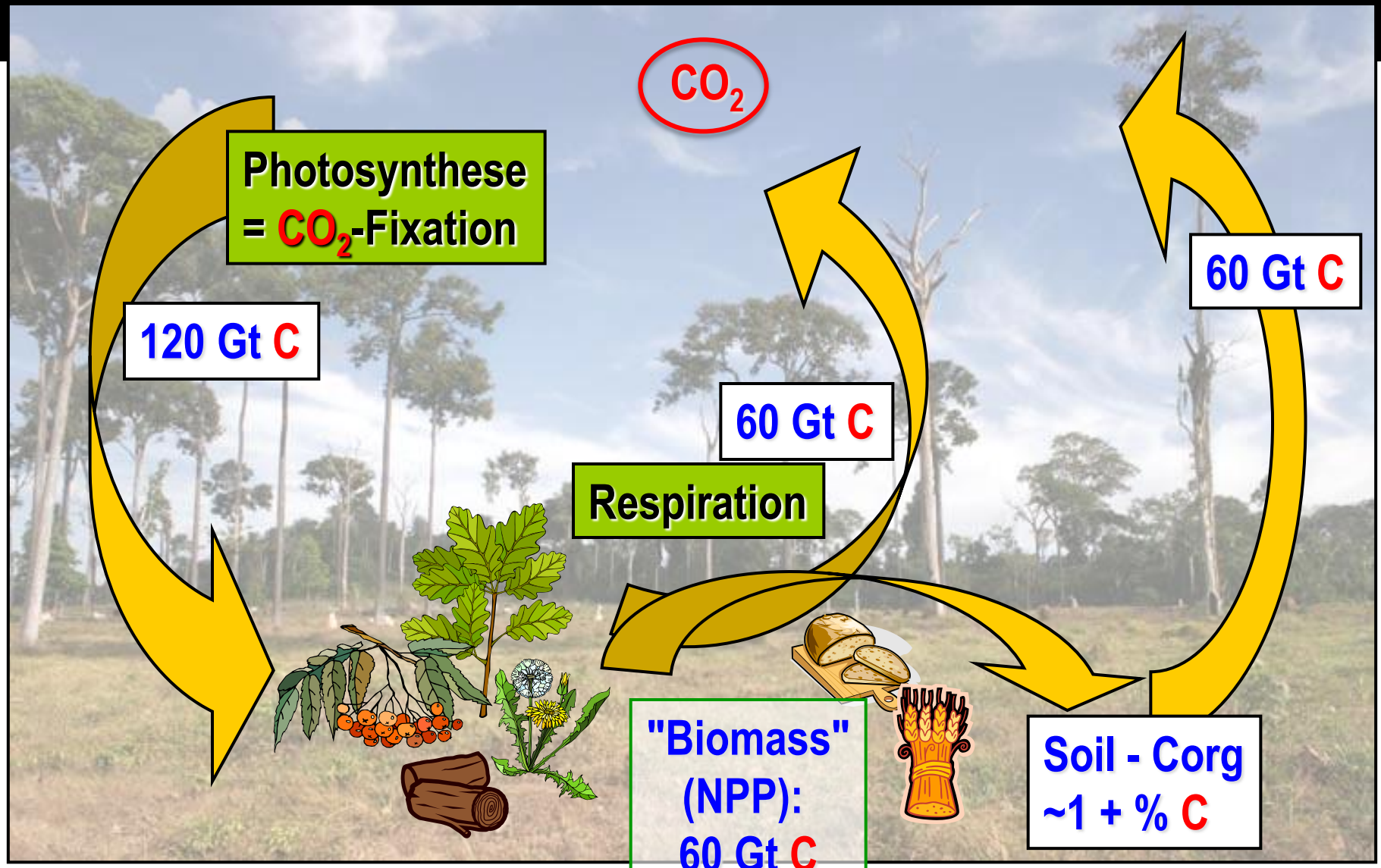
Novel Uses of Biochar – a key technology for the future of the planet

Hans-Peter Schmidt
Ithaka Institute for Biotic Carbon Cycling

ithaka institute

Carbon Exchange Market



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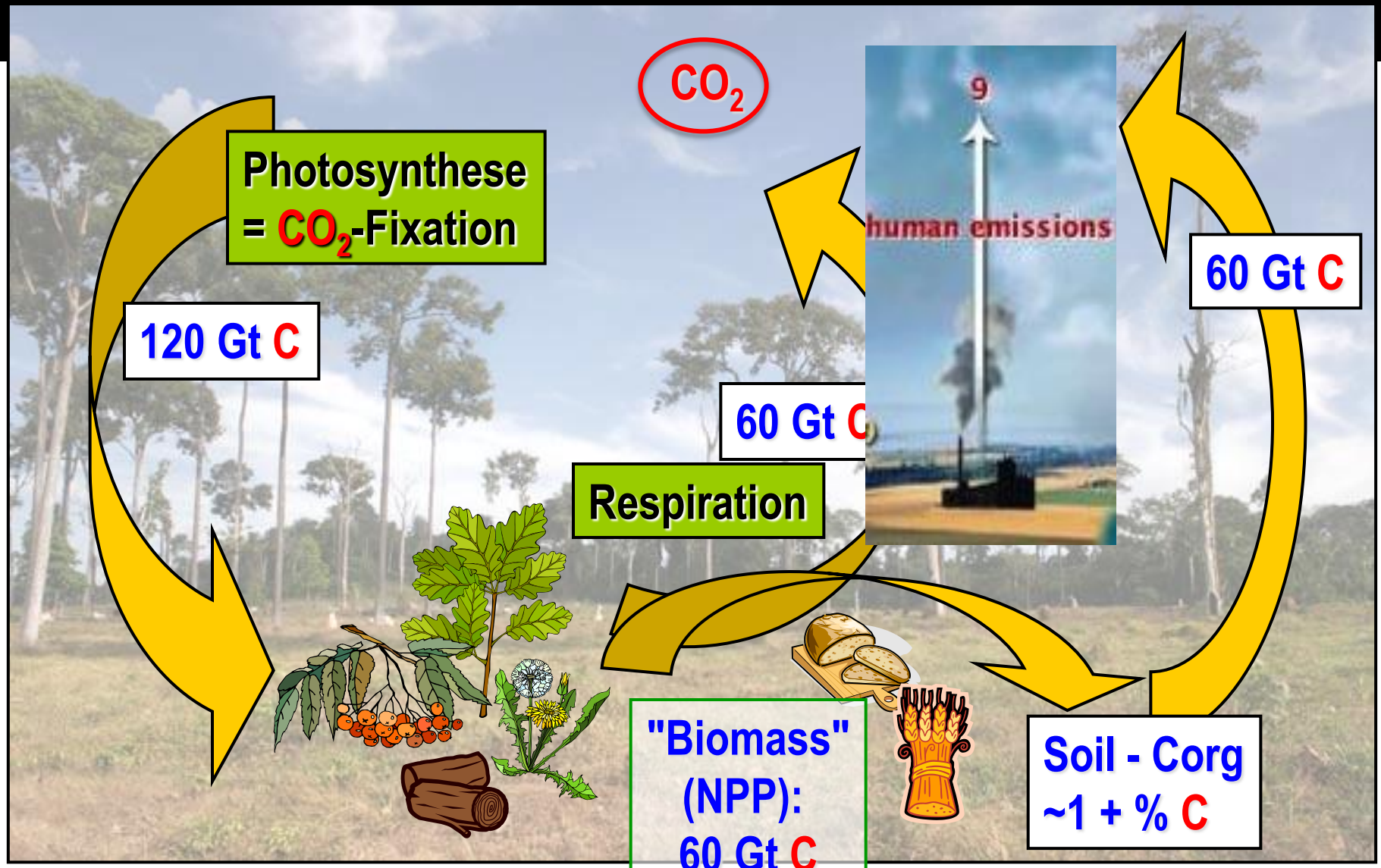

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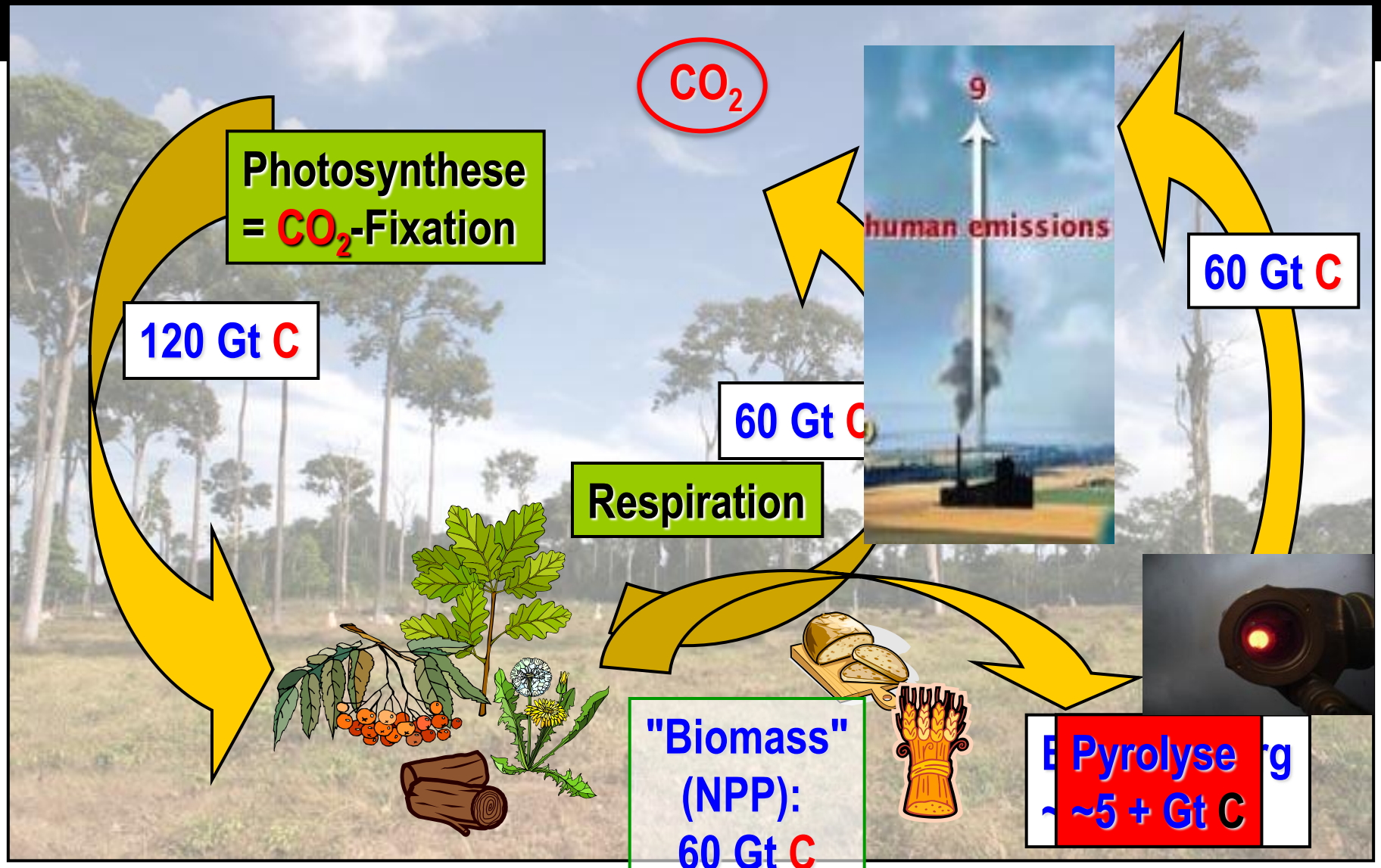

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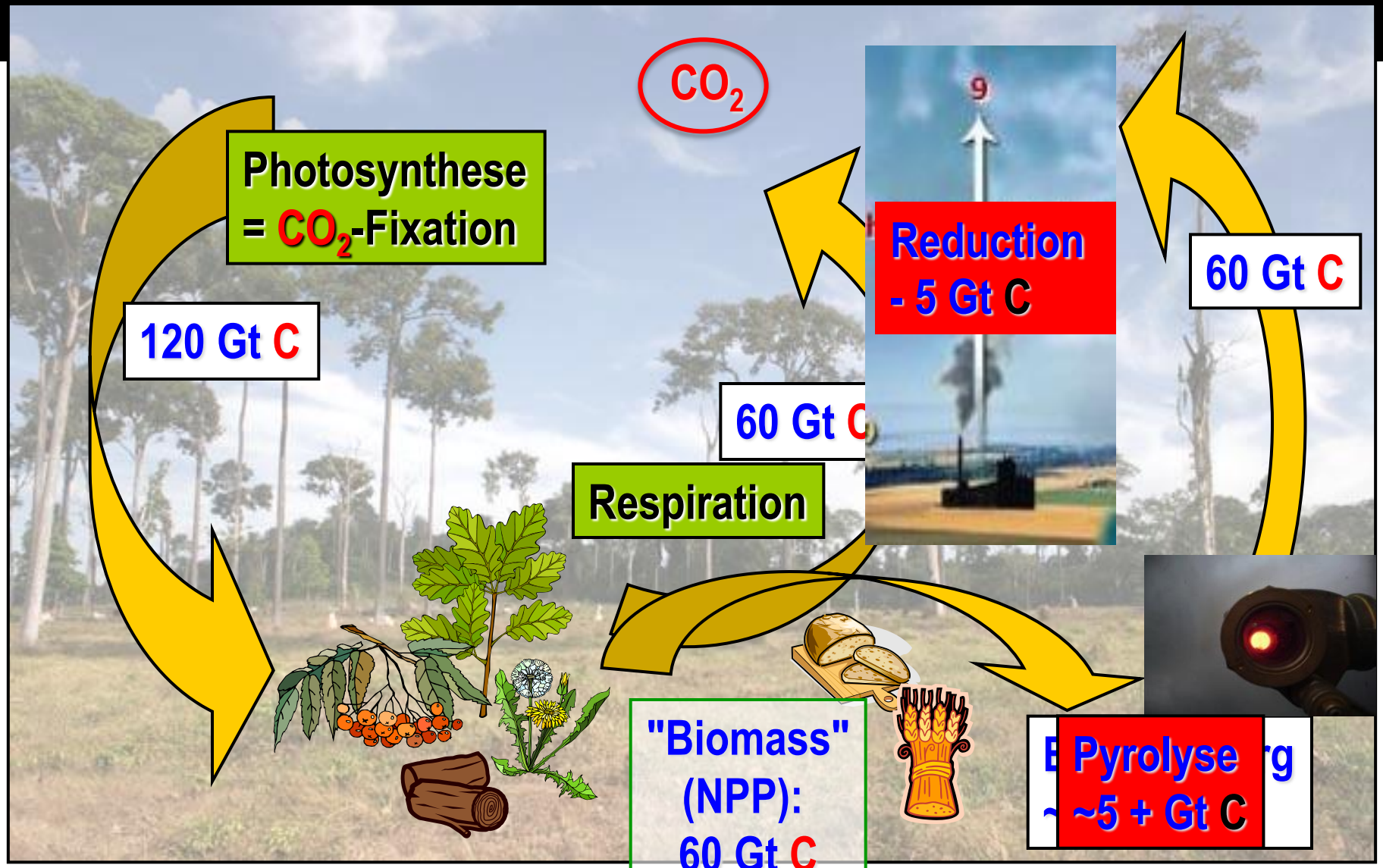
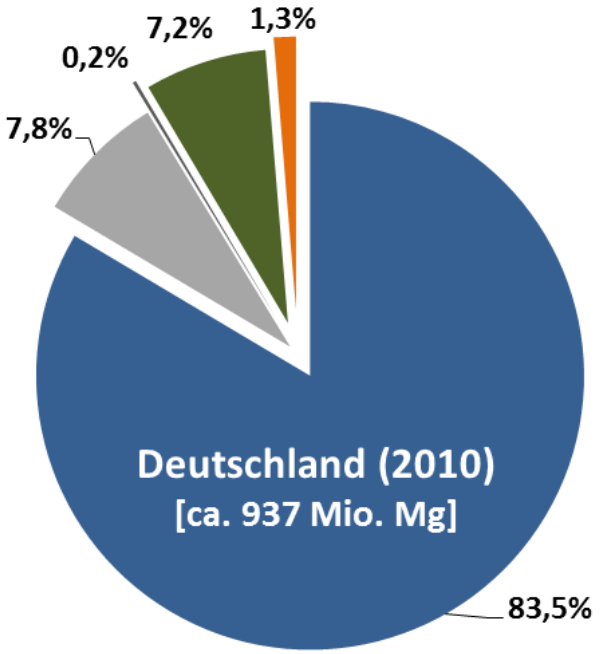


