

# Biochar: Opportunities & Challenges

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Processing Technologies  
Alberta Innovates Technology Futures



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# Alberta Innovates- Technology Futures (AITF) Overview

# Alberta Innovates

Focussed on economic sectors where Alberta has a competitive advantage:

- Energy: Oil sands, oil and gas, pipelines, tight oil and fracking
- Carbon Conversion, Capture and Storage
- Environmental Monitoring and Management
- Industrial Sensors
- Advanced Materials and Manufacturing
- Sustainable Resources: agriculture and forestry
- Health Research and Technologies



# Who is AITF?

- 90+ years of operational experience.
- 520 world-class scientists, engineers, technologists, technicians and business and investment experts
- 1 million square feet of research space.
- 1,000+ industry clients annually.
- \$75 million generated by fee for service work annually.
- **Mandate**
- ESBA: Economic and Societal Benefits for Albertans

# AITF locations: 1M sq. ft. of research space

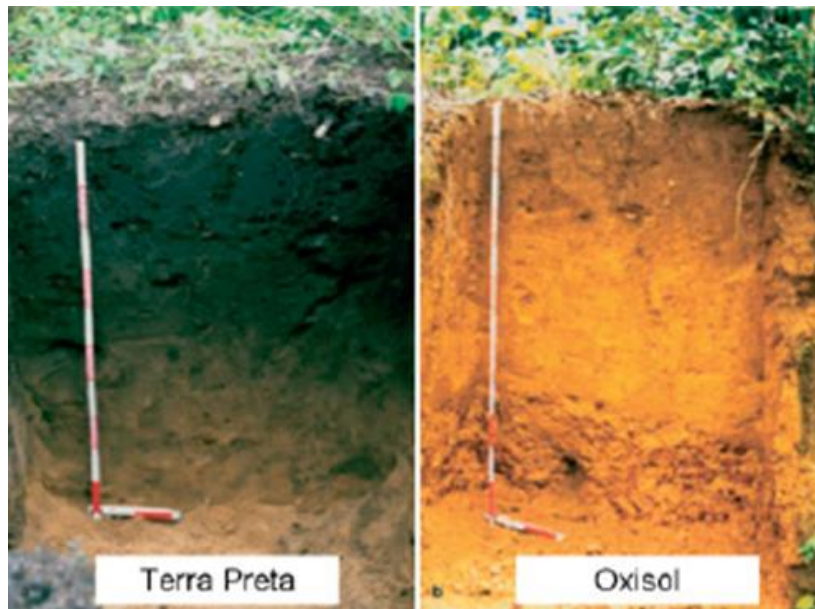


# What is Biochar?

- **Biochar is a carbon-rich solid** produced by pyrolysis of biomass under partial or complete exclusion of oxygen. The process converts carbon in biomass into ‘recalcitrant’ carbon which resists degradation and can sequester carbon in soil for centuries.
- **Biochar** is identical to charcoal, **except** it is primarily used for soil amendment purposes. However, it has myriads of applications like cleaning water, reducing odor, adsorbing toxic pollutants on soil to name a few.

