Effect of Novel Biofilter Material on Microbial Respiration

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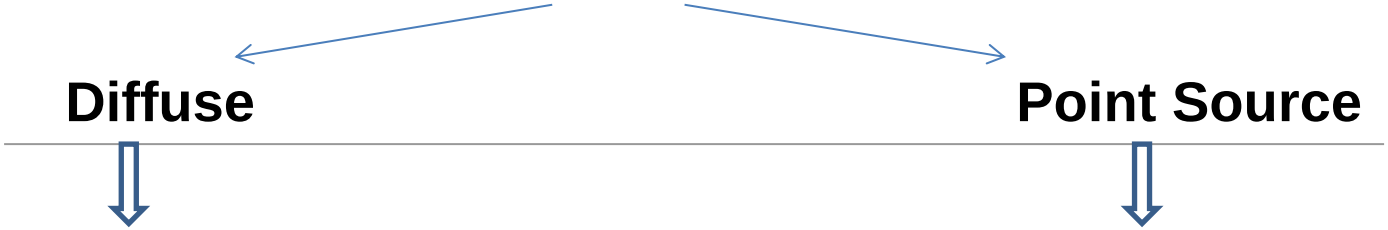
Outlook

- Introduction and Motivation
- Materials and Methods
  - Biochars
  - Digestate
  - Pesticides
- Experimental Set up
- Results
- Preliminary Conclusion and Hypothesis

