DEFINITIONS AND DELINEATION

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DEFINITIONS 1 (EUROPEAN BIOCHAR CERTIFICATE)

- Biochar is a porous, carbonaceous material that is produced by pyrolysis of biomass and is applied in such a way that the contained carbon remains stored as a long-term C sink or replaces fossil carbon in industrial manufacturing. It is not made to be burnt for energy generation.
- The biochar's organic carbon (C_{org}) content must be declared.
- The organic carbon content of biochar varies between about 35 % and 95 % of dry matter, depending on the biomass feedstock and the pyrolysis temperature.
- The molar H/C_{org} ratio must be less than 0.7.
- The molar O/C_{org} ratio should be below 0.4.
- The biochar nutrient contents must be declared at least for nitrogen, phosphorus, potassium, magnesium, calcium and iron.

DEFINITIONS 2

- Limit values for heavy metals, PCB, PCDD/F and PAH.
- pH, salt content, bulk density, and water content must be declared.
- Volatile Organic Compounds (VOC) are determined by thermogravimetric analysis (TGA).
- Electrical conductivity of the solid biochar.
- The determination of the water holding capacity (WHC)
- Specific surface area and pore size distribution are recommended as additional parameters

EBC (2012-2022) European Biochar Certificate - Guidelines for a Sustainable Production of Biochar

BIOMASS ORIGINS AND TYPES

Origin	Types
Agricultural residues	Livestock manure Straw Hulls, brans etc. from processing of cereals
Energy and non-food crops	Digestate from biogas plants Fibre fraction from bio-refining of grass
Forest residues	Willow (as energy crop) Wood
Industrial and municipal waste	Woody fraction from garden and park waste Residues from feed and food production
Wastewater treatment plants	Sewage sludge

FEEDSTOCK AND SYSTEM BOUNDARIES

Biomass	Reference situation
Straw from cereals	Straw is left after harvest and incorporated into agricultural soil.
Separated fibre fraction from digestate from biogas production	The separated fibre fraction from digestate is stored, applied and incorporated into agricultural soil
Digested and Dewatered sewage sludge (DDSS)	The anaerobic digested and dewatered sewage sludge will be stored, applied and incorporated into agricultural soil

ASSUMPTIONS ON DRY MATTER ETC.

Biomass scenario	Dry matter	Ash	Org C	Total N	NH4-N	P	K	Energy HHV*	Literature source
	(%)	(%)	(kg/t DM)					(GJ/t)	
Straw from cereals	91	5	420	4.2	0	0.72	13.6	16.4	1, 2, 6
Fibre fraction from digestate	30	20	360	12	3.5	14	3.2	16.4	3, 4
DDSS[†]	25	42	290	44	4.7	32	1.4	13.2	5