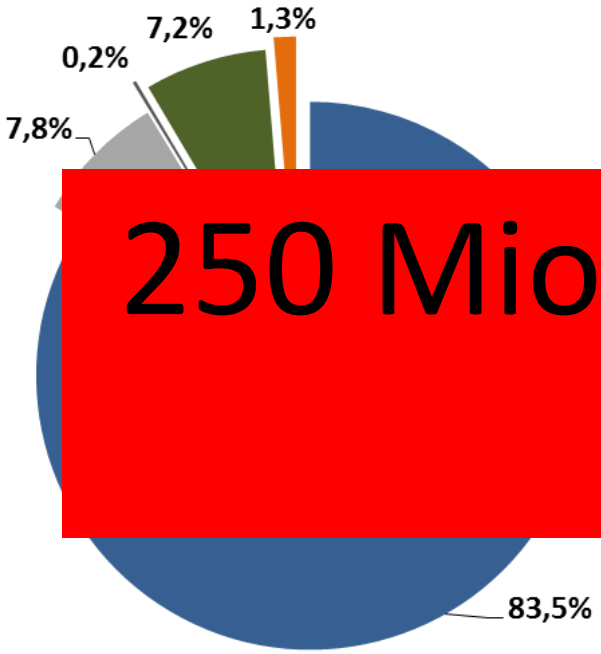
Biomasse Waste in Germany



Auszug der Anteile verschiedener Quellgruppen (ohne LUC) an den Treibhausgasemissionen (UBAa, 2012; EEA, 2011)

	quantiy	use
Biowaste	4,2 Mio. t	Composting
Green clippings	4,4 Mio. t	Composting
Food waste	1,8 Mio. t	Methanisation
Organic part of houshold waste	4,9 Mio. t	burning
Landscampe managment	0,8 Mio. t	Keep on site burning

Carbon Emission vs Carbon Waste



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250 Mio t C : 5.4 Mio t C

2%

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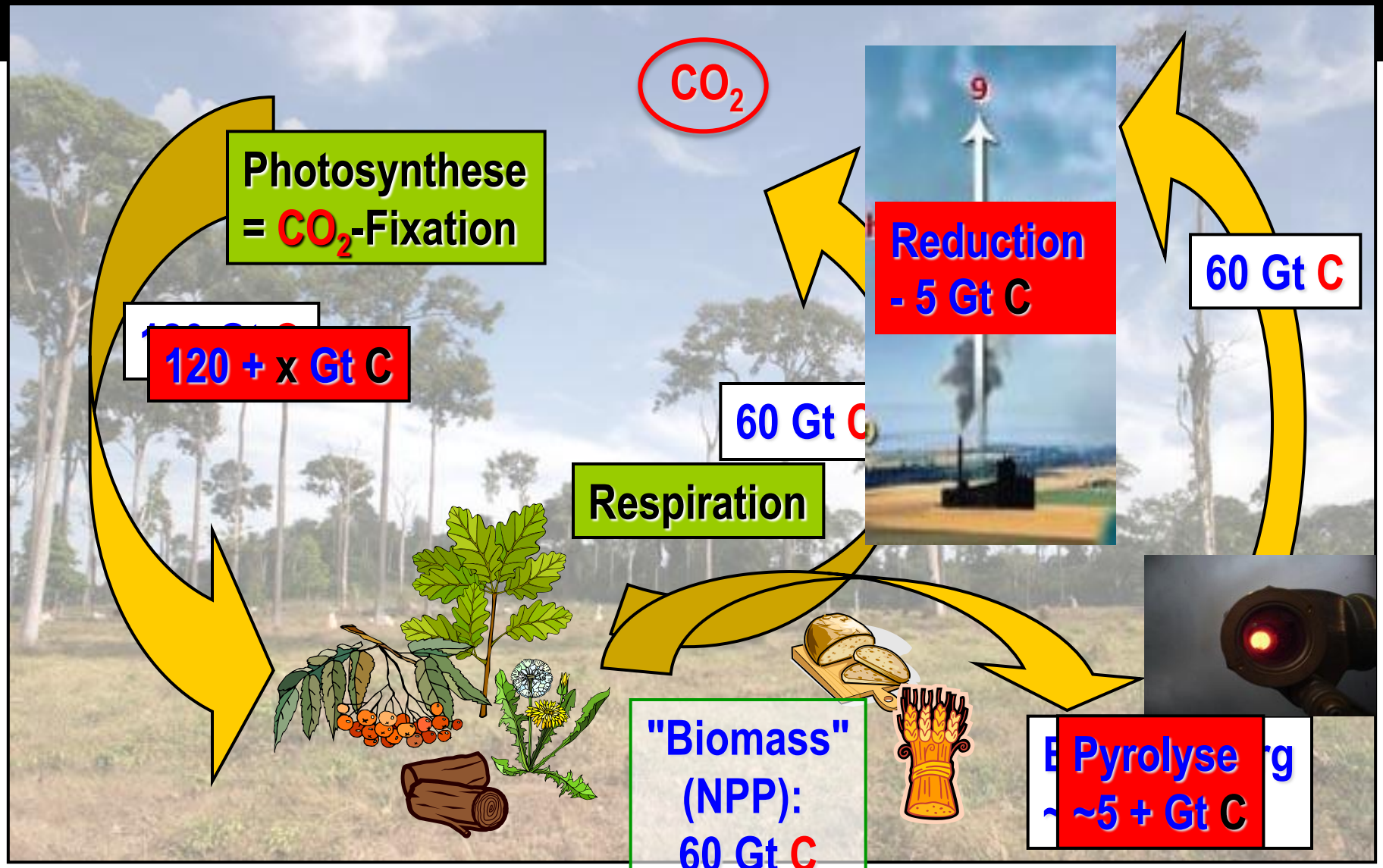
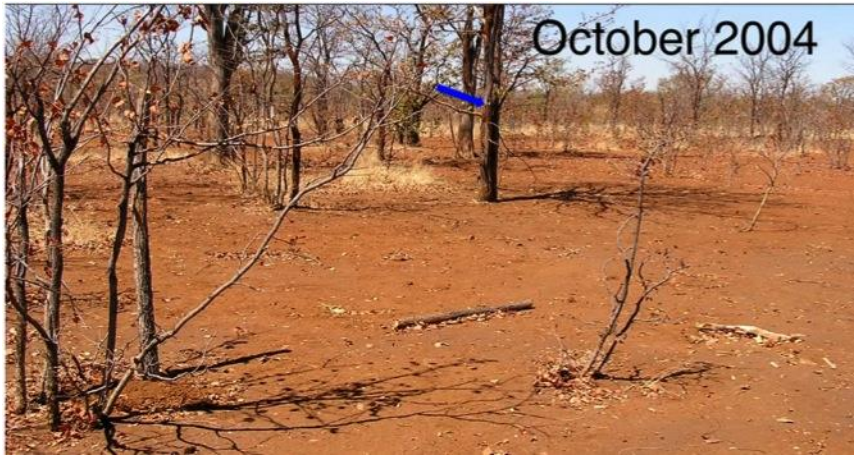


Doubling Photosynthesis



Allan Savory – Savory Institute, 2013, Simbabwe

Doubling Photosynthesis

Lessons from the Loess Plateau – John D. Liu, China

Hope in a Changing World –
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Climate Farming

photosynthesize
carbonize

55 Uses of Biochar

farming

Soil amendment

7. Carbon fertiliser, 8. Compost, 9. Substitute for peat in potting soil, 10. Plant protection, 11. Compensatory fertiliser for trace elements

Livestock farming

1. Silage agent, 2. Feed additive / supplement, 3. Litter additive, 4. Slurry treatment, 5. Manure composting, 6. Water treatment in fish farming

Biogas produktion

21. Biomass additive, 22. Biogas slurry treatment

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decontamination

Decontamination of soil and natural water

17. Soil additive for soil remediation, 18. highly adsorbing, plantable soil substrates *19. A barrier preventing pesticides getting into surface water 20. Treating pond and lake water*

2.6 Waste water and sewage treatment

23. Active carbon filter, 24. Pre-rinsing additive, 25. Soil substrate for organic plant beds, 26. Composting toilets

2.7 Treatment of drinking water

27. Micro-filters, 28. Macro-filters in developing countries

2.8 Exhaust filter

29. Controlling emissions, 30. Room air filters

55 Uses of Biochar

industry

Building material

12. Insulation, 13. Air decontamination, 14. Decontamination of earth foundations, 15. Humidity regulation, 16. Protection against electromagnetic radiation (“electrosmog”)

Textile industry

45. Fabric additive for functional underwear, 46. Thermal insulation for functional clothing, 47. Deodorant for shoe soles

Food industry

48. Conservation of food 49. Digesting helper

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Wellness
48. Filling for mattresses, 49. filling for pillows

Radio protection
*50. Shield against electromagnetic radiation (*microwaves, TV, Netzgeräte, computer)

Further uses
Industrial materials (31. carbon fibres, 32. plastics)
Electronics (33. semiconductors, 34. batteries)
Metallurgy (35. metal reduction)
Cosmetics (36. soaps, 37. skin-cream, 38. therapeutic bath additives)
Paints and colouring (39. food colorants, 40. industrial paints)
Energy production (41. pellets, 42. substitute for lignite)
Medicines (43. detoxification, 44. carrier for active pharmaceutical ingredients)

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Cascading use of biochar

Use it nine times – pay it only once

silage

feed additive

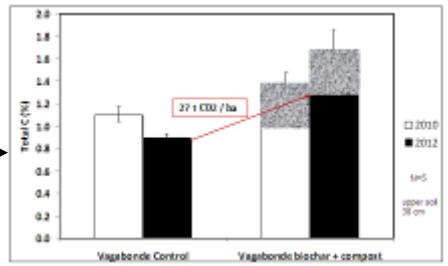
litter additive

liquid manure treatment

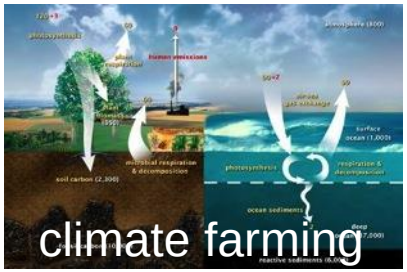
composting

urban soil substrate

soil amendment



humus increase



climate farming

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1. Silage

Cascading use of biochar

1.

Charging biochar with malolactic bacteria and add

1 % BC to silage

reducing mycotoxins and butyric acid, adsorption of pesticides and herbicides

2. Feed additive

Cascading use of biochar

2.

1 % BC for feeding

Carbon-Feed

increases energy efficiency of digestion, decreases milk cells, adsorption of gram positive bacteria (botulisme), pesticides, herbicides, reducing odors, fixation of nutrients, improvement of barn climate

CarbonFeed

- **Ingredients:** Wheat bran (40 %), biochar (15 %), sugar cane molasses, linseed, alpine herbs, corn flakes, wheat flakes, barley flakes, minerals

- Water 43 %, raw proteins 7.5 %, raw ash 5.2 %, raw fibre 4.7 %, raw fat 1.7 %, sodium 0.03 %, calcium 0.08 %, phosphorous 0.5 %, magnesium 0.2 %, lysine 2.7 g/kg, methionine 1.0 g/kg

For cows, horses, chicken, pigs, sheep – dogs, cats …

Zanzibar Red Colobus Monkey Eating Charcoal

Photo: Martin Harvey. CORBIS

The red colobus monkeys, *Procolobus kirkii*, eat charcoal, (Zanzibar, Tanzania). These endangered animals have specially adapted stomachs which enable them to feed principally on leaves. They eat charcoal from burnt tree stumps and branches to detoxify poisons (mainly phenolics) obtained from their leafy diet and convert them into proteines

Struhsaker, T.T., Cooney, D.O., Siex, K.S., 1997. Charcoal Consumption by Zanzibar Red Colobus Monkeys: Its Function and Its Ecological and Demographic Consequences. Int. J. Primatol. 18, 61–72.