Pesticides in water: sources of contamination

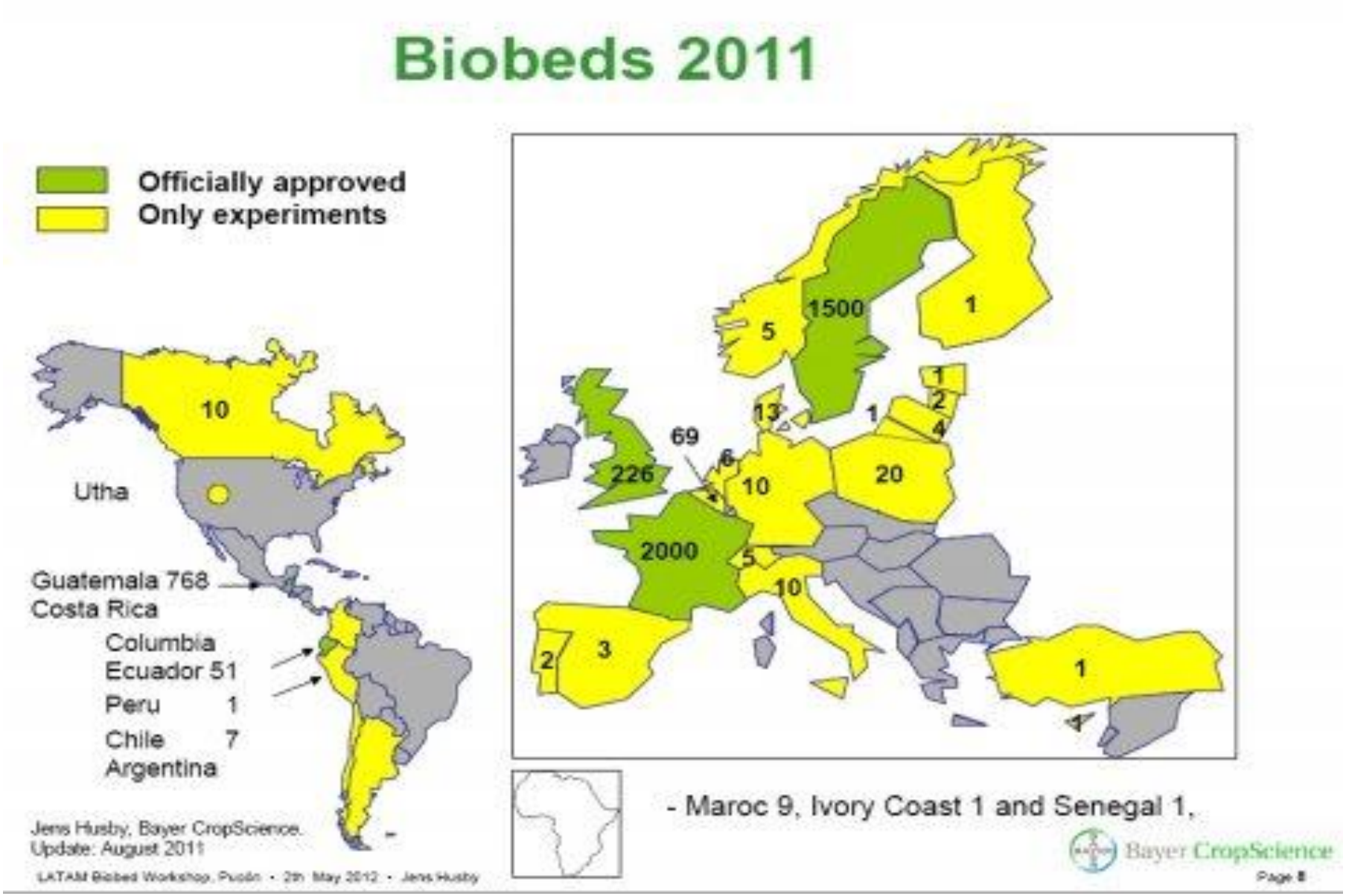


Drift
Drain flow
Surface flow
Seepage
Leaching

Tank Filling
Waste Disposal
Washings
Faulty equipment
Spillages

- "Pesticide pollution" appears twice in the top ten of The World's Worst Toxic Pollution Problems Report 2011 by the Blacksmith Institute. (http://www.worstpolluted.org/)
- Point sources of pollution contributes approximately 40-90 % of surface and ground water contamination. (De Wilde et. al., 2009)

Number of biobeds in the world (2011)



(www.biobeds.org)

Types of Biobeds in Europe

Biobeds in the UK

Biomassbed in Italy

Biobac in France

Biofilter in Belgium

Mixture: Straw to Peat to Soil (2:1:1)
Substitute for straw: Coconut Chips, Willow Chips etc.

Disadvantages: Chances of preferential flow

(Castillo et. al. , 2009)

Some useful informations about Sorbents:

Materials	Soil 1	Soil 2	BC400	BC 800	Digestate
Source /place and texture	Kaldenkirchen (loamy sand)	Merzenhausen (silty loam)	Woodchips§	Woodchips§§	Maize-silage, Chicken manure and Beef waste
pH	5.7*	7.0*	n.d	n.d	n.d
CEC($cmol_c\ kg^{-1}$)	7.8*	11.4*	n.d	n.d	n.d
C_{OC} (%)	1.07*	1.24*	75.9§	74.4§§	40
H	–	–	1.64§	0.5§§	–
O	–	–	5.05§	10.6§§	–
H/C Atomic Ratio	–	–	0.26	0.08	–
O/C Atomic Ratio	–	–	0.05	0.11	–
Surface Area (N_2) (m^2/g)	n.d	n.d	231	225	3.09
Surface Area (CO_2) (m^2/g)	n.d	n.d	634	625	37.90
Micropore volume (cc/g)	–	–	0.22	0.21	0.01

*(Kasteel et. al. , 2010), §(Carbon Terra, 2011) and §§(Pyreg, 2011)