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BIOCHAR PRODUCTION

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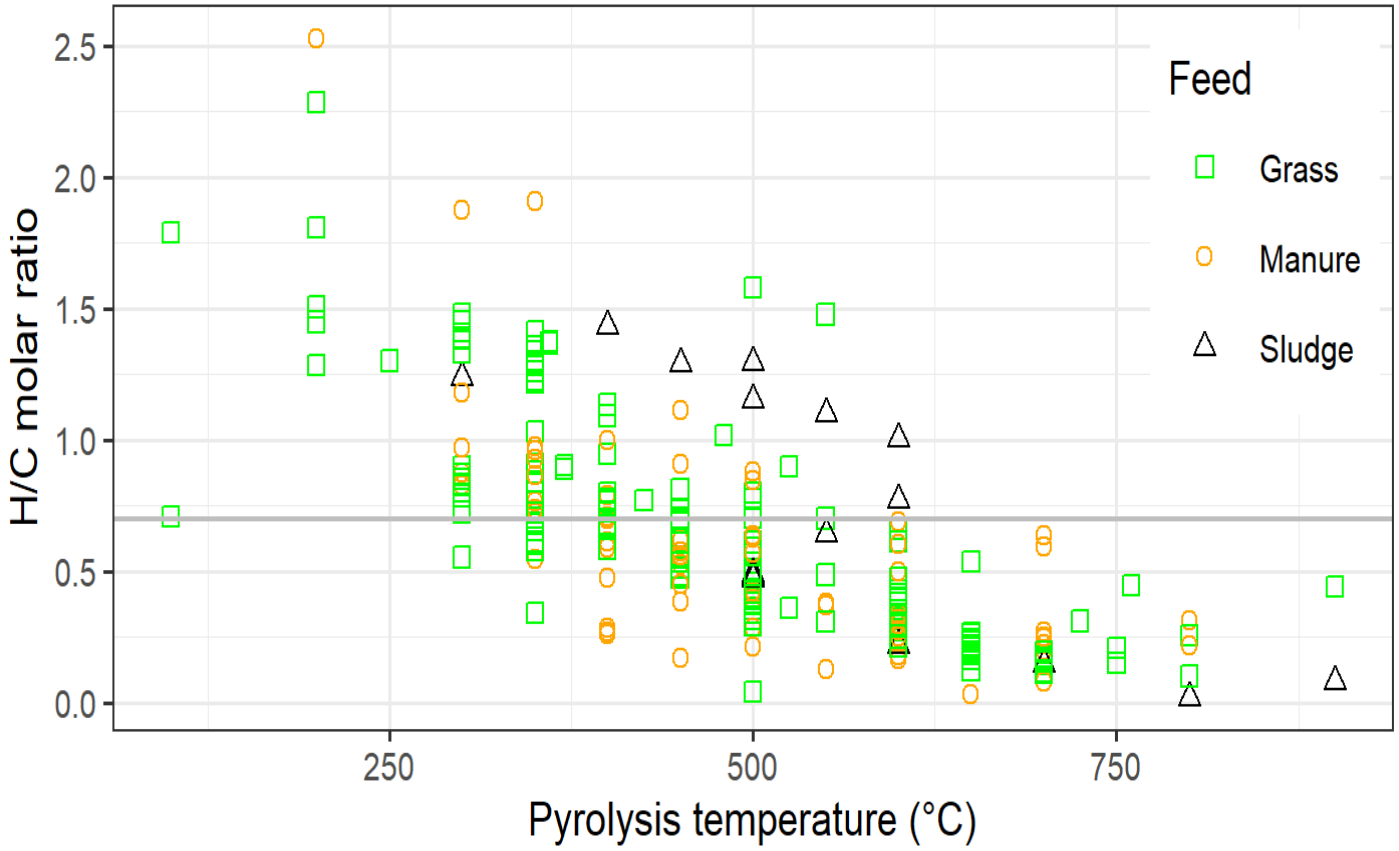
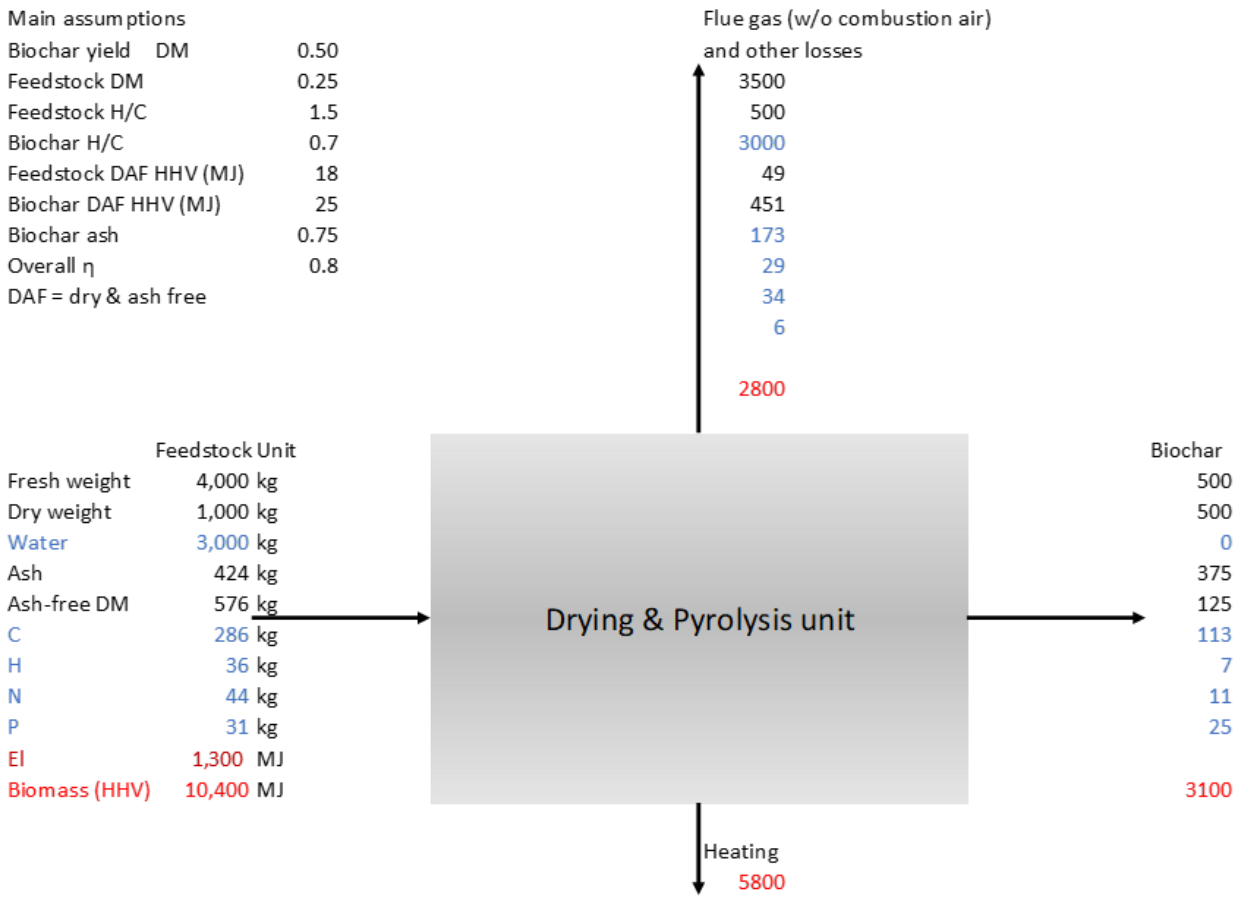
HYDROGEN/CARBON MOLAR RATIO



