^0C	60 min	38.6%
600^0C	120 min	38.3%
700^0C	30 min	36.1%
700^0C	60 min	35.5%
700^0C	120 min	35.5%

Results indicate that the amount of biochar is reduced when pyrolysis temperature and time are increased. To be more precise, temperature increase has a more significant effect on biochar yield than pyrolysis time increase.

This project sets out to produce materials such as biochar (BC) and active carbon (AC) which can be utilized in agriculture (to improve fertility and crop production), anaerobic digestion additives (to increased stability of process), biogas upgrading agents (H_2S removal) and finally, to manufacture modified BC/AC with enhanced adsorptive properties.

This is an ongoing project; further research will be conducted regarding how SFD composition influences quality of biochar and active carbon. Furthermore, the effect of BC/AC on AD process, biogas upgrading, and soil health will be examined.

References

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