1% Biochar in Feed for Germany

- 13 Million cattle (650 000 t BC)
- 27 Million pigs (780 000 t BC)
- 2,4 Million sheep (43 000 t BC)
- 130 Million poultry (260 000 t BC)

1,7 Million tonnes biochar per year

5 Million tonnes CO_2 per year

0,6% of annual CO_2 emission in Germany

All statistics refer to Germany

Adsorption of anti-bacteria, anti-infectica, anti-parasitica, hormones, analgetica, pathogenes, herbicides, pesticides

Cost of annual animal drugs: 19.2 Billion US-Dollar worldwide

Reduction of methane emission caused by rumination

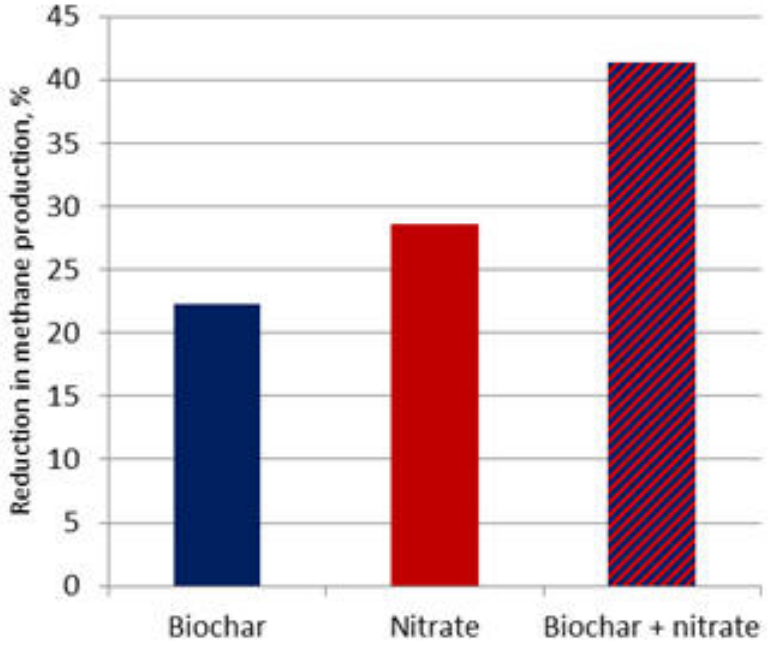


Figure 4. Reduction in methane due to biochar and nitrate in local "Yellow" cattle fed cassava root and cassava foliage supplemented or not with biochar and with urea or potassium nitrate as NPN source

http://www.lrrd.org/lrrd24/11/leng24199.htm for full details

BC – Biochar
KN – form of potassium nitrate

Leng et al 2012, Biochar reduces enteric methane and improves growth and feed conversion in local "Yellow" cattle fed cassava root chips and fresh cassava foliage

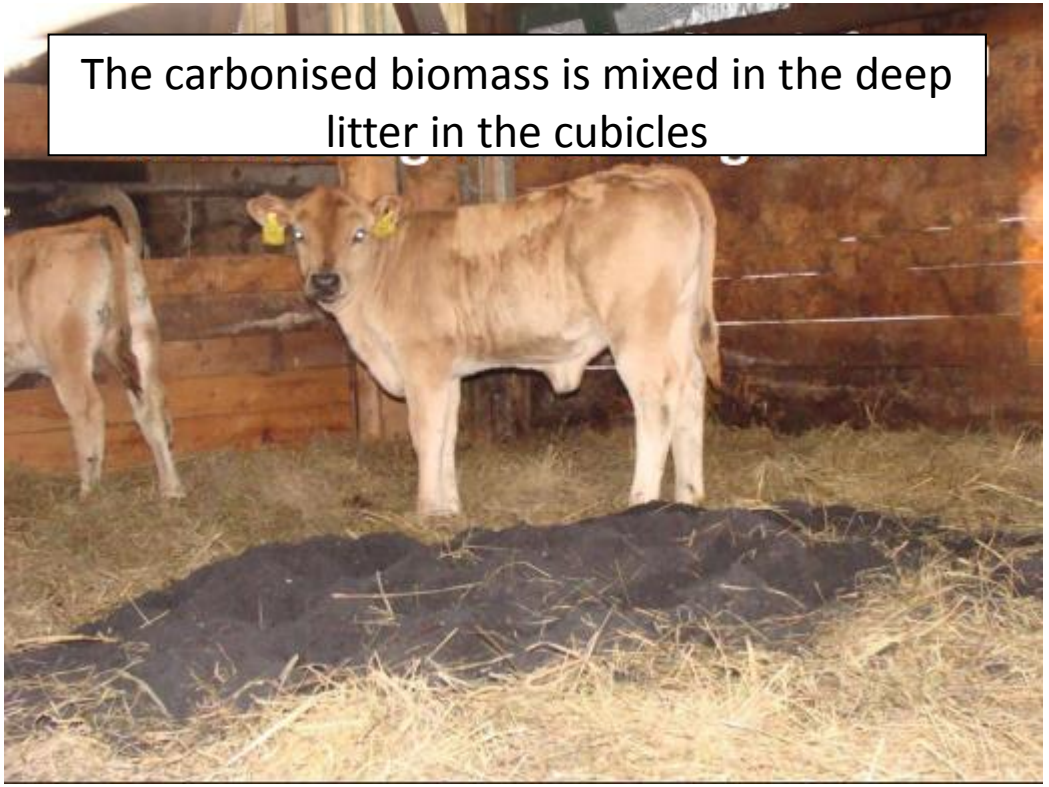
Black Burger Methane Reduction

3. Litter Amendment

Cascading use of biochar

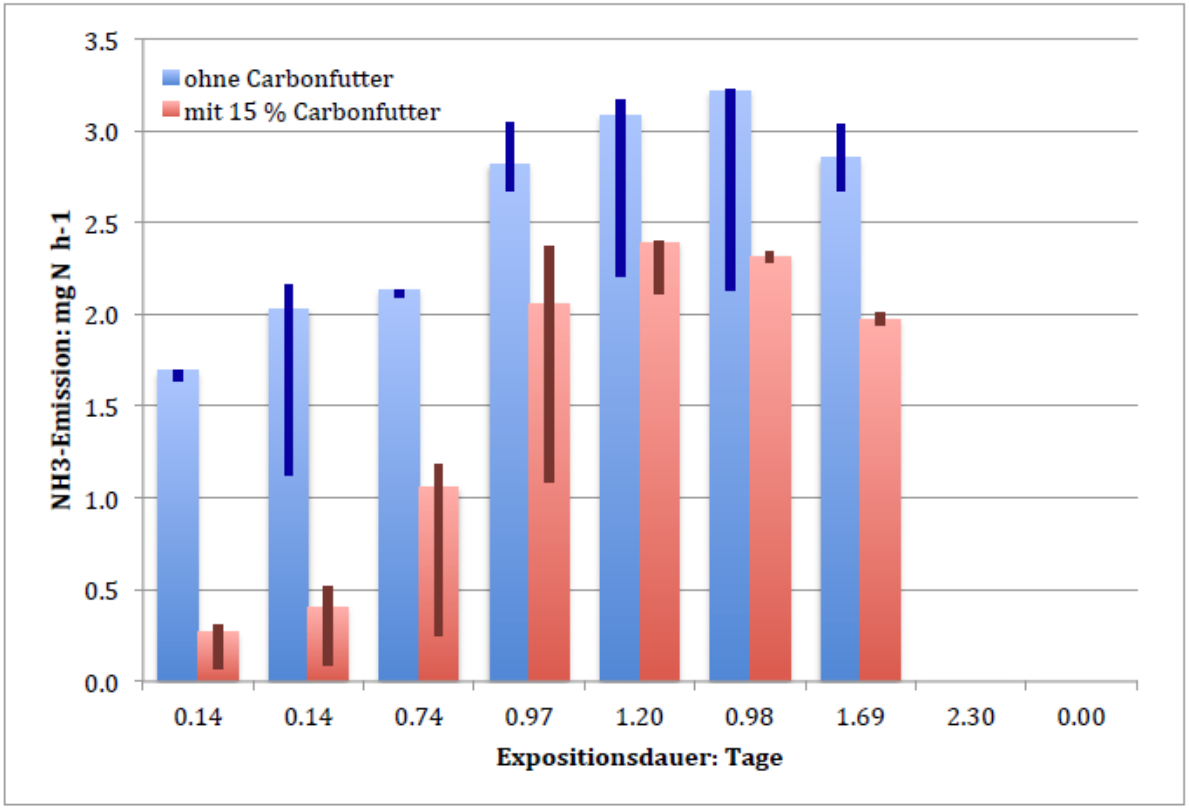
3.

5 - 10 % BC in litter



reducing humidity and odors, fixation of nutrients, reducing NH3 and CH4 emissions, ameliorates hygiene, hoof infections

Biochar induced ammonia reduction in chicken farm



4. Liquid manure additive

Cascading use of biochar

4.

1- 1,5 % BC

in liquid manure

Reducing NH3-losses, methane emissions, increases plant nutrient efficiency, decreases nutrient leaching and odors

Ammonia reduction through treating liquid manure with acidified biochar

Cumulative loss of NH_3 relative to the control:

- Slight increase for BC22
- 5-10% reduction for BC24
- ***Strong reduction*** for PSBC24 and PS (low pH of the slurry)

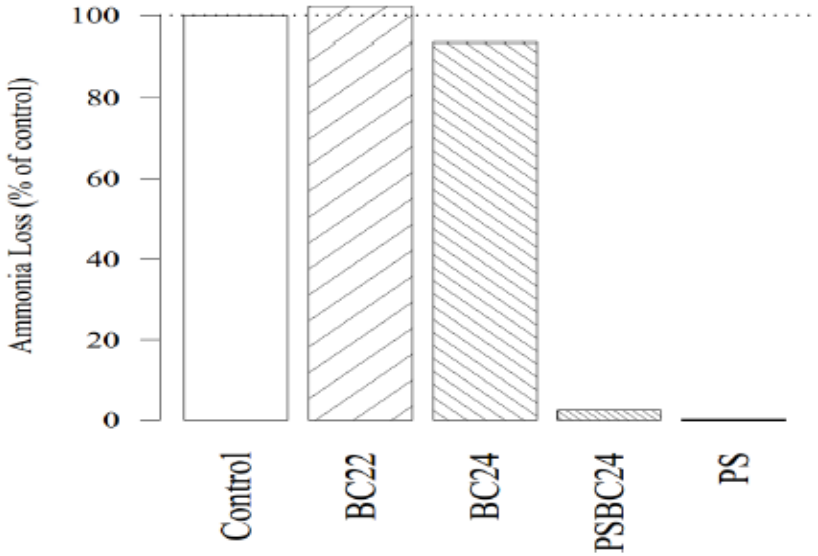


Figure 2: *Cumulative ammonia loss during 8.5 h of measurement (21 days of storage) relative to Control.*

BC - Biochar
PS – Phosphoric acid

HÄNI C, Kupper T, 2012,
Bern University of Applied Sciences,

Acidification & Charging with nutrients and MO lactic fermentation

Injecting

vinasse (rich in sugar, proteins, N, P, K)

rock powder (micro nutrients)

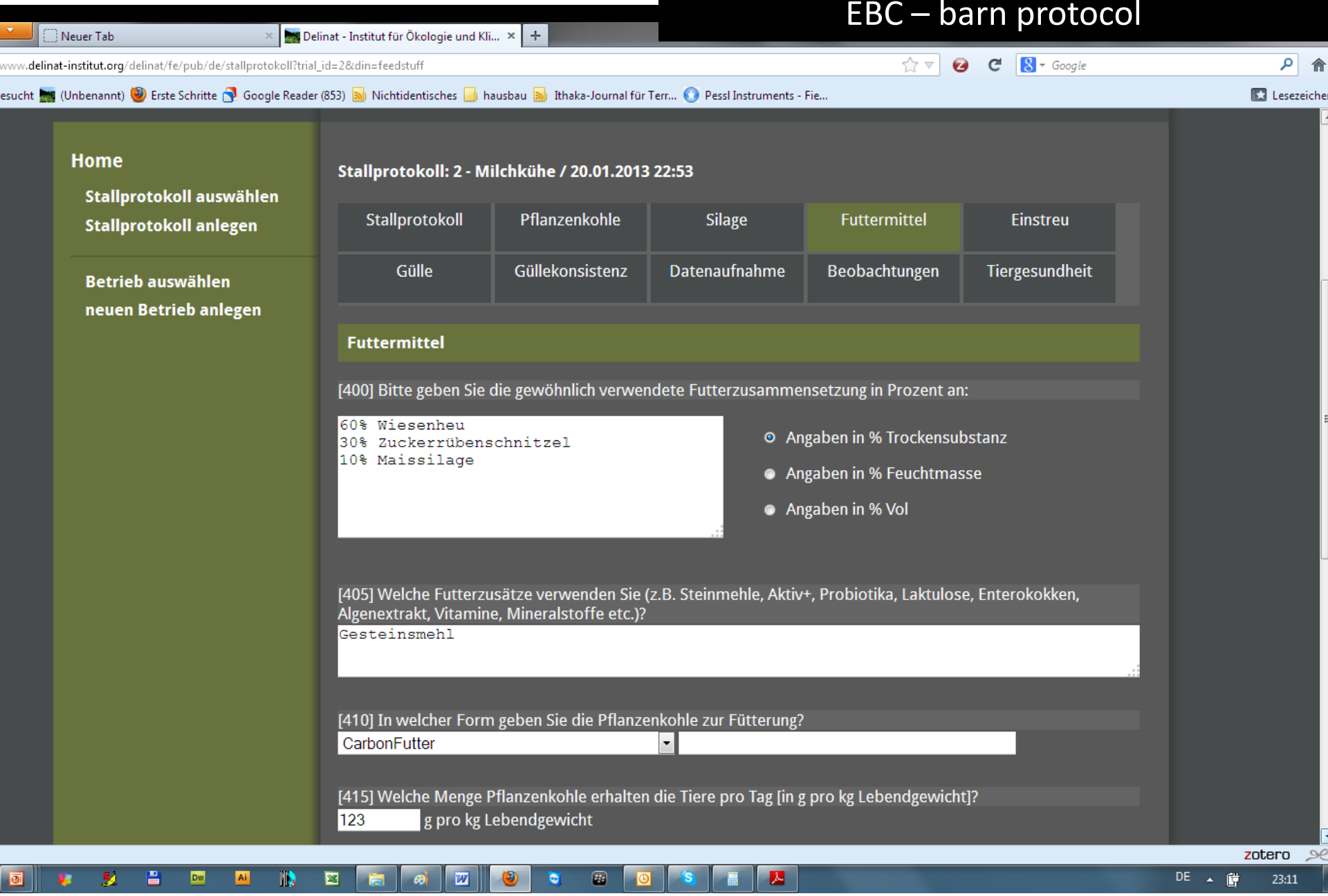
lactic bacteria

Fill it into airtight big bags for anaerobic fermentation for 10 to 14 days

pH 4.5 to 5.5

Charged with lactic acids, pyruvat, inactivated cells

EBC – barn protocol



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First results from 30 farms

Biochar for bedding:

84% less odors

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Biochar as feed additive:

77% less dysenterie

62% animals are calmer and balanced

77% less odor in barns

Observation: cells in milk decreased, less streptococcus, less rumen ulcer, better fitness

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Biochar as liquid manure additive

79% less odors
63% less cauterization of the liquid manure

More examples from livestock farms with CarbonFeed

Poultry farms

3 days after beginn of treatment with fermented biochar, vermifugation of round worms took place

Cow farm

one year after beginning administration, cows did not need any veterinary treatment during the first year of administration

Swine farms

pigs did not need any more antibiotic treatment during the first six months of administration

Chicks

the mortality rate decreased in a chicken farm, while at the same time a high and continual increase in weight of 90 - 100g per day was observed