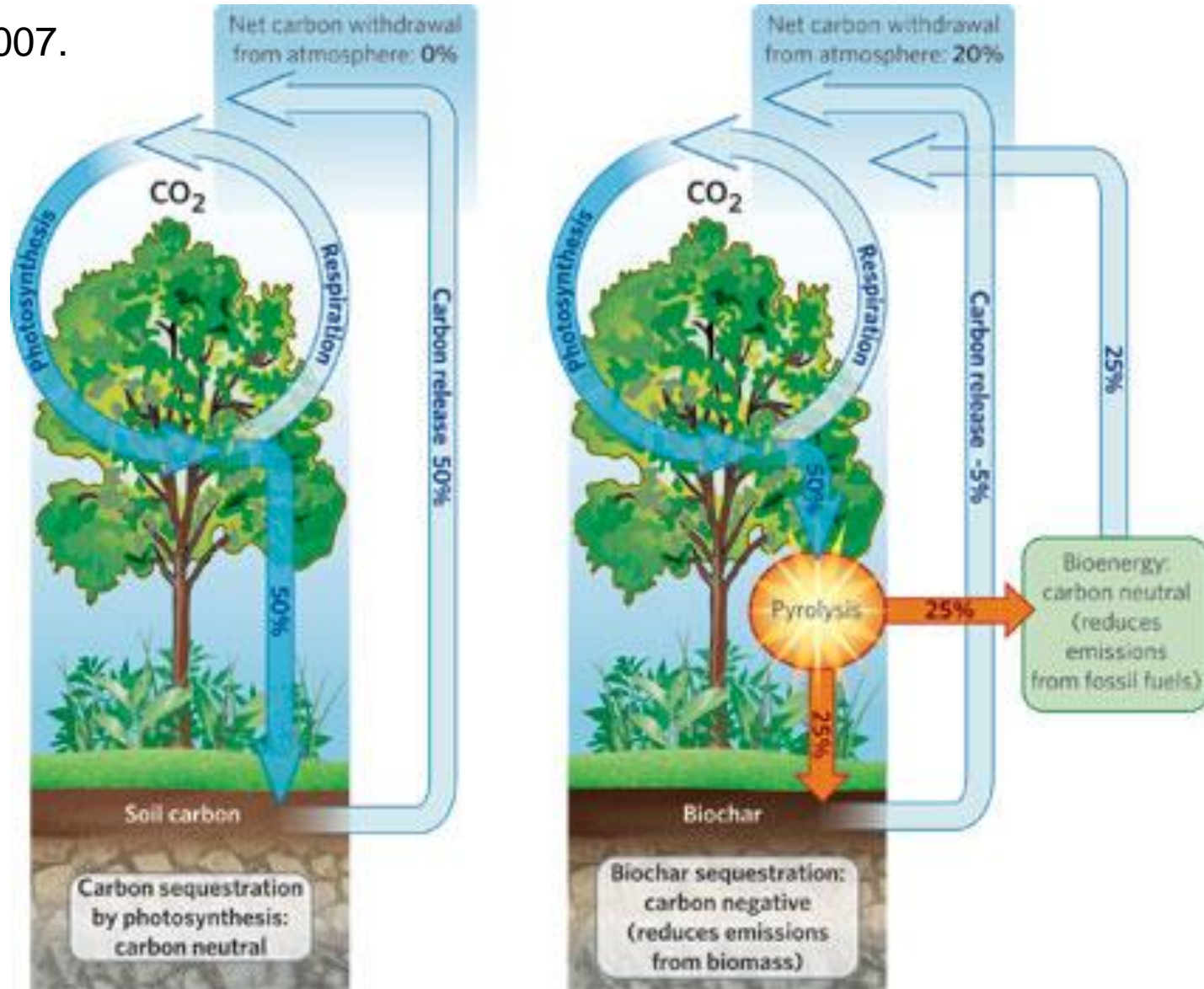
# History of Biochar

- Amazonian Dark Earths – Terra Preta Soils
- High organic matter, high moisture holding capacity and high nutrient (Ca, K, P, N)
- Oxisols are native soils in the tropical rain forest and lack organic matter due to leaching by the heavy rains



# Carbon Sustainability

Lehmann, Nature 2007.