Reasons for undertaking the proposed project

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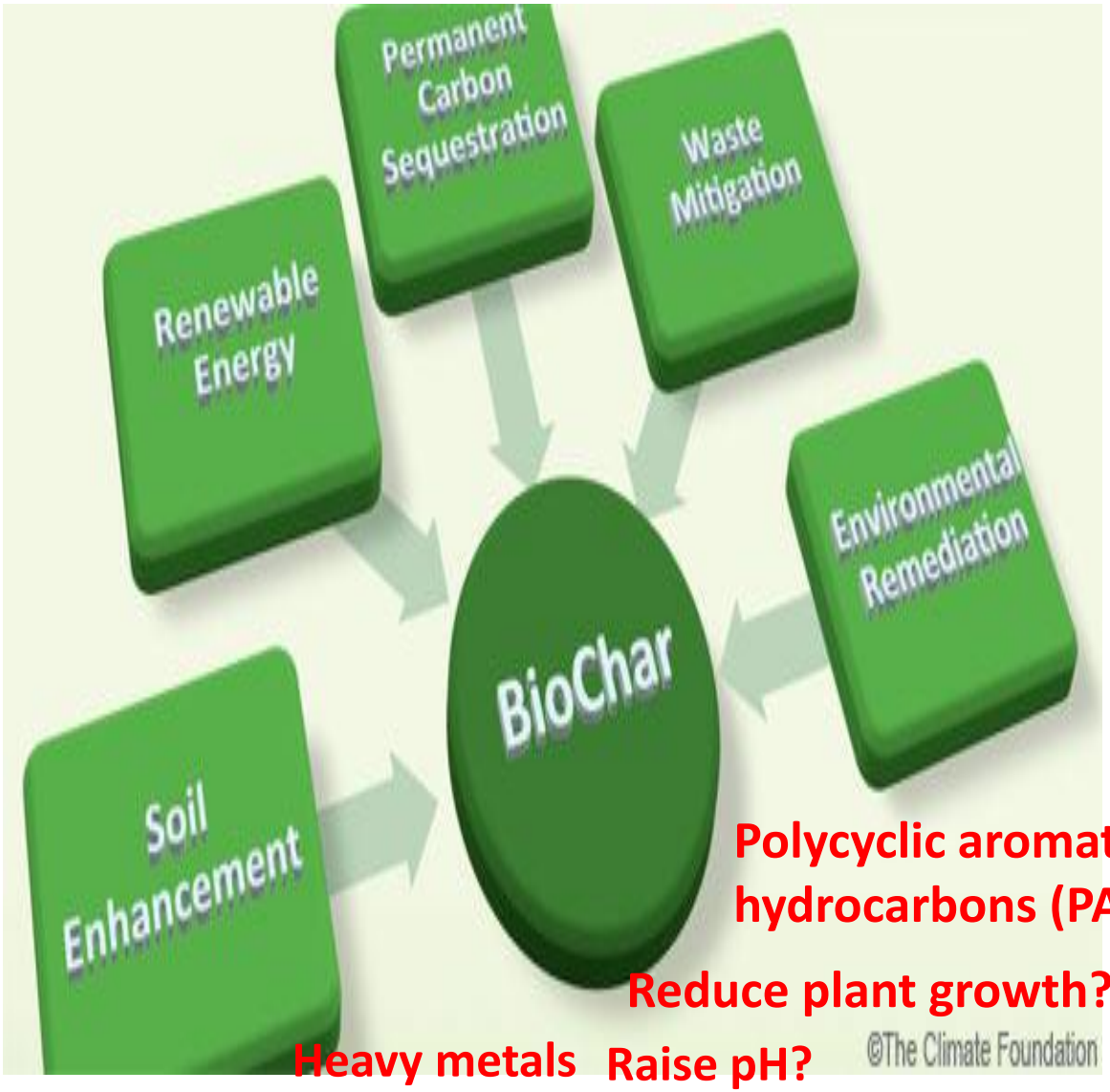
To build up and investigate the efficiency of a "**novel" biofilter material** with following objectives:

1. **Substitution** of **straw** with **digestate**
2. **Substitution of peat with biochar** (cost.european-biochar.org)

- Influence of char and digestate on **degradation** , **sorption and desorption of** pesticides?
- Effects of the proposed organic amendments on the **retardation** of pesticides?
- How does the **novel biofilter material** work under realistic conditions?

Janus faced nature of biochar

(www.treehugger.com)



Polycyclic aromatic hydrocarbons (PAH)

Reduce plant growth?

Heavy metals

Raise pH?

(www.cec.org)

Digestate : Solid material remaining after the anaerobic digestion of a **biodegradable** feedstock.

Selected characteristics of the Straw and Digestate:

Approx. Elemental Composition On Dry Matter Basis (g/kg)	* Wheat Straw	*Solid Digestate
Organic C	429	404
Total N	5.6	93
Lignin	177	200
C/N	76.6	4.34

*(Tambone et. al., 2009)

Fiber: Solid fraction of digestate with low nutrients
- used as soil conditioner

(http://en.planet-biogas.de)

Sorbates:

Supplied Pesticides :

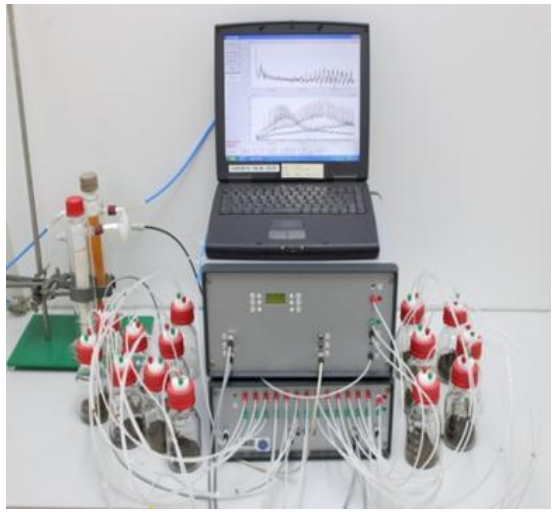
All experiments will be conducted with three radiolabelled (^{14}C) compounds.