5. Composting the manure

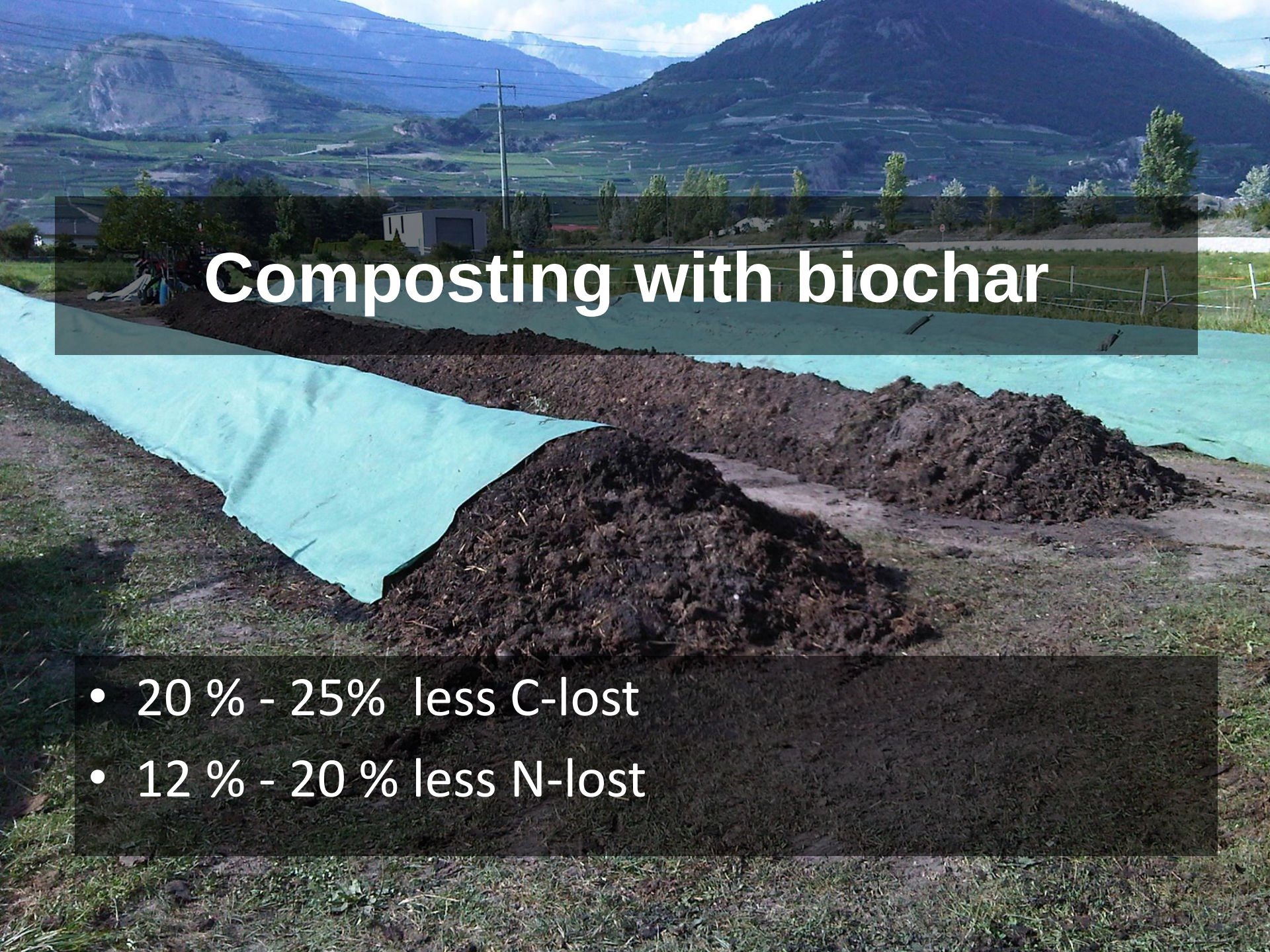
Cascading use of biochar

5.

Composting the carbon manure + the separated solids of the liquid manure

10 – 20% BC

Terra Preta



Composting with biochar

- 20 % - 25% less C-lost
- 12 % - 20 % less N-lost

reduction of GHG during composting

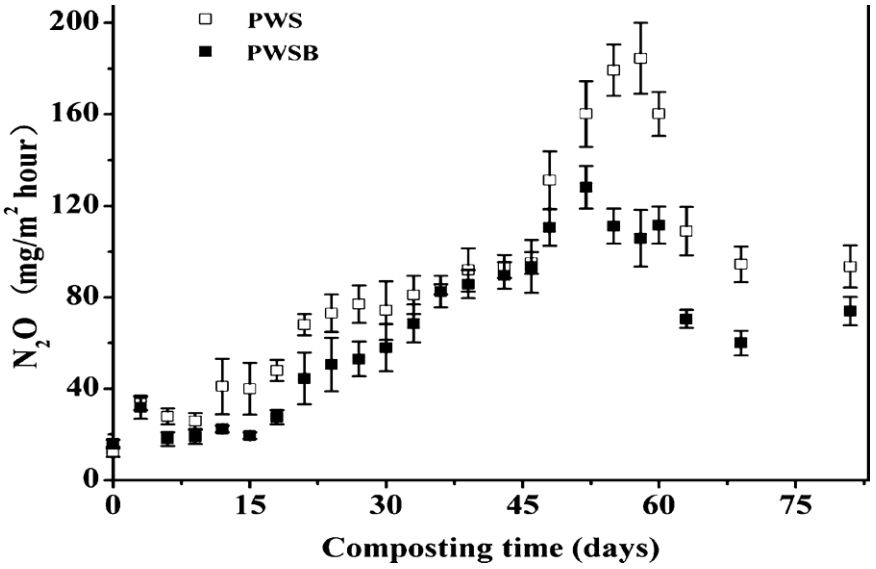


Figure 2. Changes in N2O emission rate during pig manure composting.

Wang et al. 2012: dx.doi.org/10.1021/es305293h | Environ. Sci. Technol.

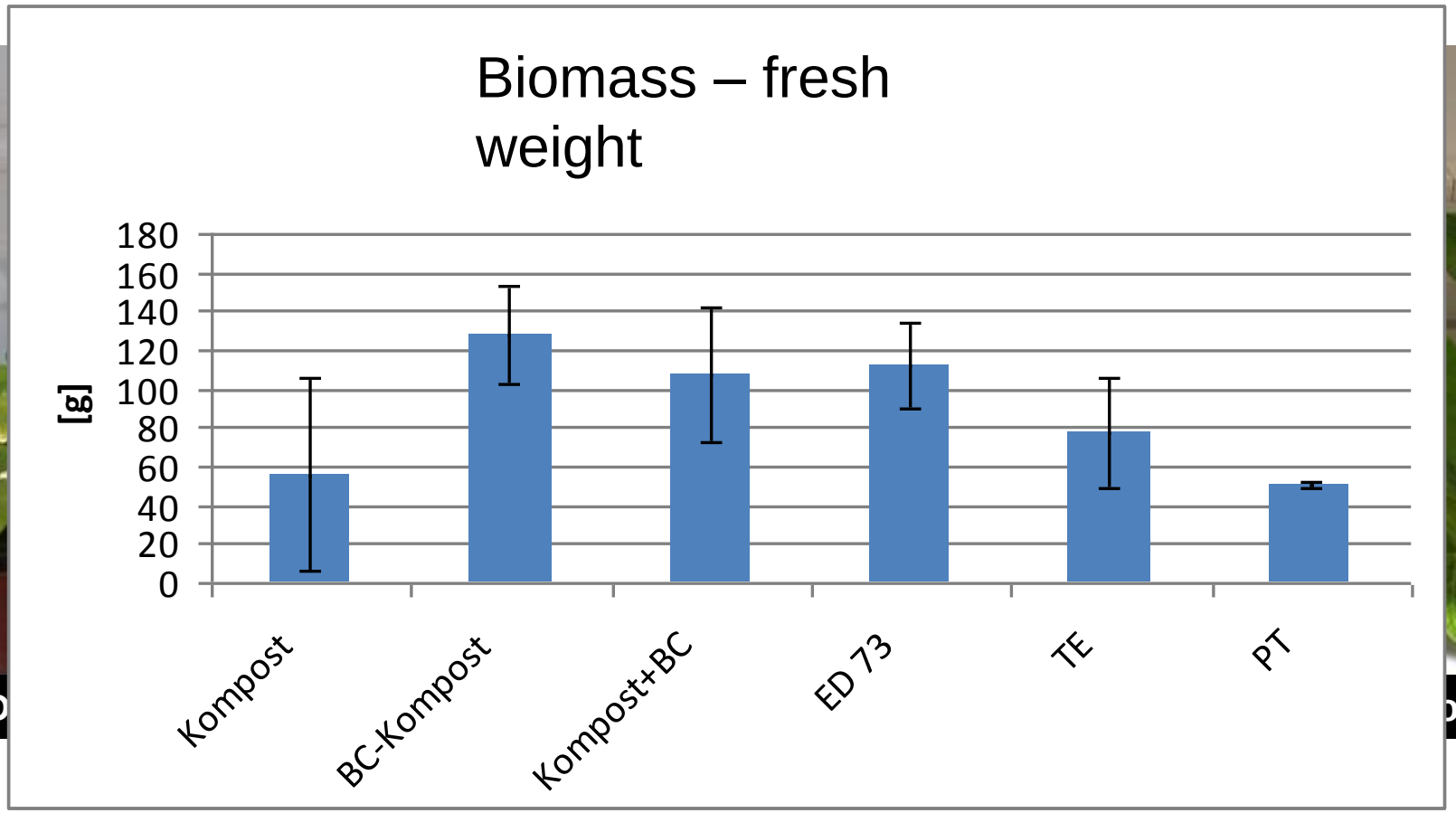
Chen et al. 2010, Chemosphere 78:
up to 65% reduced N loss (total Kjeldahl N)
with up to 9% bamboo biochar addition
(pig manure + sawdust +/- BC (pH 8.8)

Peat substrate vs BC-compost pumpkin

peat ED73 **peat substitute** **soil** **compost** **BC-compost**

Peat substrate vs BC-compost pumpkin

peat ED



ost

Nicotina benthamiana

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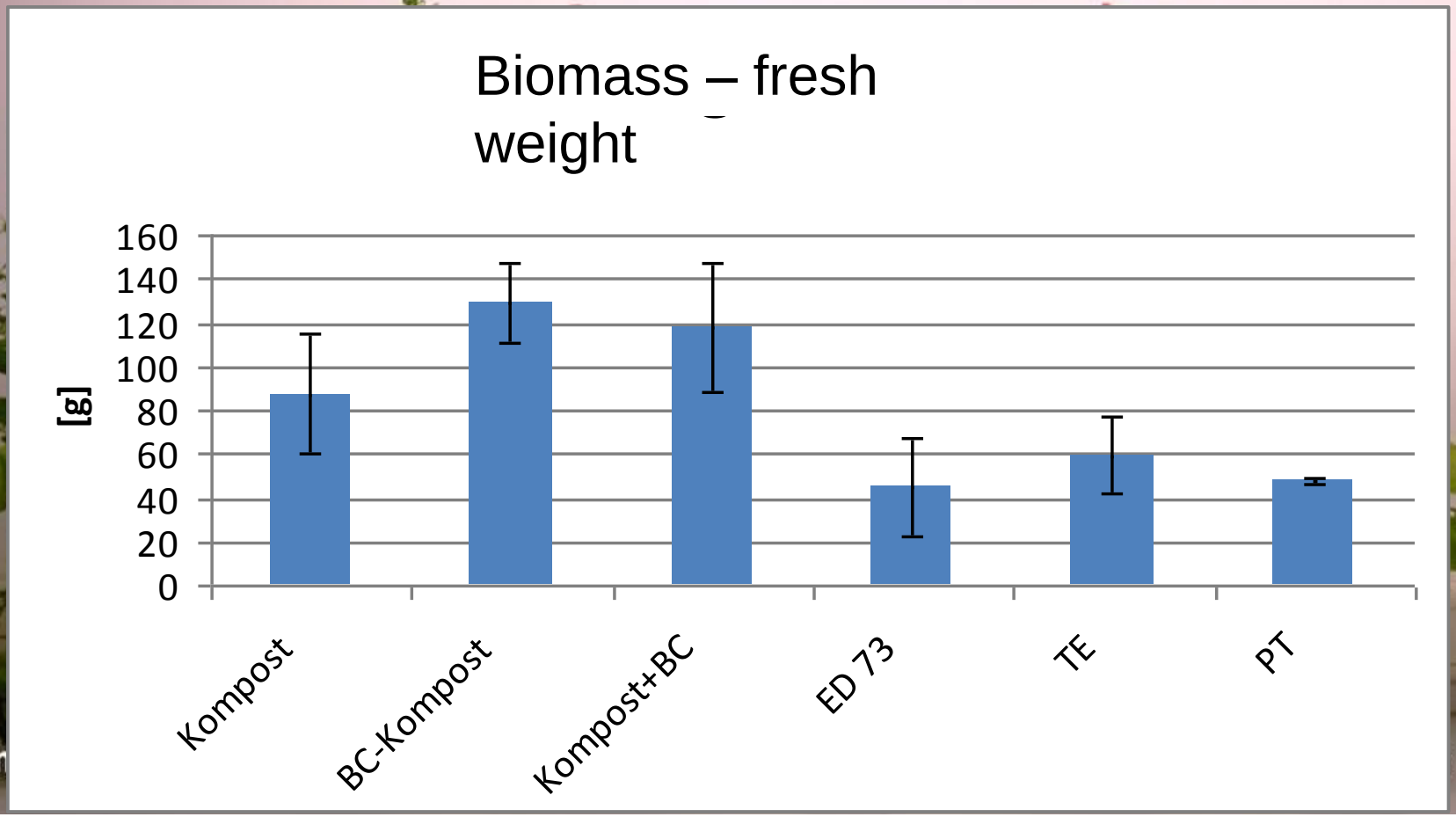