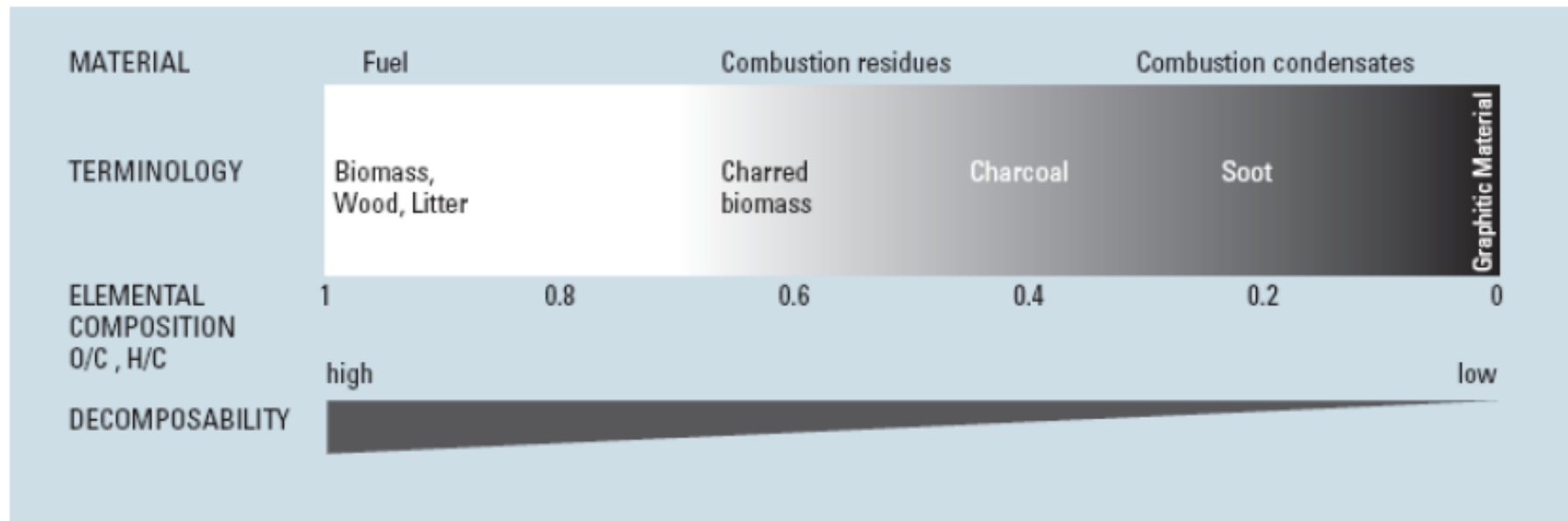
# Biochar Composition



**Table 2.1 Relative proportion range of the four main components of biochar (weight percentage) as commonly found for a variety of source materials and pyrolysis conditions (adapted from Brown, 2009; Antal and Gronli, 2003)**

<b>Component</b>	<b>Proportion (w w<sup>-1</sup>)</b>
Fixed carbon	50-90
Volatile matter (e.g. tars)	0-40
Moisture	1-15
Ash (mineral matter)	0.5-5

# Recalcitrance



**Figure 1.6 Terms and properties of pyrogenic BC (adopted from Preston and Schmidt, 2006)**

## Biochar Application to Soils

A Critical Scientific Review  
of Effects on Soil Properties, Processes and Functions

F. Verheijen, S. Jeffery, A.C. Bastos, M. van der Velde, I. Dias

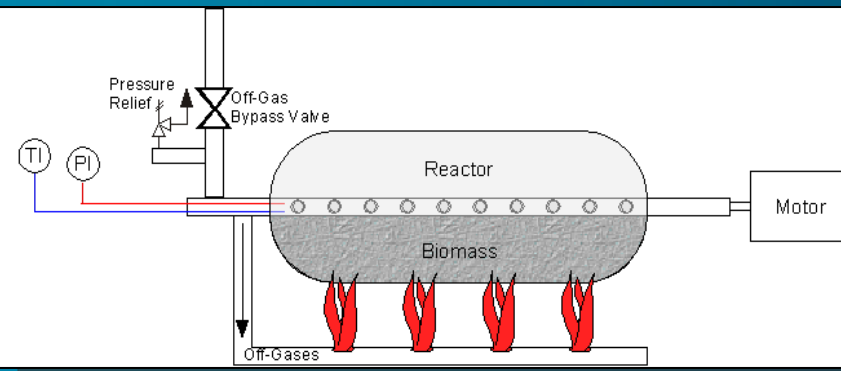
EUR 24099 - EN  
ISBN 978-92-79-14293-2  
ISSN 1018-5593  
DOI 10.2788/472

# Biochar Research @ ARC (today's AITF)

- 2006+
- Slow Release Fertilizer / Soil Amendment
- ARC + ARD Collaboration
- Pioneering Studies by Dr. Savidov @ CDC-S & N
- Emergence of Biochar as Substrate/Growing Media for Greenhouse Hydroponics
- 2007 - Biochar not approved for organic production of orchids due to high level of volatile chemicals
- 20+ extensive greenhouse hydroponic trials conducted between 2007 and 2014 @ CDC-S/-N, AITF-Veg, GPRC, KPU
- Biochar performance similar to Coconut coir
- Alberta News Print Company (ANC) sponsored