From UC Davis Biochar database

TENTATIVE MASS AND ENERGY BALANCES FOR DIGESTED AND DEWATERED SEWAGE SLUDGE

Main assumptions	
Biochar yield DM	0.50
Feedstock DM	0.25
Feedstock H/C	1.5
Biochar H/C	0.7
Feedstock DAF HHV (MJ)	18
Biochar DAF HHV (MJ)	25
Biochar ash	0.75
Overall η	0.8
DAF = dry & ash free	



CARBON SEQUESTRATION OF DIGESTED AND DEWATERED SEWAGE SLUDGE

Biomass	Soil temp (°C)	c_{hc}	m_{hc}	H/C_{org} ratio	F_{perm}	C (kg)	$C_{100\ yr}$ (kg)	CO_2-eq (kg)	Source
Biochar	10	1.040	0.590	0.7	0.627	113	71	260	Woolf et al. (2021)
Sludge	-	-	-	-	0.125	257	32	118	Larsen et al. (2013)

EMISSION FROM PRODUCTION OF DIGESTED AND DEWATERED SEWAGE SLUDGE

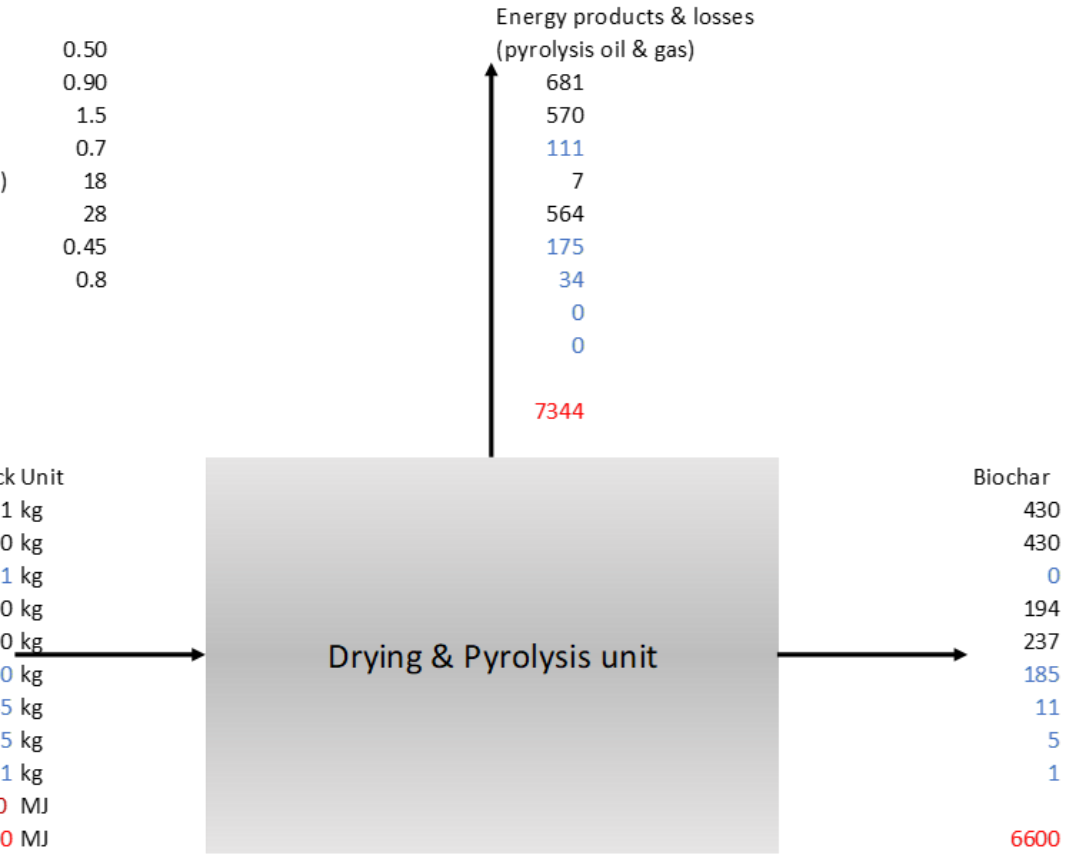
	Values	Unit	EF	Unit	GWP	kg CO_2-eq t biochar^{-1}	Comments
Electricity	360	kWh	0.070	kg CO_2-eq kWh^{-1}	1	25	Consumption
Surplus heat	5800	MJ	0.068	kg MJ^{-1}	1	-390	Substitutes natural gas
Net emission						-365	