Beet root

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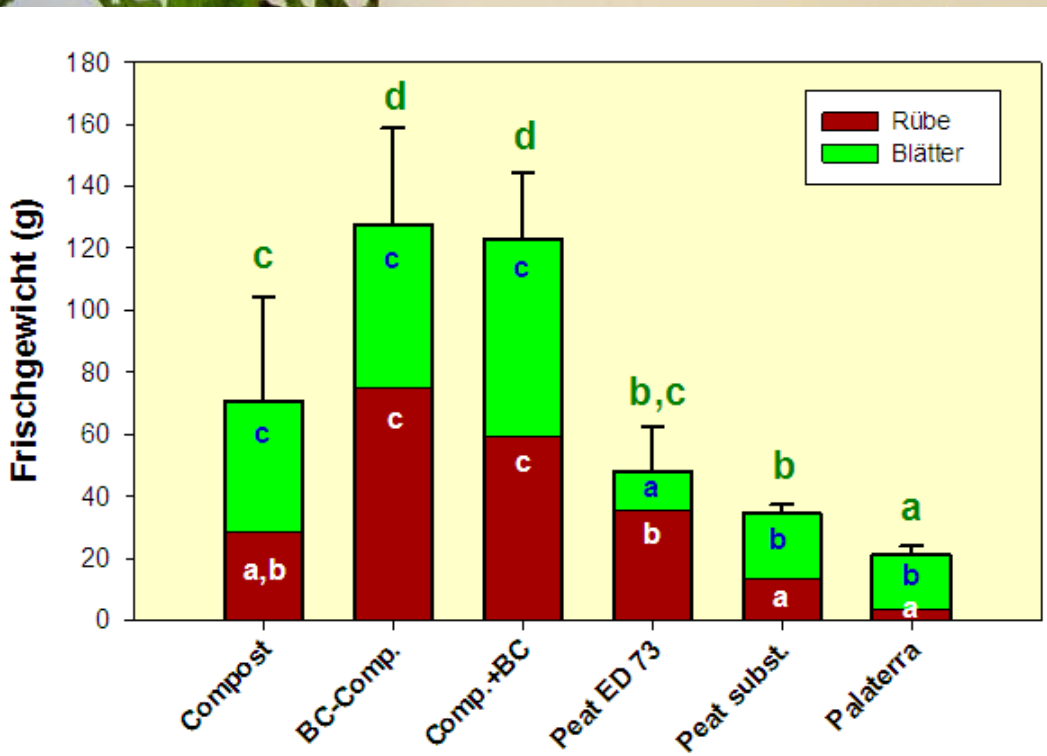
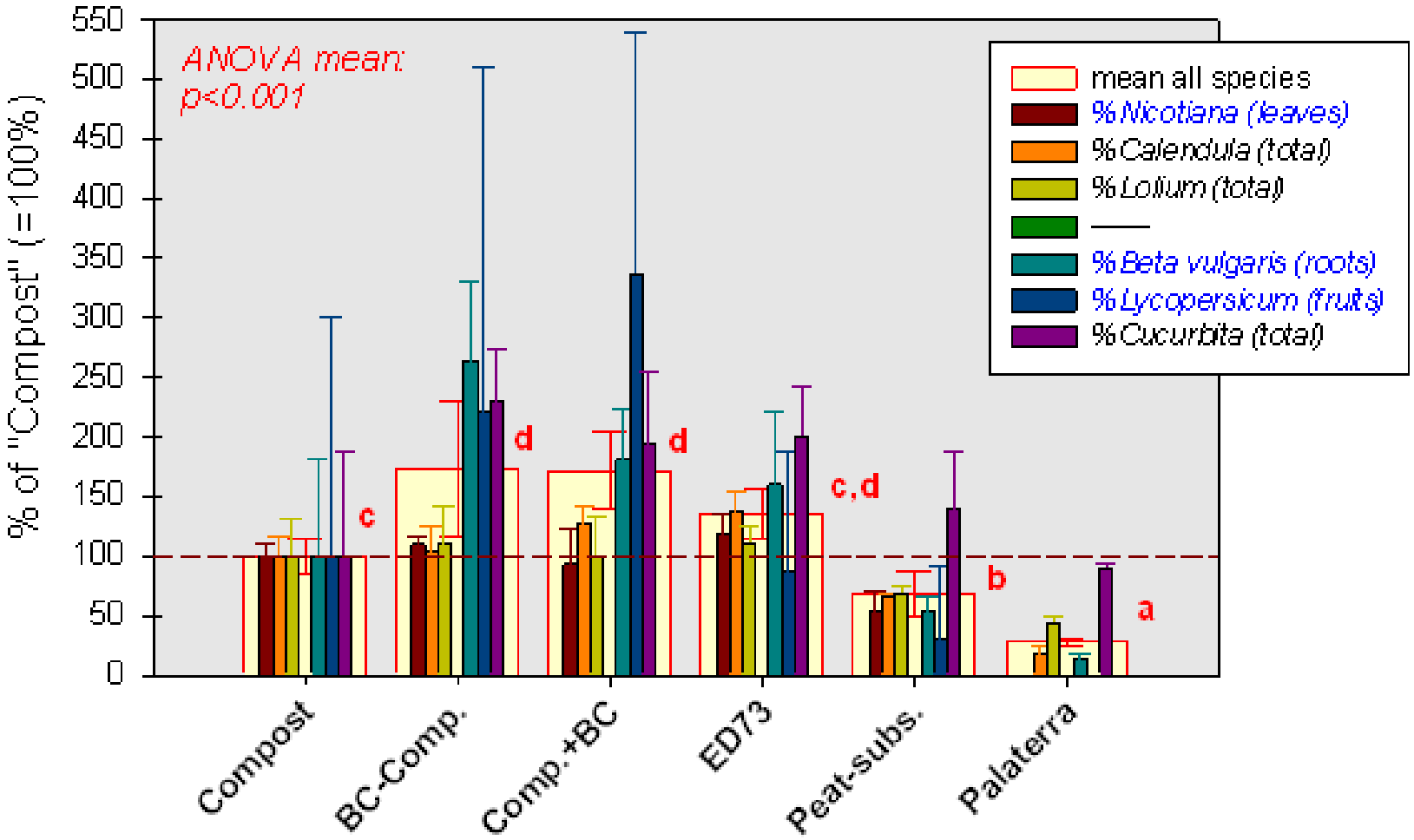
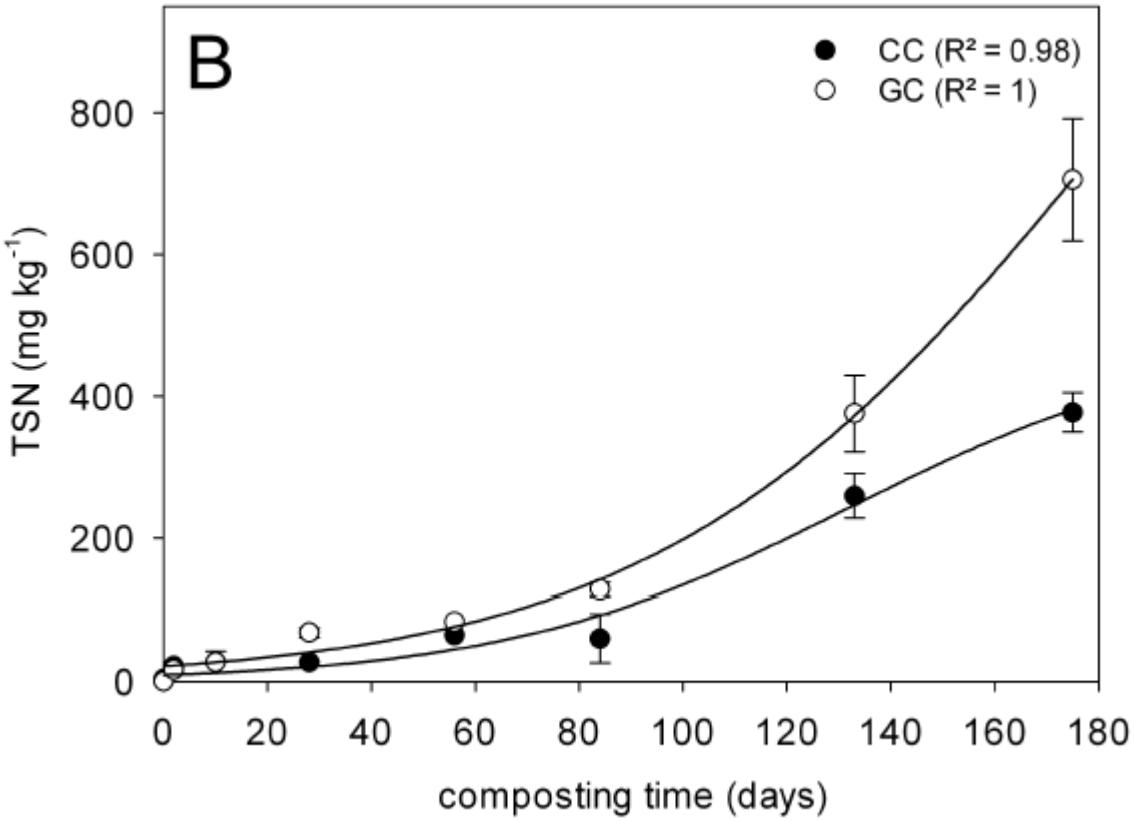


Abb. 4.3: *Biomasse von Blättern und Knollen bei roter Rübe (Beta vulgaris 'Cylindra'), Mittelwerte (+ Stabw. nur bei der Gesamtbiomasse).*

Summary – biomass yield changes



Total soluble nitrogen in biochar after composting



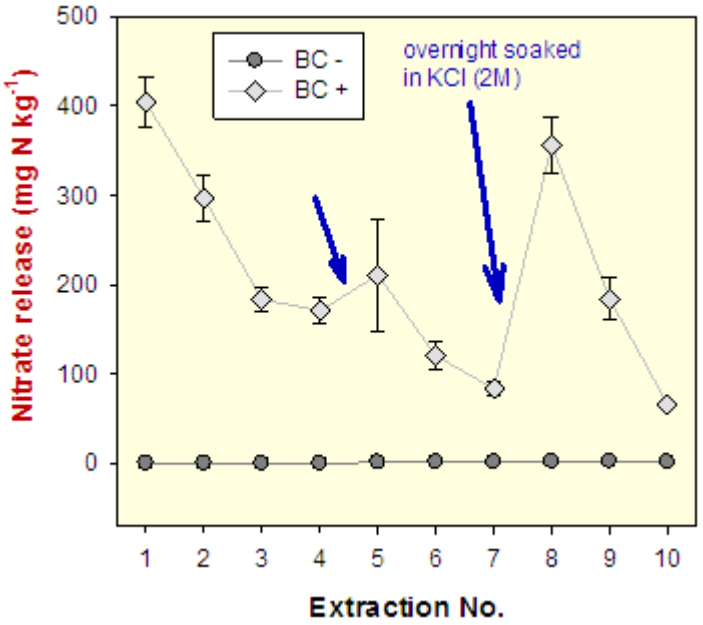
total soluble nitrogen,

gasification coke: from 0.0 to 11 705.5 mg kg-1,

charcoal from 3.2 to 377.2 mg kg-1

Prost, Borchard et al. (2012)

Nitrate extraction from composted biochar



∑ Nitrate N BC+: 2078 mg N kg^{-1}

Kammann, Messerschmidt et al.

Swiss Terra Preta

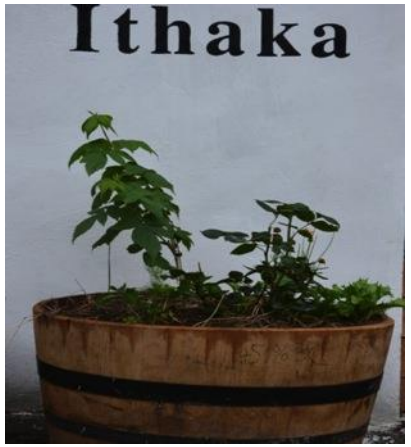
greenhouse substrates, urban farming, pot substrates, special cultures, tree nurcery

Corresponding to 1000 t biochar / ha

Biochar-Compost Substrates

100% BC

70% BC



45% BC

0% BC

15% BC

30% BC

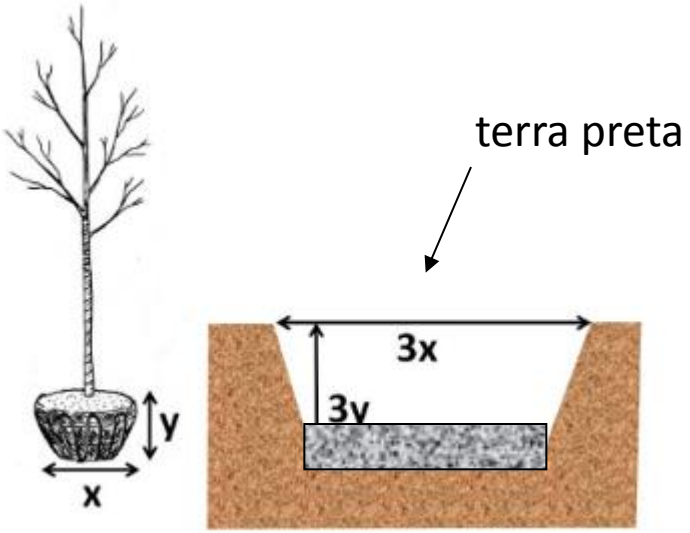
Biobeds for streetwater decontamination

Blanc, Boivin, Schmidt (2013)

HEPIA Genève &

ithaka institute

Planting trees with terra preta



Highly concentrated hotspots close to the roots

under the roots: biochar substrates

7. Soil Amendment

Cascading use of biochar

7.

Soil amendment

Fixation of nutrients

Increase of SOM

free ranging animals

biocharen gesunden Boden

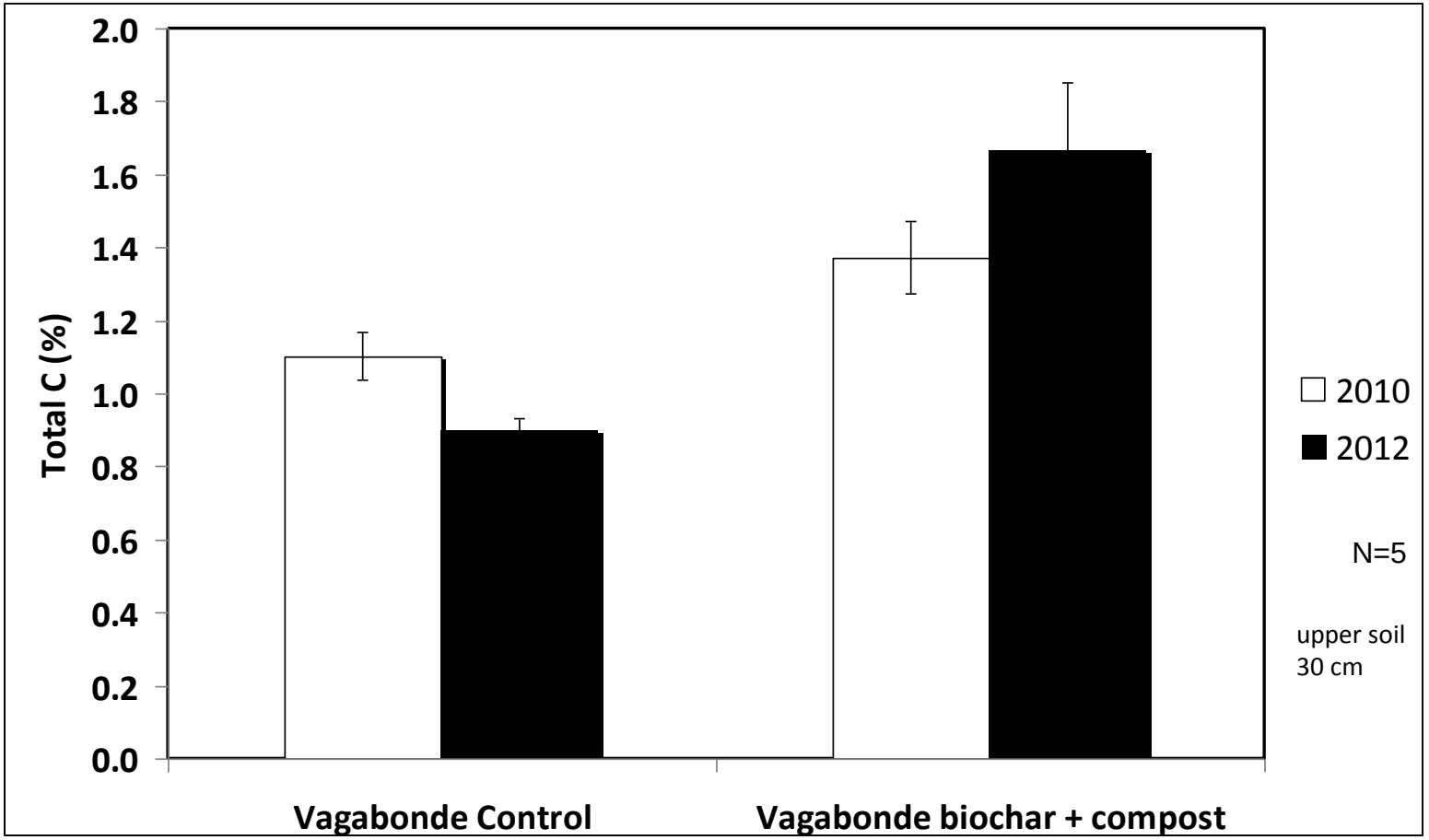
in combination with photosynthesizing green cover