# ARC 'fabricated' Carbonizers

< 3 Kg/h



< 20 kg/batch

# Growth Media Applications

- *The same or higher yields achieved using biochar-based media in greenhouse crops production*
- *No phytotoxic effect of carbonization on greenhouse crops*



# Biochar in Hydroponics



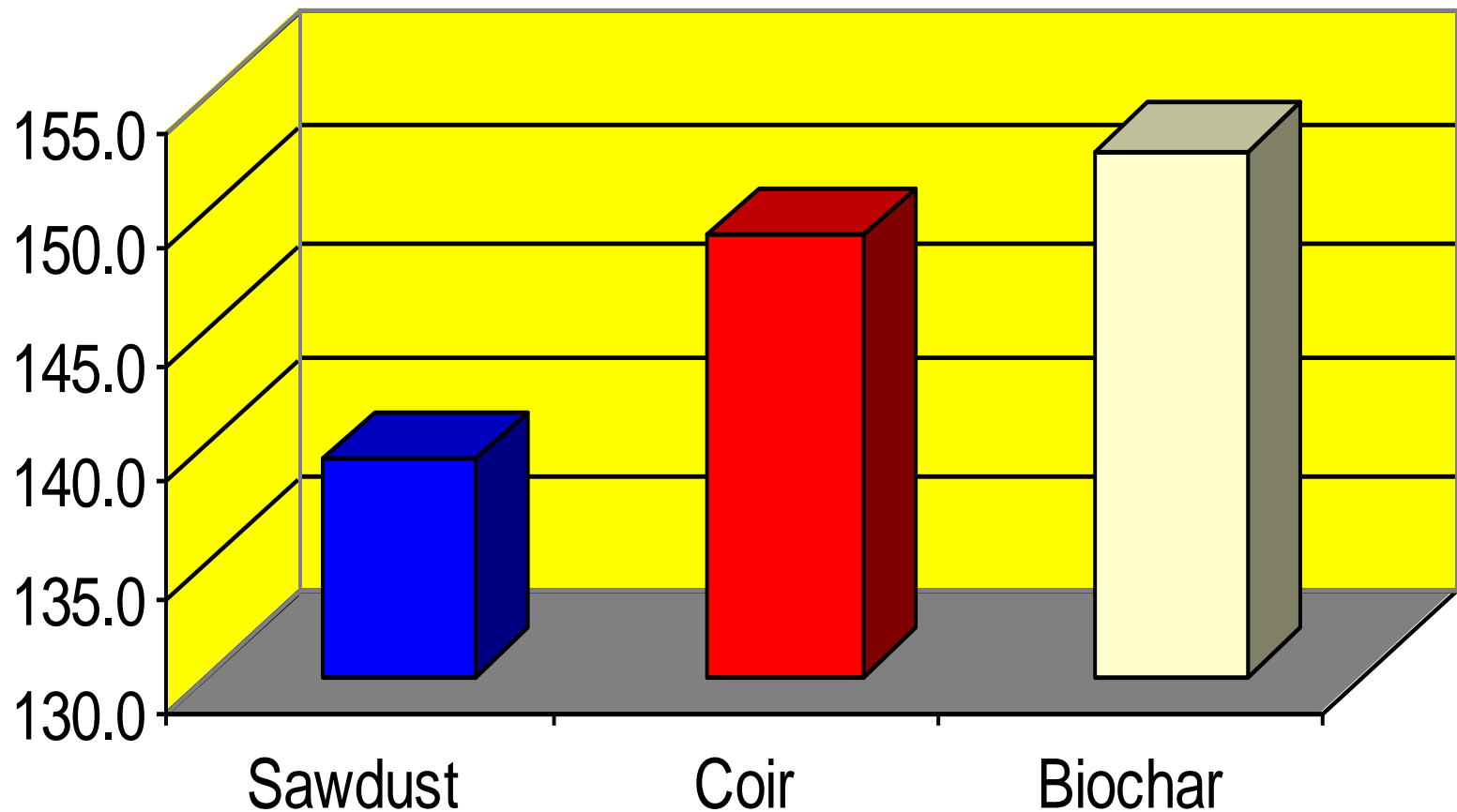
Biochar

Sawdust

Coir

Courtesy – Dr Nick Savidov, ARD

# Effect of various substrates on yield of greenhouse bell peppers in 2009, number of peppers/sq. m

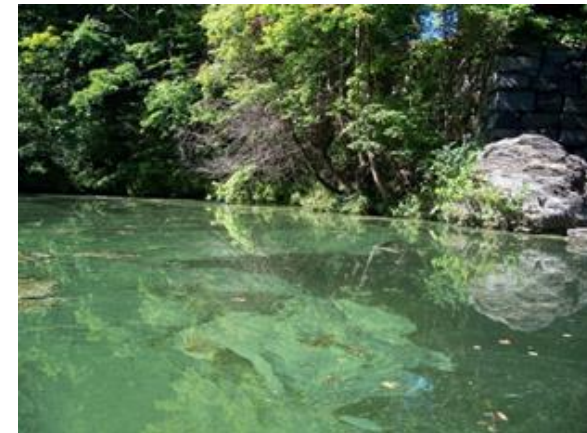


# Applications

- Soil Amendment/Ameliorant
- Growth Media (Hydroponics/Horticulture)
- Carbon Sequestration
- Land Reclamation/Remediation
- Oil Sand Tailing Waste Water Treatment
- Lake De-eutrophication
- Filter Media (Gas/Liquid)
- Niche Applications



Soil Ameliorant



Algal Bloom



# CHALLENGES

- Economics
- Quality and Standards
- Fate of biochar in soils
- Government Policies

# Quality Control Challenge



- Feedstock Quality
  - Unprocessed
    - Agricultural Residue
    - Forestry Residues
    - Livestock Residues
  - Processed
    - Treated Wood
    - CDW
    - MSW/RDF
- Process Variability
  - Temperature