Active Substance	Chemical Name	Water Solubility (mg/L) at 20°C	Log K_{OW} at 21°C	DT_{50}in soil(day)
Bentazone*	3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)one2,2-dioxide	570	0.77	13
Pyrimethanil	*N*-(4,6-dimethylpyrimidin-2-yl)aniline	121	2.84	55
Boscalid *	2-chloro-N-(4'-chlorobiphenyl-2-yl)nicotinamide	4.6	2.96	200

(http://sitem.herts.ac.uk/aeru/footprint/en/index.htm)

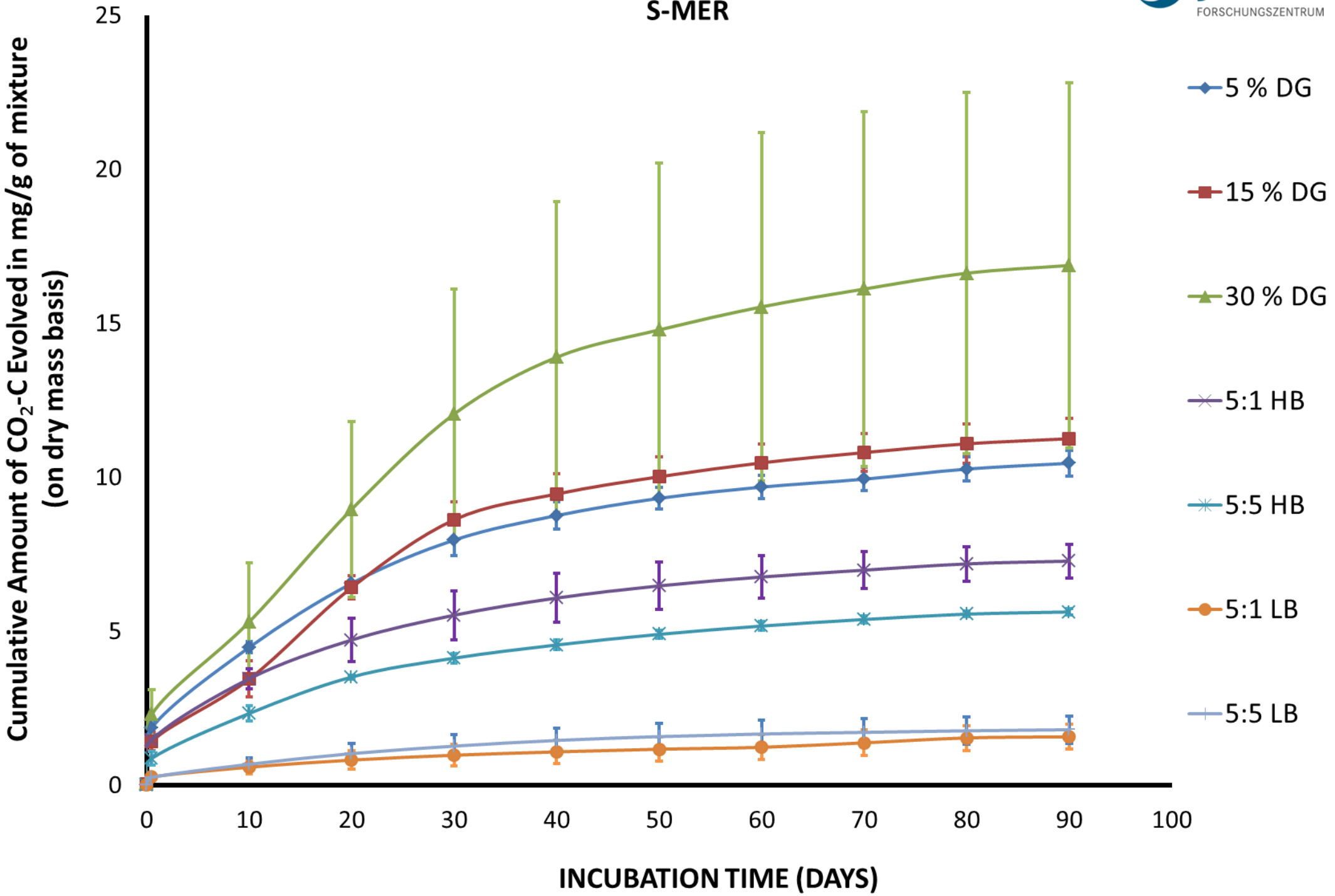
Our Proposed Approach:

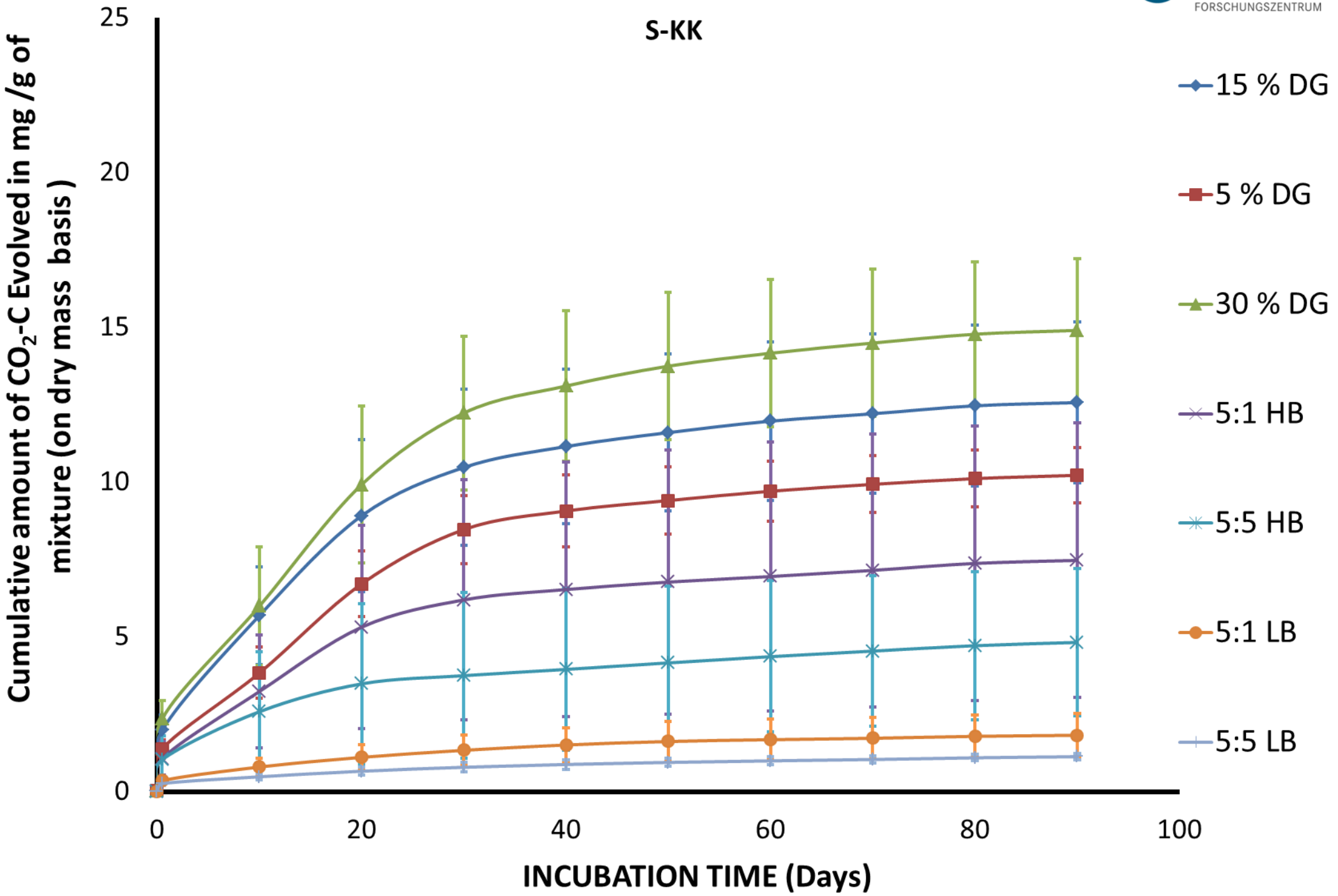
- ❑ Incubation experiment (ongoing ..)
- ❑ Degradation study **(soils from incubation)**
- ❑ Batch sorption-desorption study **(soils from incubation)**
- ❑ Unsaturated column set up **(soils from incubation)**
- ❑ Construction of **pilot biofilter system**