10 kg biochar per sheep and year

8. Increase of humus (SOC)

Cascading use of biochar

10 t BC / ha
= ca. 0,5%
total C in
upper soil



Data from a vineyard field trial in Valais

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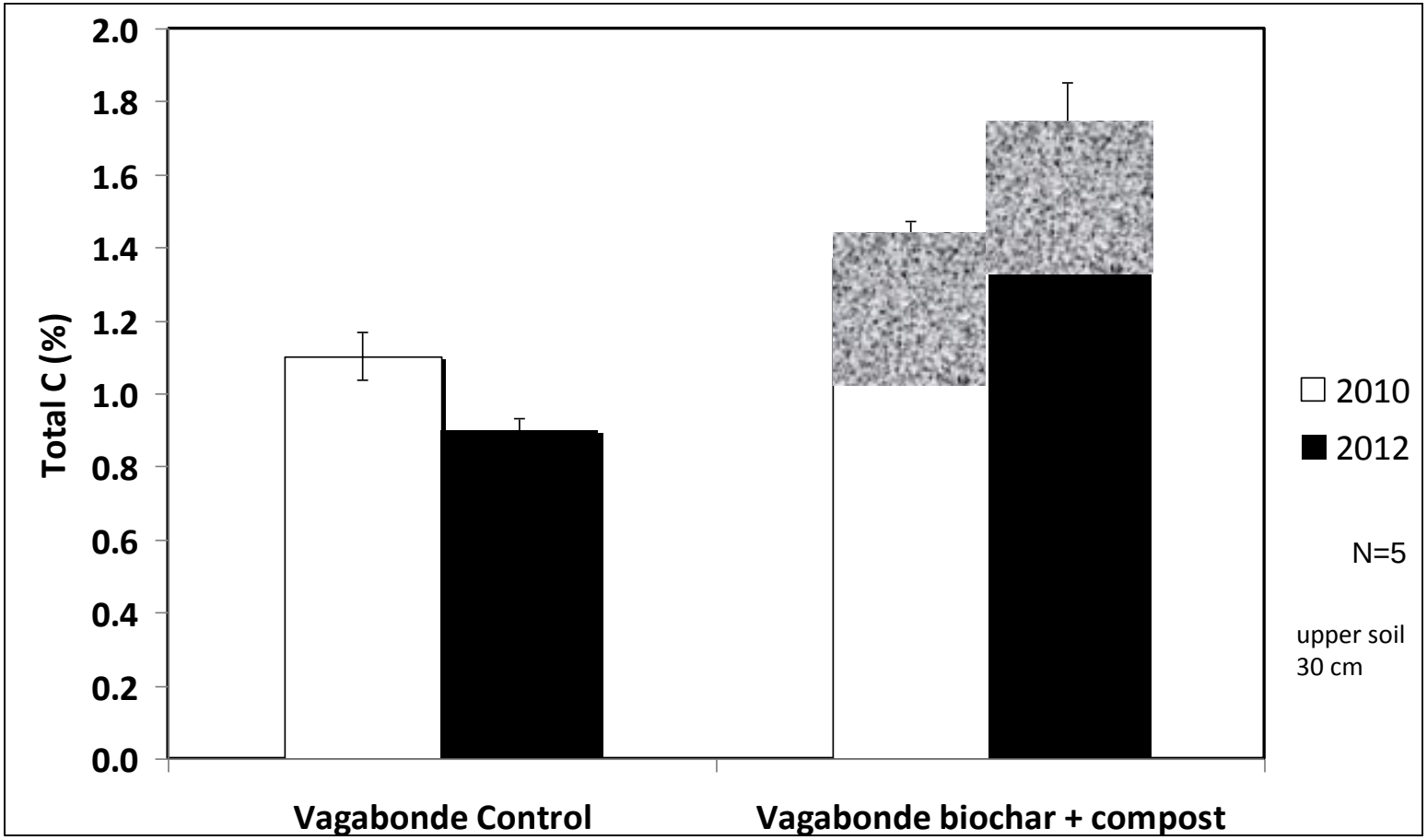

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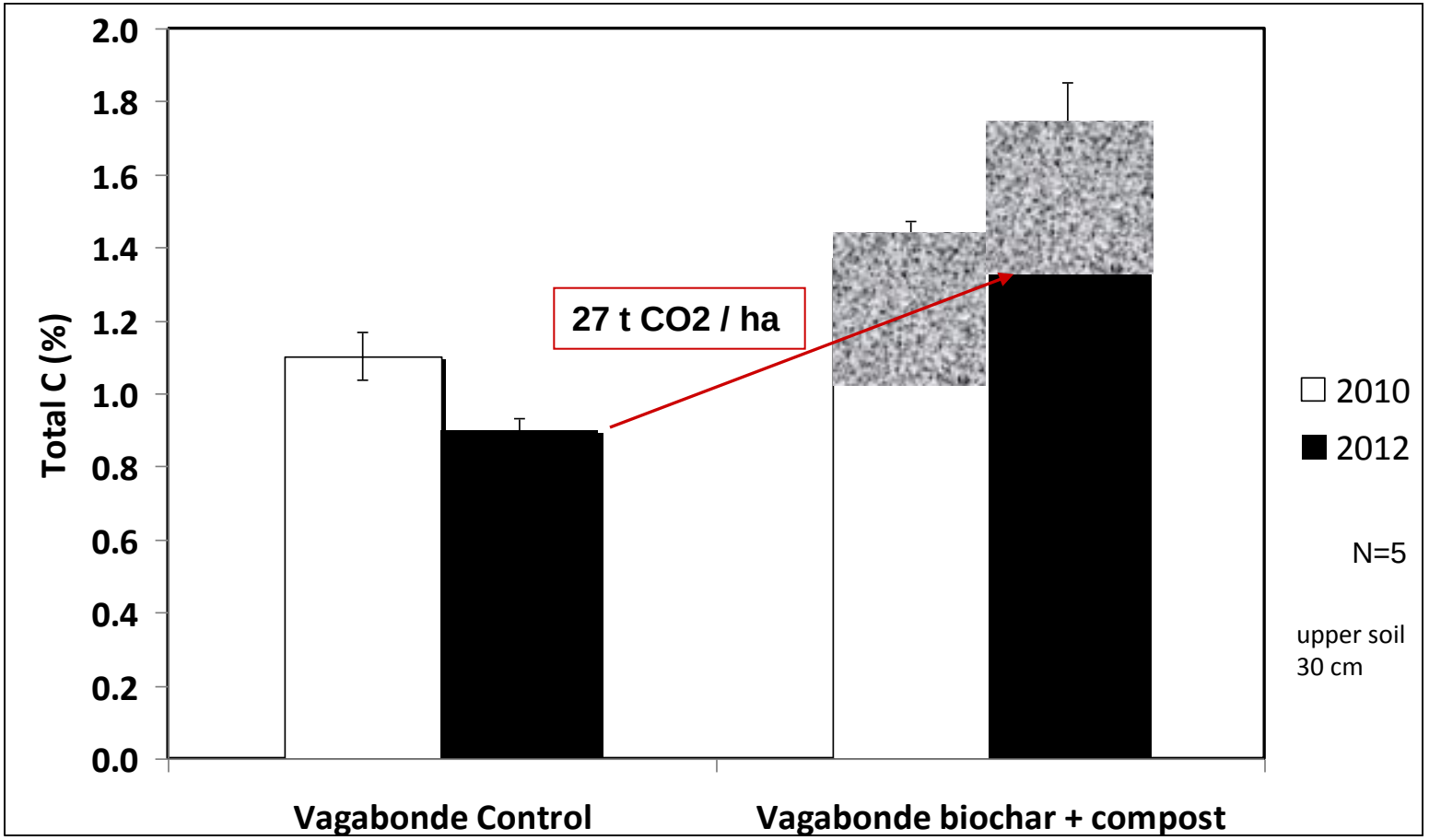


Data from a vineyard field trial in Valais

9. Carbon sequestration

Cascading use of biochar

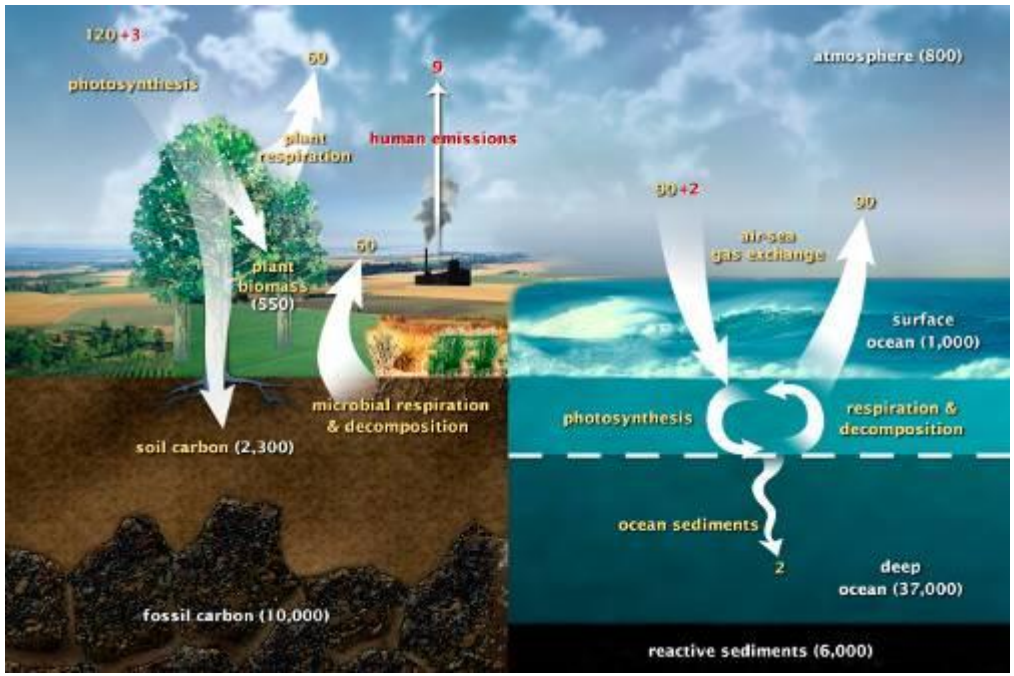
9.

Carbon sequestration:

SOM, BC

Reducing NH3, CH4

CO2-certificates?



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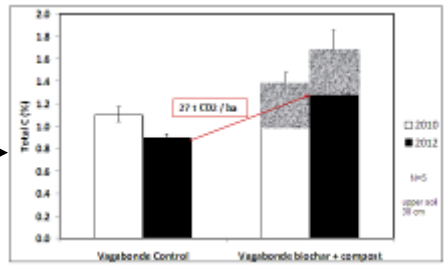
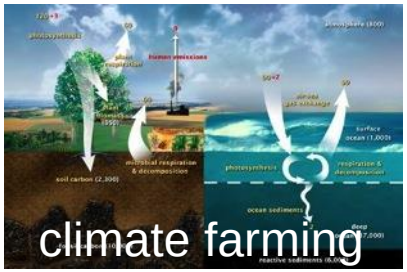


humus increase



climate farming

ithaka institute

Slow release carbon fertilizer

Carbon and Nutrient Recycling

Slow release carbon fertilizers

wool – cont. 12% Amino-N

wool + 20 % Biochar

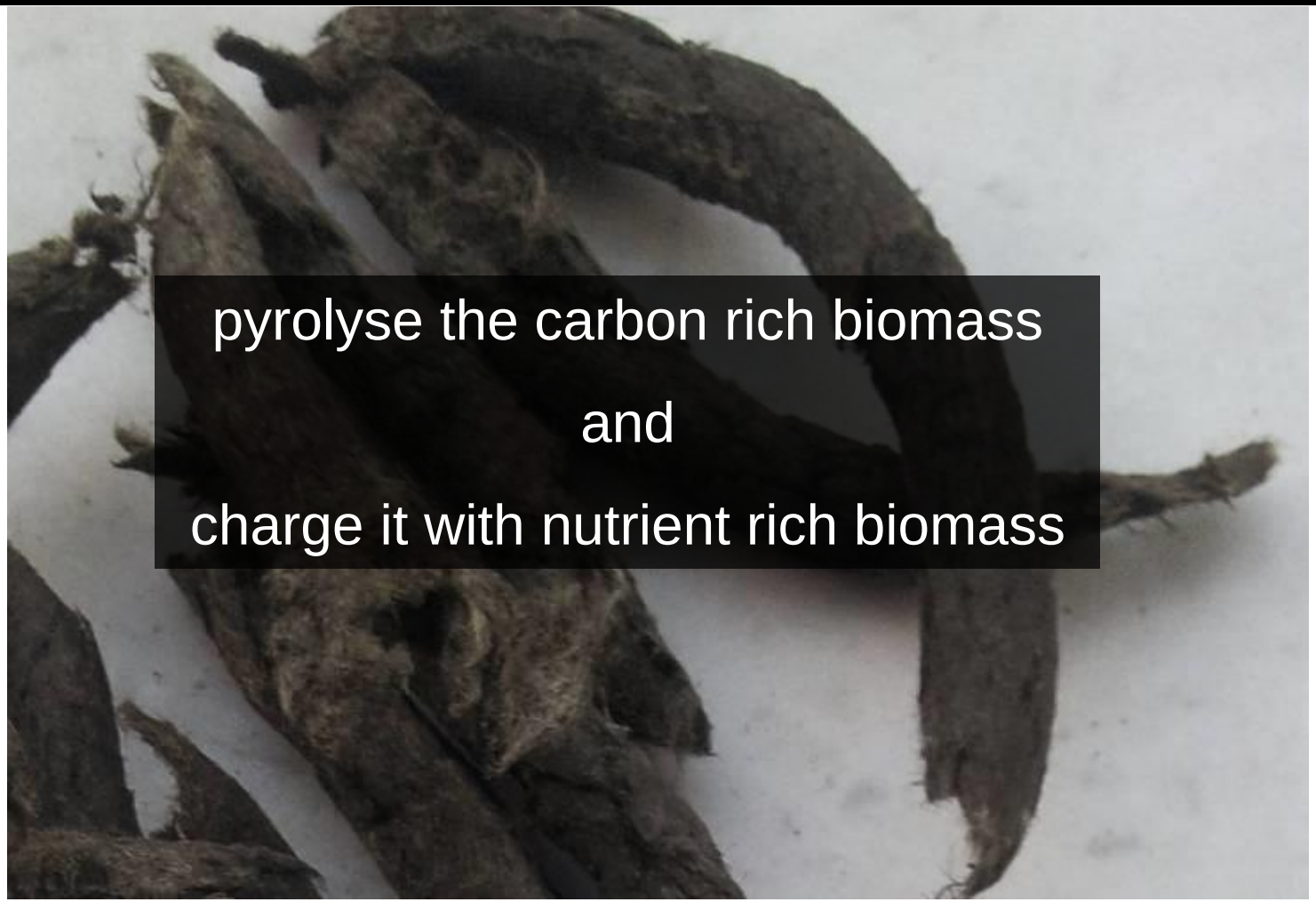
wool + 20 % BC + 20 % vinasse (7% Norg)

Norg – Nitrogen bound in organic molecules or cells
Vinasse - cheap organic fertiliser a waste from sugar made from cane sugar
BC - Biochar

wool + 20 % BC + 20 % vinasse + 30% pyrolyse ash

(7% Norg / 6.5% P_2O_5 / 6% K_2O)