EMISSION FROM DIGESTED AND DEWATERED SEWAGE SLUDGE IN THE REFERENCE SITUATION

Location and climate gas	Length (mo.)	Initial C or N (kg/t DM)	EF	Unit	Emission (kg/t DM)	GWP AR6†	CO_2-eq (kg)‡	Comments
Storage								
CH_4	6	286	0.030	kg CH_4 kg C^{-1}	8.6	27	232	Larsen et al. (2018)
N_2O	6	44	0.005	kg N_2O-N kg N^{-1}	0.22	273	94	IPCC (2006) table 10.21
Field								
CH_4	-		0	kg CH_4 kg C^{-1}	0			Willen et al. (2016)
N_2O*	-	42	0.010	kg N_2O-N kg N^{-1}	0.42	273	180	IPCC (2006) Table 11.1
Net emission							506	

TENTATIVE MASS AND ENERGY BALANCES FOR FIBRE FRACTION FROM DIGESTATE

Main assumptions	
Biochar yield DM	0.50
Feedstock DM	0.90
Feedstock H/C	1.5
Biochar H/C	0.7
Feedstock DAF HHV (MJ)	18
Blochar DAF HHV (MJ)	28
Biochar ash	0.45
Overall η	0.8
DAF = dry & ashfree	



CARBON SEQUESTRATION OF BIOCHAR FROM FIBRE FRACTION FROM DIGESTATE

Biomass	Soil temp (°C)	c_{hc}	m_{hc}	H/C	F_{perm}	C (kg)	$C_{100\ yr}$ (kg)	CO_2-eq (kg)	Source
Biochar	10	1.040	0.590	0.7	0.627	185	116	425	Woolf et al. (2021)
Fibre fraction	10	-	-	-	0.10	324	36	132	See text