  - Retention Time
  - Rate of Heating

# Biochar Quality Guidelines

Biochar*	IBI <sup>1</sup>	EBC <sup>2</sup>		BQM <sup>3</sup>	
<b>General Characteristics</b>					
<b>Organic Carbon Content</b>	≥ 10 wt.%	≥ 50 wt.%		≥ 10 wt.%	
<b>H:C<sub>org</sub></b>	≤ 0.7	≤ 0.7		≤ 0.7	
<b>Classification Criteria</b>	Organic Carbon	Contaminants		Contaminants	
<b>Classes</b>	<b>Class 1:</b> ≥ 60 wt.% <b>Class 2:</b> ≥ 30 wt.% and < 60 wt.% <b>Class 3:</b> ≥ 10 wt.% and < 30 wt.%	<b>Premium grade</b>	<b>Basic grade</b>	<b>High grade</b>	<b>Standard grade</b>
<b>Toxicants</b>					
<b>PAHs</b>	6 – 20 mg/kg	4 mg/kg	12 mg/kg	≤ 20 mg/kg	≤ 20 mg/kg
<b>Dioxins/Furans</b>	9 ng/kg (I-TEQ)	20 ng/kg (I-TEQ OMS)	20 ng/kg (I-TEQ OMS)	20 ng/kg	20 ng/kg
<b>PCBs</b>	0.2 – 0.5 mg/kg	0.2 mg/kg	0.2 mg/kg	0.5 mg/kg I-TEQ	0.5 mg/kg I-TEQ
<b>Metals (mg/kg)</b>					
<b>As</b>	12 - 100	-	-	10	100
<b>Cd</b>	1.4 - 39	1	1.5	3	39
<b>Cr</b>	64 -1200	80	90	15	100
<b>Cu</b>	63 -1500	100	100	40	1500
<b>Pb</b>	70 - 500	120	150	60	500
<b>Hg</b>	1 - 17	1	1	1	17
<b>Mo</b>	5 - 20	-	-	10	75
<b>Ni</b>	47 - 600	30	50	10	600
<b>Se</b>	1 - 36	-	-	5	100
<b>Zn</b>	200 - 7000	400	400	150	2800

