Biochar systems for carbon finance – an evaluation based on Life Cycle Assessment studies in New Zealand

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Abstract

Char produced from the pyrolysis of biomass and applied into soils (biochar) can, under some conditions, improve soil functions and sequester carbon (C) over millennia. In New Zealand, if 80% of the available biomass residues were converted into biochar, about 1.7 Mt CO_2 could be sequestered annually. This represents ~2.4% of NZ's total annual greenhouse gas (GHG) emissions. However, the trade-offs associated with alternative uses of biomass need to be assessed from a life cycle perspective, particularly when considering policymaking.

The biomass feedstocks evaluated using Life Cycle Assessment were orchard prunings, logging residues, and wheat straw. The goals were i) to compare alternative management scenarios and ii) to determine the use of biomass that can achieve the largest amount of carbon credits in order to support policymaking. The biomass for heat-only (HO) scenario could mitigate 276 – 1,064 kg CO_2-eq per t biomass; the combined heat and power (CHP) scenario could reduce 410 – 1,608 kg CO_2-eq per t biomass; and the biochar scenario could abate 271 – 792 kg CO_2-eq per t biomass. Ranges vary according to the type of feedstock assessed and the type of fossil fuel (coal or natural gas) displaced. The assessment of the HO and CHP systems giving greater GHG emission reductions than the biochar system can be misleading as these only involve fossil-fuel offsetting whereas the biochar system would sequester some carbon irrespective of the other activities assumed to be displaced. The biochar carbon stability factor is the key component that affects its capacity to mitigate climate change. A distinctive C accounting, reporting and crediting approach should be developed for biochar to have high economic potential in carbon-pricing mechanisms.

Several approaches for incentivising biochar carbon sequestration were explored. These include using conservative carbon-accounting estimates, issuing temporary credits, establishing buffer funds, creating carbon credit multipliers, and inventing a new unit such as ppm CO_2 reductions for recognising atmospheric CO_2 removals as opposed to avoiding GHG emissions. While biochar technology is currently facing numerous barriers for acceptance in carbon markets, its future is promising since biochar production also offers potential in the agriculture, energy and waste management sectors.

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Abbreviations and acronyms

AAU	assigned amount unit
ADE	Anthropogenic Dark Earths
AIJ	activities implemented jointly
ALCA	attributional Life Cycle Assessment
AOS	Alberta Offset System
A/R	afforestation/reforestation
BAU	business as usual
BCSF	biochar carbon stability factor
BECCS	bioenergy with carbon capture and storage
BMF	biochar migration factor
BP	before present
C	carbon
C_{org}	organic carbon
Ca	calcium
CAN	calcium ammonium nitrate
CCS	carbon capture and storage
CDM	clean development mechanism
CEC	cation exchange capacity
CER	certified emission reduction
CF	carbon footprint
CH_4	methane
CHP	combined heat and power
CLCA	consequential Life Cycle Assessment
CMF	carbon maintenance fee
CMS	Carbon Market Solutions
CNI	Central North Island
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-eq	carbon dioxide equivalent

COP	conference of the parties
CPY	central processing yard
CROPS	crop residue oceanic permanent sequestration
EECA	Energy Efficiency and Conservation Authority
ELB	end-of-life biomass
ERU	emission reduction unit
ET	emissions trading
ETS	emissions trading scheme
EU	European Union
FAO	Food and Agriculture Organisation
FSC	Forest Stewardship Council
GHG	greenhouse gas
GJ	gigajoule
GWP	global warming potential
H_2	hydrogen
H_2O	water
ha	hectare
HB	Hawke's Bay
HO	heat only
HTC	hydrothermal carbonisation
HWP	harvest wood products
IBI	International Biochar Initiative
IEA	International Energy Agency
ILCD	International Reference Life Cycle Data System
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
JI	joint implementation
K	potassium
KCl	muriate of potash
kWh	kilowatt hour

LCA	Life Cycle Assessment
LCI	life cycle inventory
LCIA	life cycle impact assessment
LUCAS	Land Use and Carbon Analysis System
LULUCF	land-use, land-use change and forestry
LPG	liquefied petroleum gas
MAF	Ministry of Agriculture and Forestry
MBIE	Ministry of Business, Innovation and Employment
MfE	Ministry for the Environment
Mg	magnesium
MJ	megajoule
MPI	Ministry for Primary Industries
MSC	Marine Stewardship Council
MSDS	material safety data sheet
MSW	municipal solid waste
Mt	megatonne
MW	megawatt
N	nitrogen
N_2O	nitrous oxide
NER300	New Entrants' Reserve
NETs	negative emission technologies
NZ	New Zealand
NZAGRC	New Zealand Agricultural Greenhouse Gas Research Centre
NZFOA	New Zealand Forest Owners Association
O-I	Owens-Illinois
P	potassium
PAHs	polyaromatic hydrocarbons
PCRs	Product Category Rules
PET	polyethylene terephthalate
PETRA	PET Resin Association
PJ	petajoule

ppm	parts per million
REDD	reduced emissions from deforestation and forest degradation
RSB	Roundtable on Sustainable Biomaterials
S	sulphur
SEM	scanning electron microscopy
SETAC	Society of Environmental Toxicology and Chemistry
SO_2	sulphur dioxide
SOC	soil organic carbon
SOM	soil organic matter
SP	superphosphate
t	tonne
TRV	total recoverable volume
TP	terra preta
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
VCS	Verified Carbon Standard
VMRV	validation, monitoring, reporting and verification
WFPS	water filled pore space
WHS	wood harvest and storage
WWF	World Wildlife Fund
Zn	zinc

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