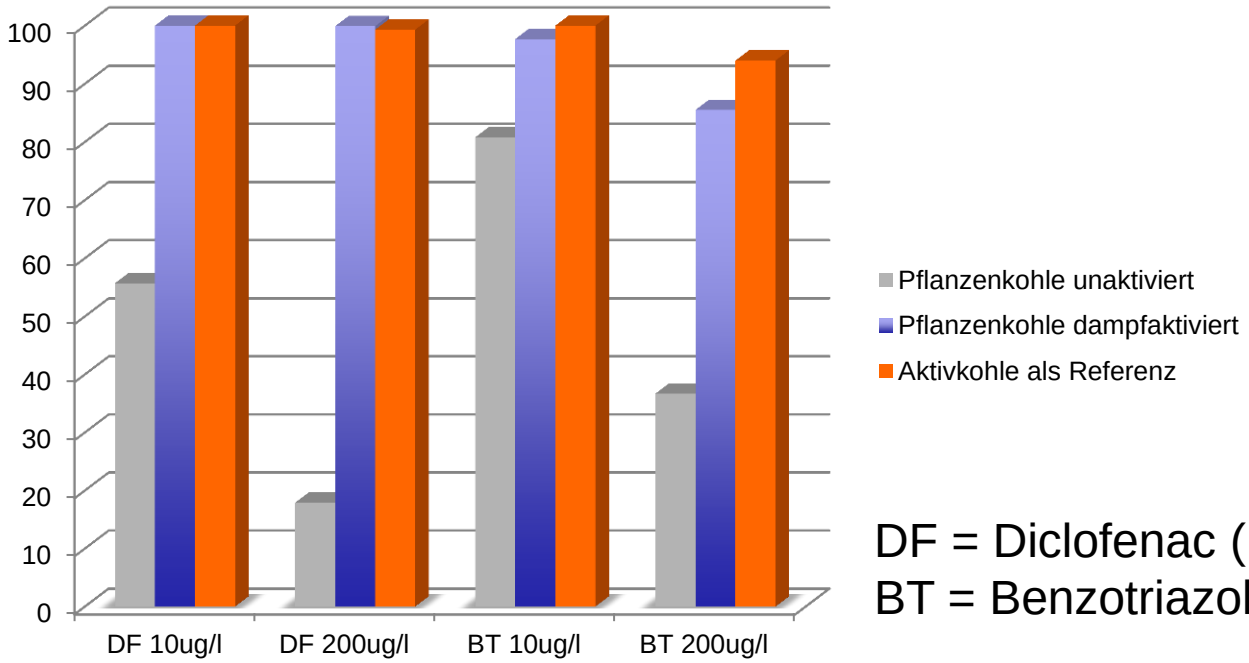
Slow release Carbon Fertilizer (8% Norg)



Biochar will play it’s most important agronomic role as additive where organic matter decomposes or labile organic mater tends to get lost.

Decontamination of waste water

Adsorption of contaminents by activated biochar



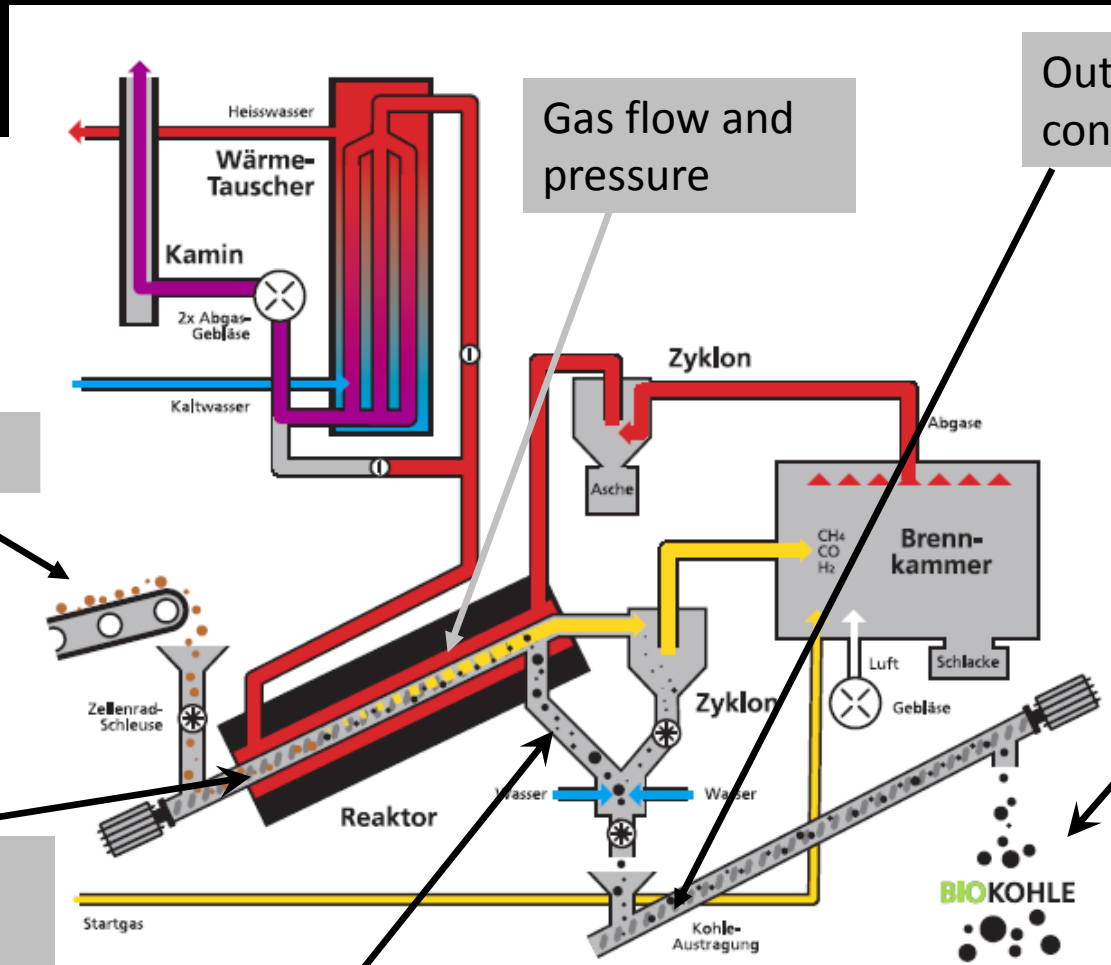
DF = Diclofenac (Entzündungshemmer)
BT = Benzotriazole (Rostschutzmittel)

Magnetic charging of biochar

Biochar

Ferrous sulfate

Integrated Activation of Biochar



Gas flow and pressure

Outgasing & condensation

Feedstock blending

Low temperature charging with Nutrients

High temperature activation > 600°C:

KOH or K2CO3

Middle temperature activation (< 600°C):

H3PO4 or lacto ferments

Low temperature inoculation with MO

ithaka institute

European BioChar Certificate

Betriebsbeurteilung Pflanzenkohle - Biochar 2012

q.inspecta

bio inspecta AG / q.inspecta GmbH
Ackerstrasse
CH 5070 Frick
Tel. 0041-(0)62-865 63 00
Fax 0041-(0)62-865 63 01
service@bio-inspecta.ch

bio.inspecta-Nummer	
Betrieb	
Name, Vorname	
Adresse	Tel.
PLZ, Ort	E-mail

Allgemeine Anmerkungen des Inspektors

Antrag des Inspektors

Datum, Stempel, Unterschrift Inspektor/ Inspektorin:

- ☐ Anerkennung als basic, premium oder bio: _____
- ☐ Der Betrieb kann nicht anerkannt werden
- ☐ Fehlende Unterlagen nachreichen (Frist: 6 Wochen)

Datum, Stempel, Unterschrift Betriebsleiter/ Betriebsleiterin:

Der / Die Unterzeichnende hat die Unterlagen eingesehen und bestätigt die Vollständigkeit und Richtigkeit der bei der Kontrolle gemachten Angaben. Er / Sie hat die Auflagen und Fristen zur Kenntnis genommen. Sofern nicht anders vermerkt, müssen die Auflagen inkl. Fristen gemäss Inspektor/Inspektorin eingehalten werden.

Anmerkung der Zertifizierungsstelle

Entscheid der Zertifizierungsstelle (q.inspecta)

- ☐ Anerkennung gemäss Antrag des Inspektors
- ☐ Anerkennung als basic, premium oder bio: _____
- ☐ Der Betrieb wird nicht anerkannt

Datum, Stempel, Unterschrift Zertifizierer/ Zertifiziererin:

EBC-Certificate

ID	Massnahme	Analysewert	basic	premium	bio	Anlage*	Methode	Bemerkungen, Grenzwerte
Eingesetzte Biomasse								
110	Es wurden ausschließlich naturbelassene, unbehandelte, lösungsmittelfreie organische Biomassen verwendet?		☐					
120	Es wurden ausschliesslich Biomassen verwendet, die auf der Positivliste geführt sind?		☐					
130	Wurden landwirtschaftliche Primärprodukten (Nawaro) verwendet?		☐					
140	Landwirtschaftliche Primärprodukte (Nawaro) stammen ausschließlich aus biologischem Anbau. Ein aktuelles Zertifikat liegt vor.				☐	*		
340	Blei-Konzentration der Pflanzenkohle in g/t	_____	☐	☐	☐		☐	basic: 150 g/ t_____ premium/bio: 120 g/t
350	Cadmium-Konzentration der Pflanzenkohle in g/t	_____	☐	☐	☐		☐	basic: 1.5 g/t: _____ premium/bio: 1 g/t:
360	Kupfer-Konzentration der Pflanzenkohle in g/t	_____	☐				☐	Grenzwert: 100 g/t

www.european-biochar.org

analyses from accredited labs

EBC-Certificate

	Massnahme	Beurteilg.	basic	premium	bio	Anlage*	Bemerkungen, Mängel, Fristen
Allgemeines							
001	Die Pflanzenkohle – Biochar Richtlinien liegen dem Betriebsleiter vor und sind ihm bekannt		☐				
002	Auflagen aus dem Vorjahr erfüllt		☐				
Dokumente							
010	Eingangsbelege Rohstoffe vollständig vorhanden		☐				
011	Produktionsprotokolle vollständig vorhanden		☐			x	
Wareneingang					☐		
021	Auf Lieferscheinen und/ oder Rechnungen ist die Qualität der		☐				

Control of sustainable production (feedstock positive list)
Quality control of biochar
Characterization of biochar
Classification of biochar

250	Staub-Konzentration im Abgas der Synthesegasverbrennung (bez. auf 11 vol% O2) wird eingehalten		☐				basic/premium/bio: 50 mg/m3 _____
260	NOx-Konzentration im Abgas der Synthesegasverbrennung (bez. auf 11 vol% O2) wird eingehalten		☐				basic/premium/bio: 500 mg/m3 _____
270	Gesamt-C-Konzentration im Abgas der Synthesegasverbrennung (bez. auf 11 vol% O2) wird eingehalten		☐				basic/premium/bio: 50 mg/m3_____

55 Uses of Biochar

Building material
12. Insulation, 13. Air decontamination, 14. Decontamination of earth foundations, 15. Humidity regulation, 16. Protection against electromagnetic radiation ("electrosmog")

Textile industry
45. Fabric additive for functional underwear, 46. Thermal insulation for functional clothing, 47. Deodorant for shoe soles

Food industry
48. Conservation of food 49. Digesting helper

Wellness
48. Filling for mattresses, 49. filling for pillows

Radio protection
*50. Shield against electromagnetic radiation (*microwaves, TV, Netzgeräte, computer)

Further uses
Industrial materials (31. carbon fibres, 32. plastics)
Electronics (33. semiconductors, 34. batteries)
Metallurgy (35. metal reduction)
Cosmetics (36. soaps, 37. skin-cream, 38. therapeutic bath additives)
Paints and colouring (39. food colorants, 40. industrial paints)
Energy production (41. pellets, 42. substitute for lignite)
Medicines (43. detoxification, 44. carrier for active pharmaceutical ingredients)

Biochar in Textile Industry

45. Fabric additive for functional underwear,
46. Thermal insulation for functional clothing,
47. Deodorant for shoe soles