\*All the parameters shown are in terms of dry weight basis (db)

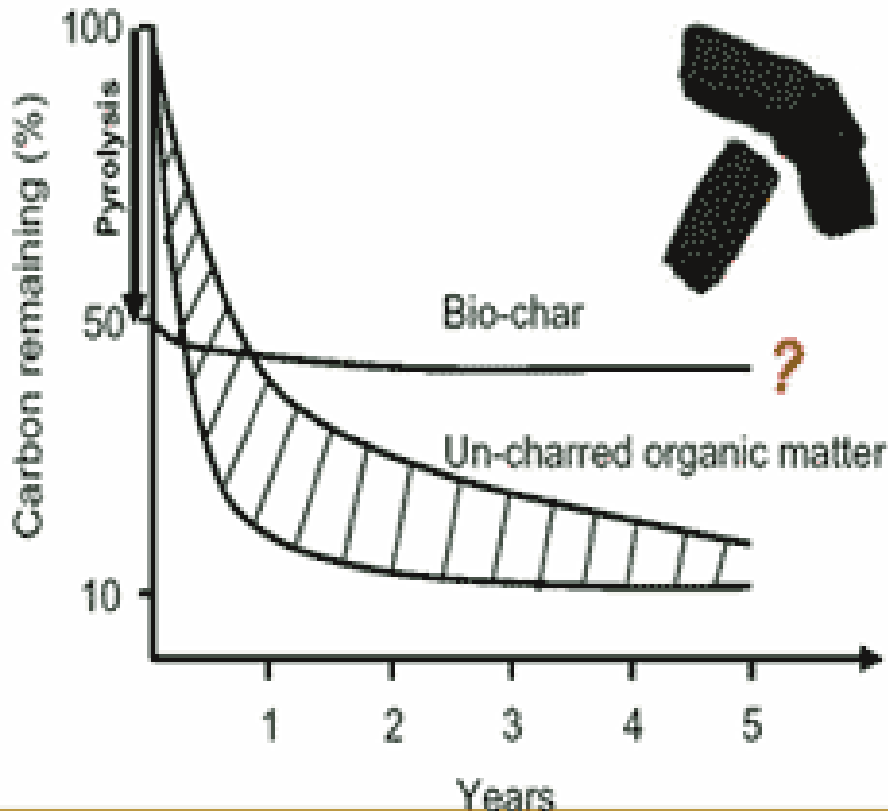
1. IBI Biochar Standards - International Biochar Initiative (IBI)
2. European Biochar Certificate (EBC) – European Biochar Foundation (EBF)
3. Biochar Quality Mandate (BQM) – British Biochar Foundation (BBF)

# Biochar Characterization

- Basic Analyses
  - Proximate (moisture, volatiles, fixed C, Ash)
  - Ultimate (C, H, N, O, and S)
  - Heating Value
- Toxicity Analyses
  - Germination Inhibition Assay
  - Earthworm Avoidance Test
  - PAHs/Dioxins/Heavy Metals
- Advanced Analyses
  - Morphological Analyses (surface area, porosity)
  - Carbon Stability (Aging Effects)

# Biochar Stability

The essential stability of bio-char



O/C ratio t $\frac{1}{2}$  year  
< 0.2 >1000  
<0.6 >100  
Spokas et al.,



Canadian Food  
Inspection Agency

Agence canadienne  
d'inspection des aliments

Plant Health and Biosecurity Directorate  
Field Crops and Inputs Division  
Fertilizer Safety Section  
59 Camelot Dr.  
Ottawa, Ontario  
K1A 0Y9

December 11, 2013

Alok Dhungana  
Coordinator, Alberta Biochar Initiative  
Lakeland College  
5707 College Drive  
Vermilion, Alberta T9X 1K5

Re: Canadian Regulatory Requirements for Biochar

## Canadian Food Inspection Agency

[Home](#) > [Plants](#) > [Fertilizers](#) > [Trade Memoranda](#) > [T-4-113](#) > T-4-113 (Suppl.1)

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**T-4-113**

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### **(Suppl.1) - Data Requirements for Product Safety Evaluations: Explanatory Notes**

**September 1997**

This guideline provides an explanation of the data requirements for safety evaluations of fertilizers and soil supplements. It is to be used in conjunction with [Trade Memorandum T-4-113 - Guidelines to Safety Assessments of Fertilizers and Supplements and to Information to be Submitted in Demonstrating Product Safety](#).