EMISSIONS FROM PRODUCTION OF FIBRE FRACTION FROM DIGESTATE

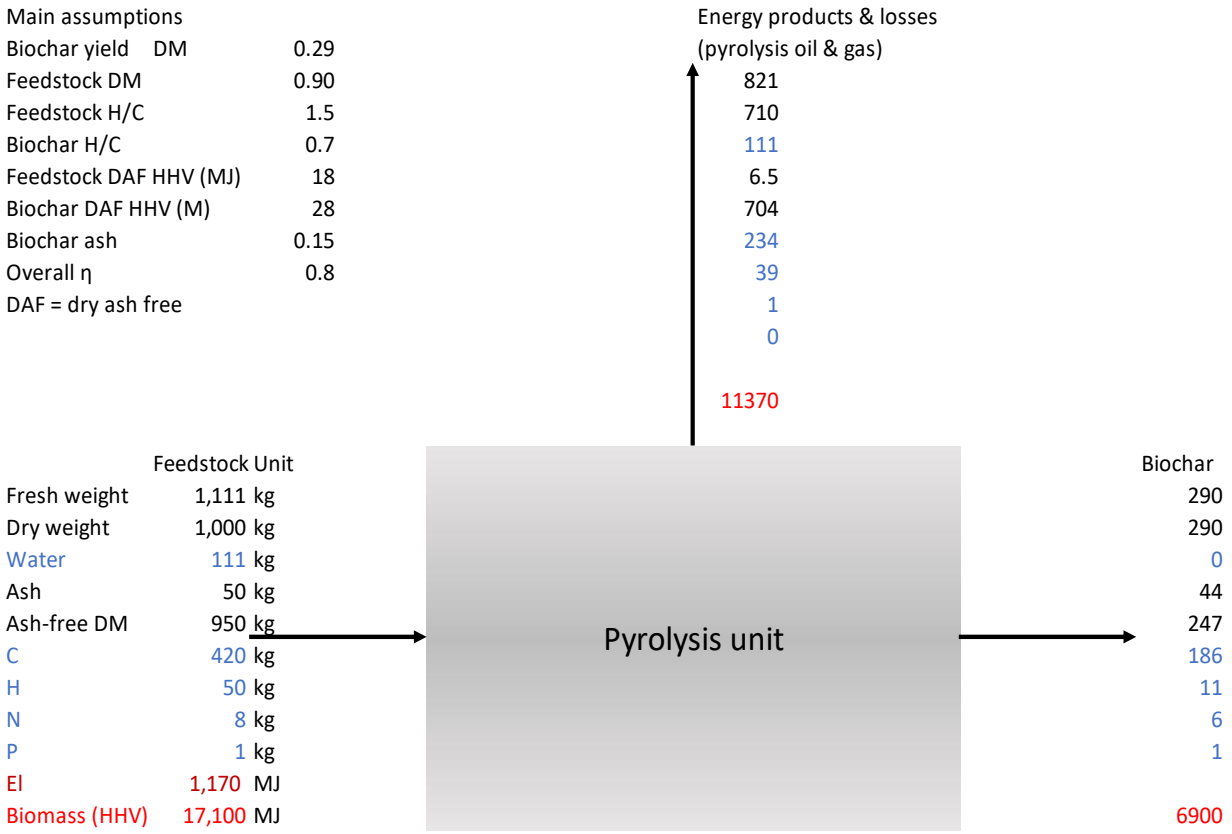
	Values	Unit	EF	Unit	GWP	kg CO_2-eq t biochar^{-1}	Comments
Electricity	383	kWh	0.070	kg CO_2-eq · kWh^{-1}	1	27	Consumption
Surplus energy	5878	MJ	0.068	kg · MJ^{-1}	1	-400	Substitutes natural gas
Net emission						-373	

EMISSIONS FROM FIBRE FRACTION FROM DIGESTATE IN THE REFERENCE SITUATION

Location	Length (mo.)	Initial C or N (kg/t DM)	EF	Unit	Emission (kg/t DM)	GWP AR6[†]	CO_2-eq (kg)[‡]	Comments
Storage								
CH_4	6	360	0.017	kg CH_4 kg C^{-1}	6.1	27	165	
N_2O	6	5.0	0.005	kg N_2O-N kg N^{-1}	0.025	273	11	IPCC (2006) Table 10.21
Field								
CH_4	-		0	kg CH_4 kg C^{-1}	0			Willen et al. (2016)
N_2O*	-	4.8	0.010	kg N_2O-N kg N^{-1}	0.048	273	21	IPCC (2006) Table 11.1
Net emission							197	

TENTATIVE MASS AND ENERGY BALANCES FOR BIOCHAR FROM STRAW

Main assumptions	
Biochar yield DM	0.29
Feedstock DM	0.90
Feedstock H/C	1.5
Biochar H/C	0.7
Feedstock DAF HHV (MJ)	18
Biochar DAF HHV (M)	28
Biochar ash	0.15
Overall η	0.8
DAF = dry ash free	



CARBON SEQUESTRATION OF BIOCHAR FROM STRAW

Biomass	Soil temp (°C)	c_{hc}	m_{hc}	H/C	F_{perm}	C (kg)	$C_{100\ yr}$	CO_2-eq (kg)	Source
Biochar	10	1.040	0.590	0.7	0.627	186	116	427	Woolf et al. (2021)
Straw	10	-	-	-	0.030	420	13	46	See section 1.7.3

EMISSIONS FROM PRODUCTION OF BIOCHAR FROM STRAW

	Values	Unit	EF	Unit	GWP	kg CO_2-eq t biochar^{-1}	Comments
Electricity	325	kWh	0.070	kg CO_2-eq · kWh^{-1}	1	23	Consumption
Surplus energy	9100	MJ	0.068	kg · MJ^{-1}	1	-619	Substitutes natural gas
Net emission						-596	

EMISSIONS FROM STRAW IN THE REFERENCE SITUATION

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UNCERTAINTIES

- Carbon storage and sequestration
- Separation efficiency of digestate
- Emission from stored digestate fibre fraction
- Emission from stored sewage sludge
- Emission from combustion of pyrolysis gas and oil
- Pyrolysis parameter

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