30% bambou-char

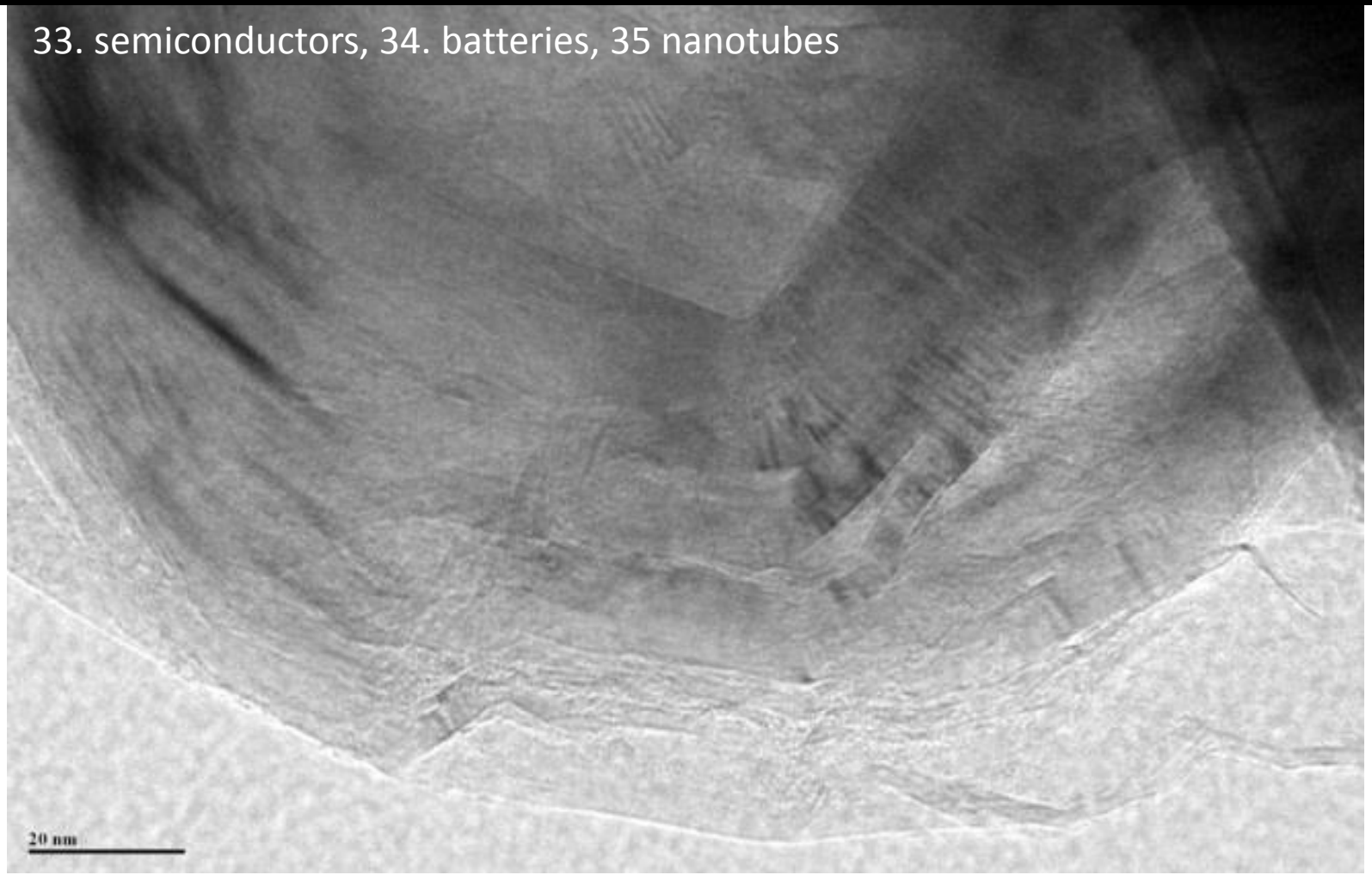
Conservation of Food

Regulation of humidity, anti-bacteriologic,
adsorption of ethylen

Cosmetics

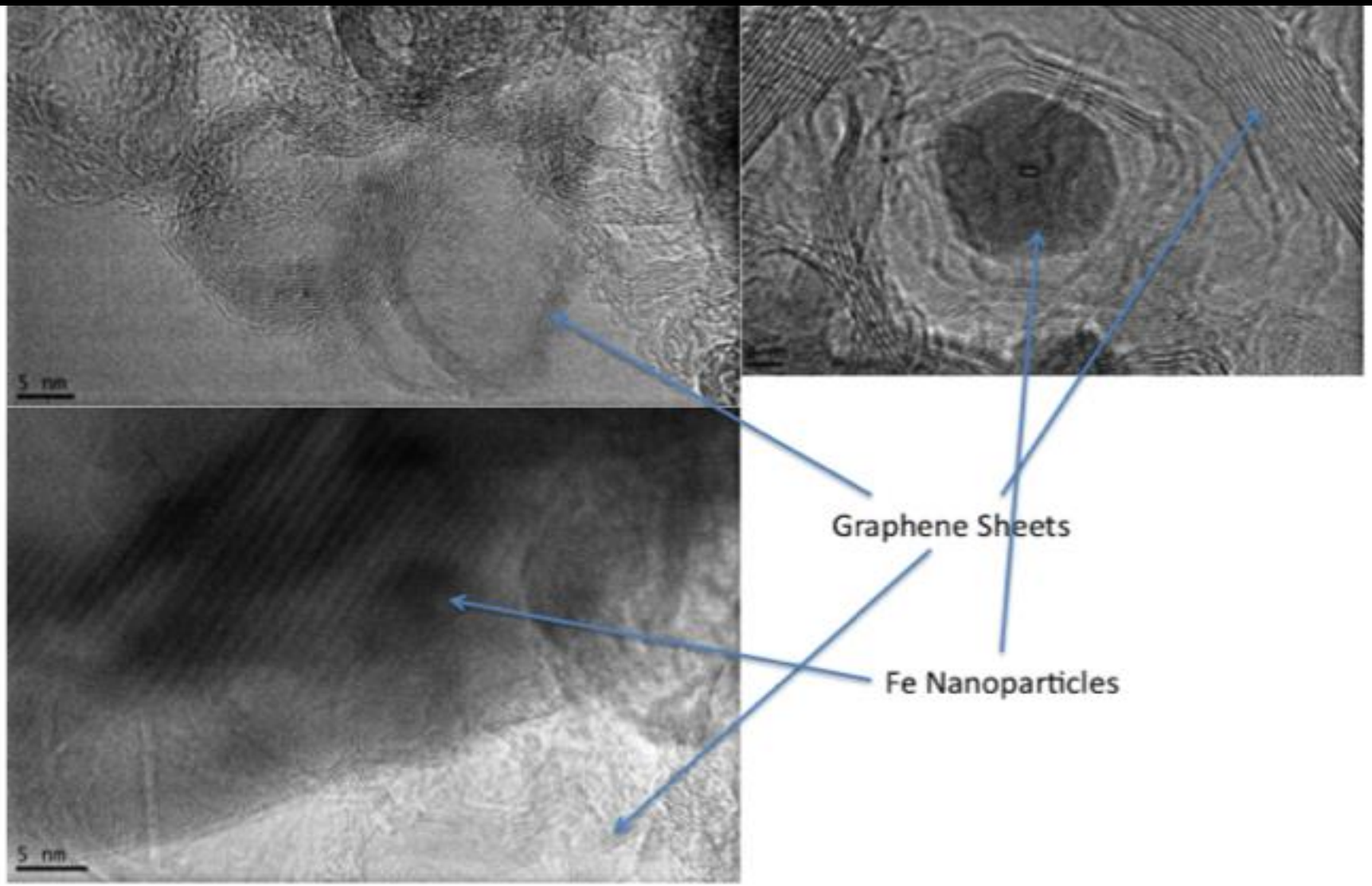
36. soaps, 37. skin-cream, 38. therapeutic bath additives)

Graphen



Zhengrong Gu,, 2013. American Transactions on Engineering & Applied Sciences. Volume 2 No.1 ISSN 2229-1652
TEM of Activated carbon from DDGS biochar (KOH 0.075 1050 °C). TEM at 20 nm,

Graphen



Biochar-Clay-Plaster for optimal indoor climate

humidity control, thermal insulation, toxin fixation, electro-magnetic shielding

Jet application of biochar + argile + sand

50% Biochar

Biochar for habitats

Effects of Biochar-Plaster

- Regulation / buffering of humidity
- Insulation
- Noise protection
- Toxin binding (solutes, VOC)
- Blocking of high frequency radiation
- Low electrostatic charging of air
- Conservation of wood
- Reduction of dust (Milben!)

Effects of Biochar-Plaster

- Deodorising
- aesthetic
- Anti-bacteriological, fungicide (repellent)
- Air cleaning
- Increase of redox potential
- Emission of far-infrared radiation

Ithaka Institute‘s conferencing room

Ithaka Institute‘s conferencing room

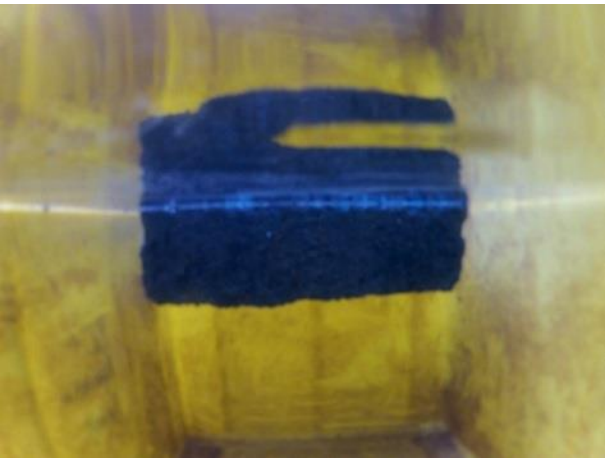
Painted with with Claycolour

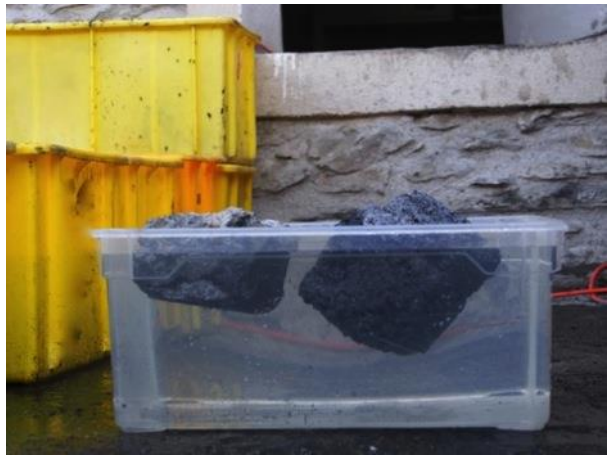
Ithaka Institute‘s Office

Biochar Bricks

Cement
Lime
Clay

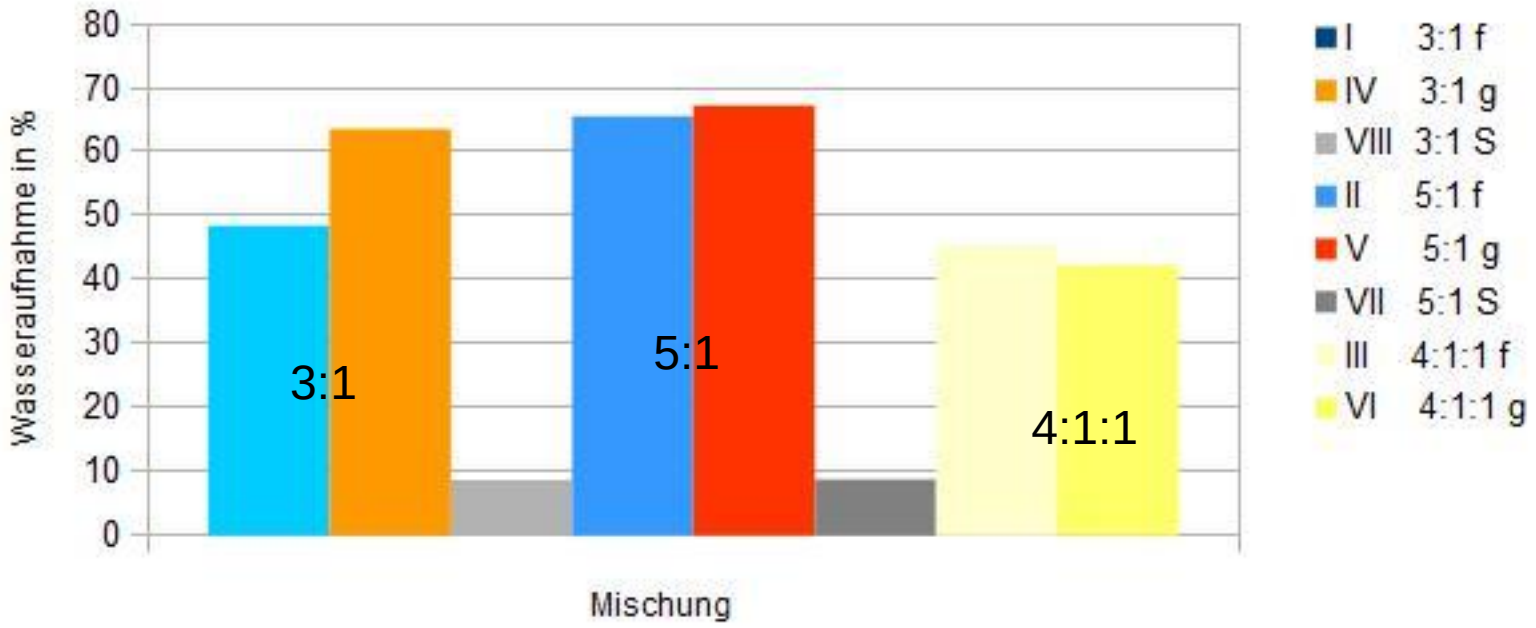
Light Weight Biochar Bricks can swimm





Water Uptake of Biochar Bricks

biochar-cement – bricks
water up-take after 12 hours



Fridge House in Kenya

Biochar Housing as Carbon Sink

Biochar Housing as Carbon Sink

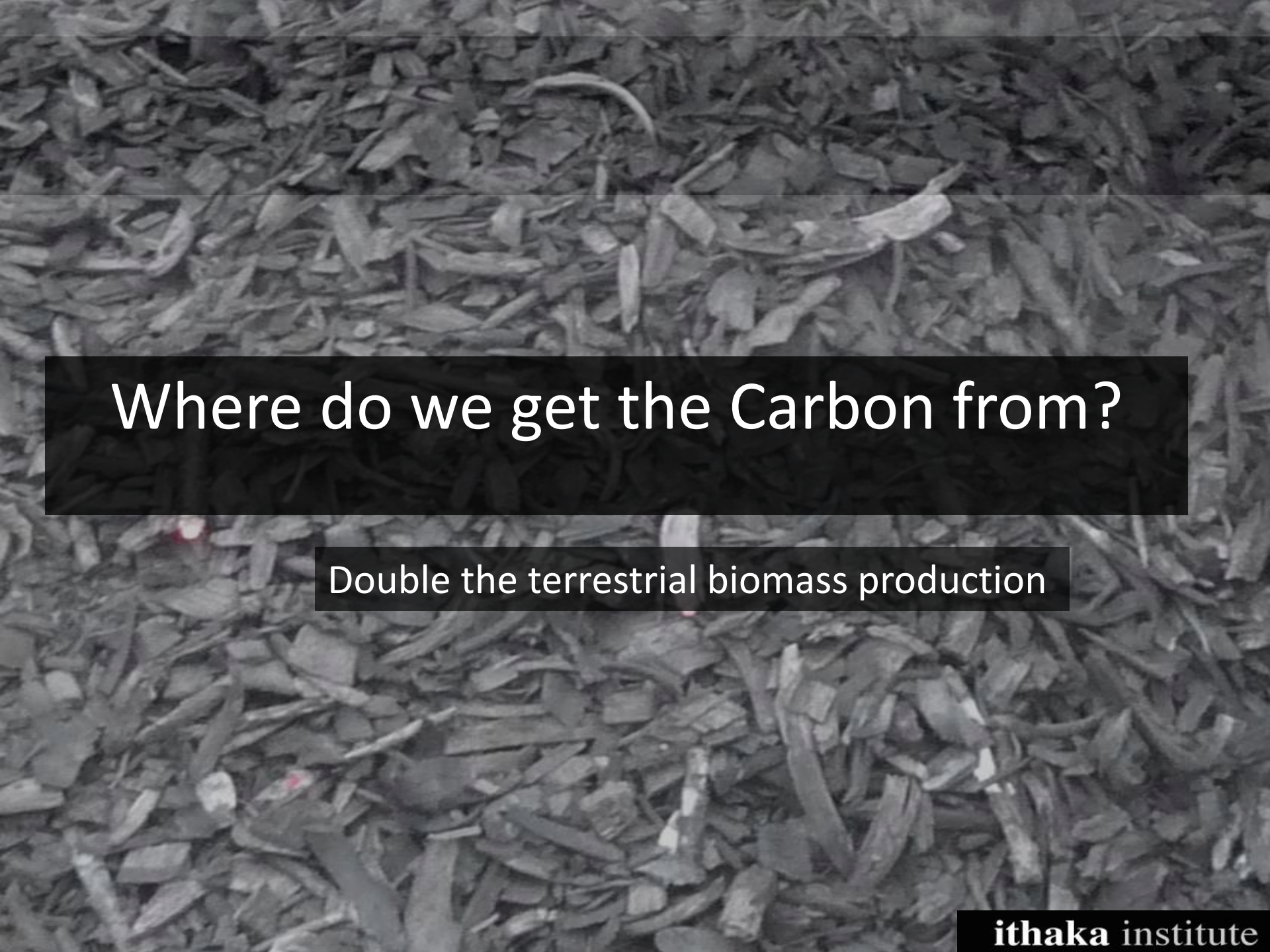
Biochar Pillows

sleep on you char

carbon recycling is the key for the sustainable development of the human civilisation

At least 4 Gt C would have to be fixated by biomass recycling while reducing the human emissions by at least 5 Gt C.


Where do we get the Carbon from?


Where do we get the Carbon from?
Double the terrestrial biomass production
ithaka institute

Carbon Exchange Market