# CFIA

Under the federal *Fertilizers Act and Regulations*, biochar is considered a supplement (a substance or mixture of substances, other than a fertilizer, that is manufactured, sold, or represented for use in the improvement of physical condition of soils or to aid plant growth or crop yields) and requires registration prior to importation or sale in Canada. Moreover, if field trials are being conducted, a research authorization (RA) is required from the CFIA. RAs must be obtained prior to the environmental release of all novel supplements, that is, supplements that are not registered and not exempt from registration or that contain a novel trait.

Any biochar product that is currently in the marketplace that is not registered must be submitted for registration. Moreover, any field trials must have written authorization prior to taking place. To apply for the registration or the experimental release of biochar, please refer to Trade Memoranda *T-4-107: Registration of Supplements under the Fertilizers Act* and *T-4-103: Guidelines for Research Authorizations for Testing Novel Supplements*, respectively, which may be found on the CFIA website at [www.inspection.gc.ca](http://www.inspection.gc.ca). For further guidance, please feel free to contact the Fertilizer Section of the CFIA at [fertilizer@inspection.gc.ca](mailto:fertilizer@inspection.gc.ca) and we would be happy to discuss the regulatory requirements of biochar with you in more detail. Please note that all future release of biochar into the environment or marketplace must be approved by the CFIA. Products found to be non-compliant in the marketplace are subject to regulatory action, which may include product detention and, in severe cases, prosecution.



# Alberta Environment

- Code of Practise – Pyrolyzers or Carbonizers
  - Currently does not exist
- Classified under Small scale incinerators
- Compliance with existing COP small incinerators
- Research Permit – Commissioning phase
- Operational Permit – Commercial Operation

# Alberta Environment



## **Code of Practice for Small Incinerators**

**September 2005**

*made under the Environmental Protection and Enhancement Act*

# OPPURTUNITIES

# Biochar Applications

- **High Value – Low to Medium Volume**
  - Functionalized Biochars
  - Activated Carbon Replacement
  - Filter Media (industrial water clean-up, ie oil sands tailings)
  - Mercury/Sulfur capture
  - Inoculant carriers
- **Low Value – High Volume**
  - Soil Amendment and Fertilizer Carrying Agents
  - Growth Media
  - Land Reclamation/Remediation
  - Lake De-eutrophication
  - Potting Mixes (Commercial & Retail)

# Biochar Value Proposition:

- **Biochar**

- Market price \$500 - \$1500 / tonne (db)
- Product scarcity
- Markets not well established
- Capital intensive equipment

- **Activated**

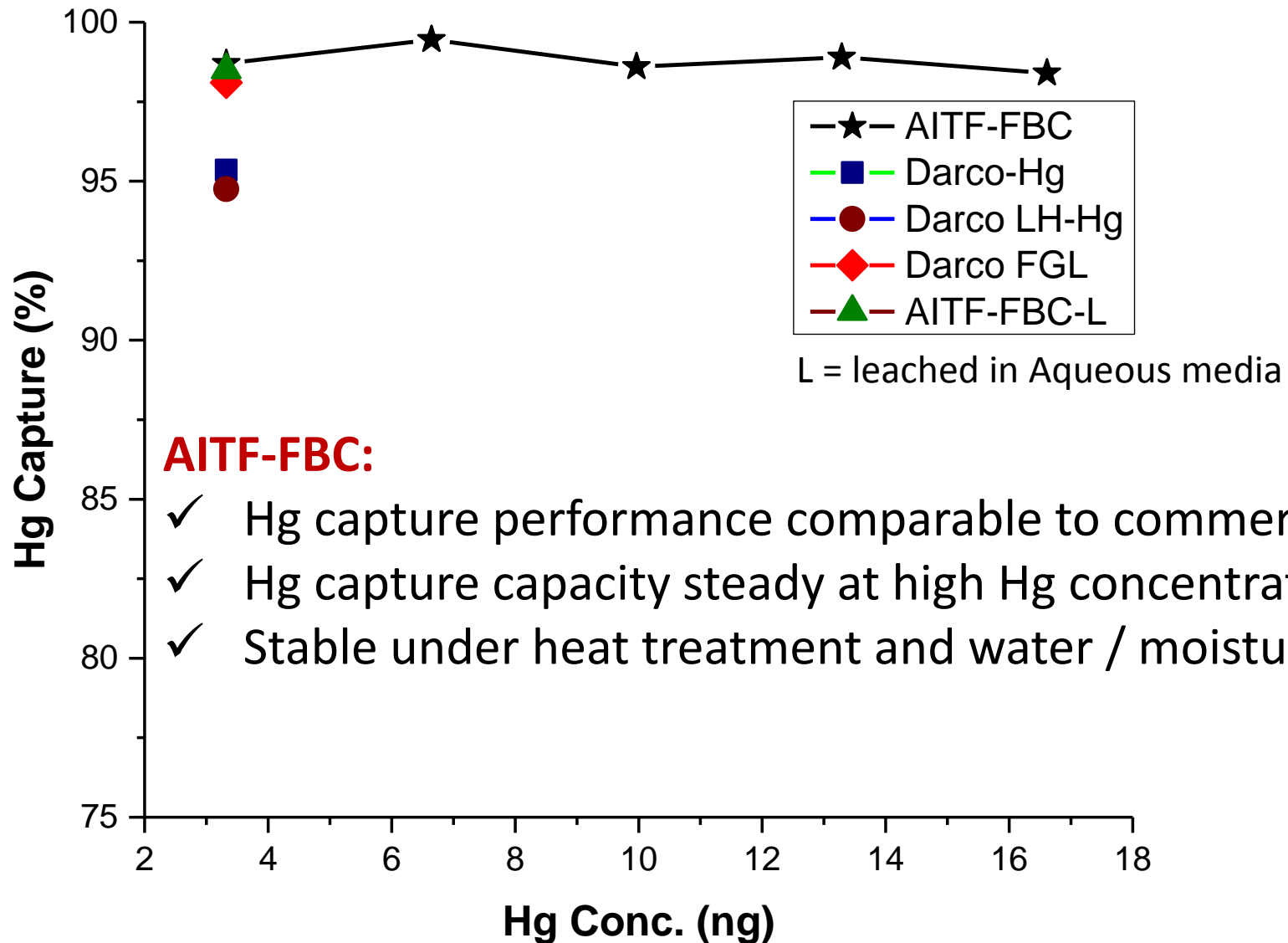
- Market price \$2000 – 9000 / tonne (db)
- Well defined product quality
- Well established market and applications
- Capital intensive equipment

# Higher Value Proposition



- Explore alternate strategies to transform biochar (carbonized biomass) to high value activated carbon replacements

# Mercury Capture Tests @ 100 °C



# Alberta Biochar Initiative (ABI)

- Partners: AITF, Lakeland College, Industry
- Two Mobile Demo Units (0.5 tonne/day biochar output)
  - Abri-Tech (Canadian)
    - Retort Auger (indirect heat)
  - Black is Green (Australian)
    - Rotary Multi Hearth Furnace (direct heat)
- Biochar Network & Partnership Engagement
- ABI Website: [www.albertabiochar.ca](http://www.albertabiochar.ca)





# Demo Scale Biochar Production Systems

(0.5 tonne/day)

**ABRI-Tech (Canada)**



**Auger Retort – Indirect Heat**

**Black is Green (Australia)**



**Multi-Hearth Furnace – Direct Heat**

# AITF - Vegreville



24,269 square meters of building space;  
259 hectares (640 acres) of land  
120-150 staff (depending on season)

# Thank you!

**Ataullah Khan, PhD | Research Scientist**  
Processing Technologies

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