Respirometer system

Reduction of combinations

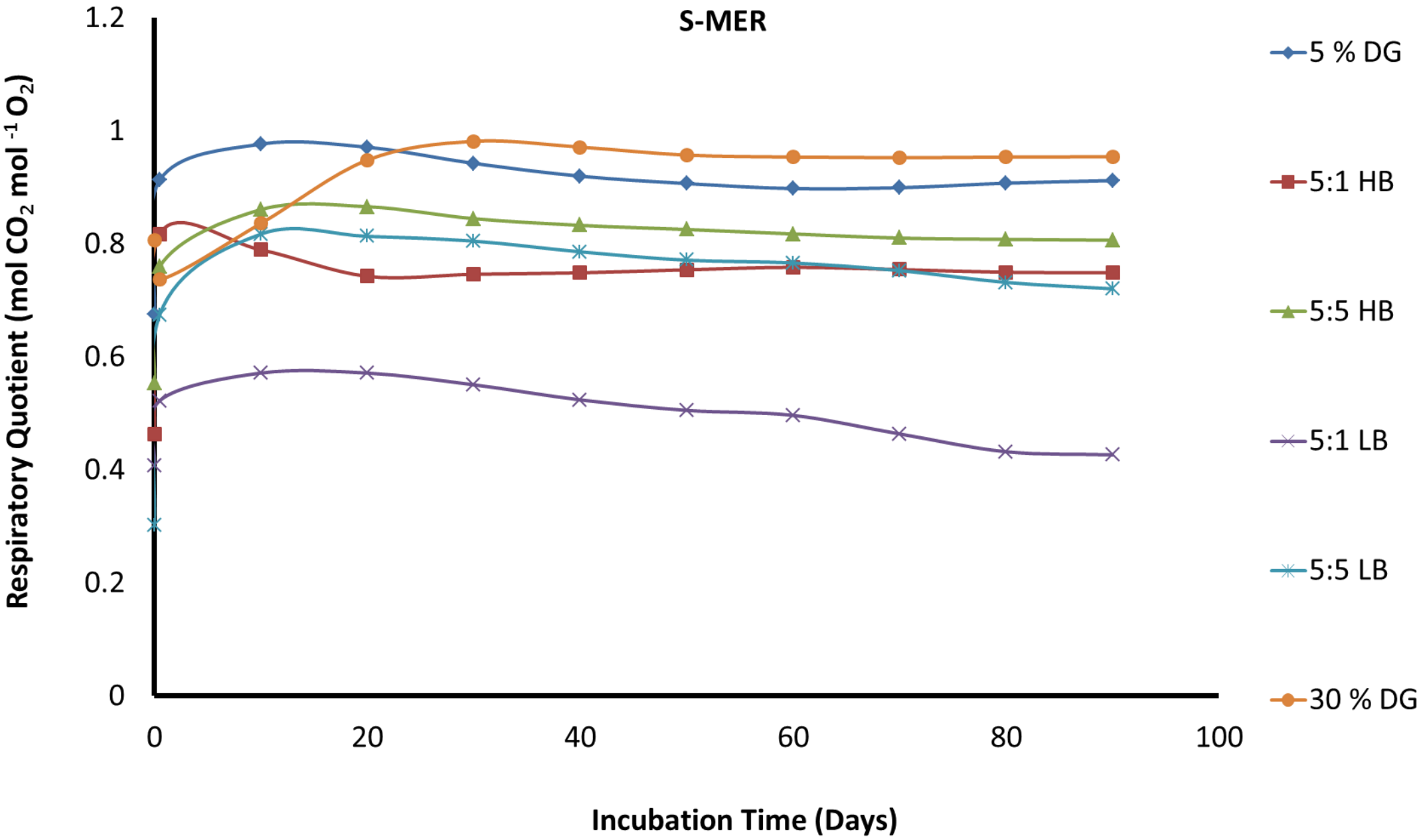




Preliminary Conclusion :

- KK soil showed 35 % less CO_2-C compared to MER soil without amendment.
- Addition of biochar to soils increase CO_2-C only slightly. (graph not shown)
- KK soil showed 12 % less CO_2-C release for 30% digestate compared to MER soil.
- CO_2-C evolved increased with increasing C-input (digestate). In mixtures (with char) pronounced negative priming effects occured (Zimmerman et. al., 2011).
- For both soils and digestate mixtures (5 % w/w) addition of biochar (1 and 5 % w/w) reduces CO_2-C release dramatically in a range between 31 % (HB) to 87 % (LB) for MER soil and 47 % (HB) to 92 % (LB) for KK soil.

RQ = mol $CO_{2\ evolved}$ / mol $O_{2\ consumed}$



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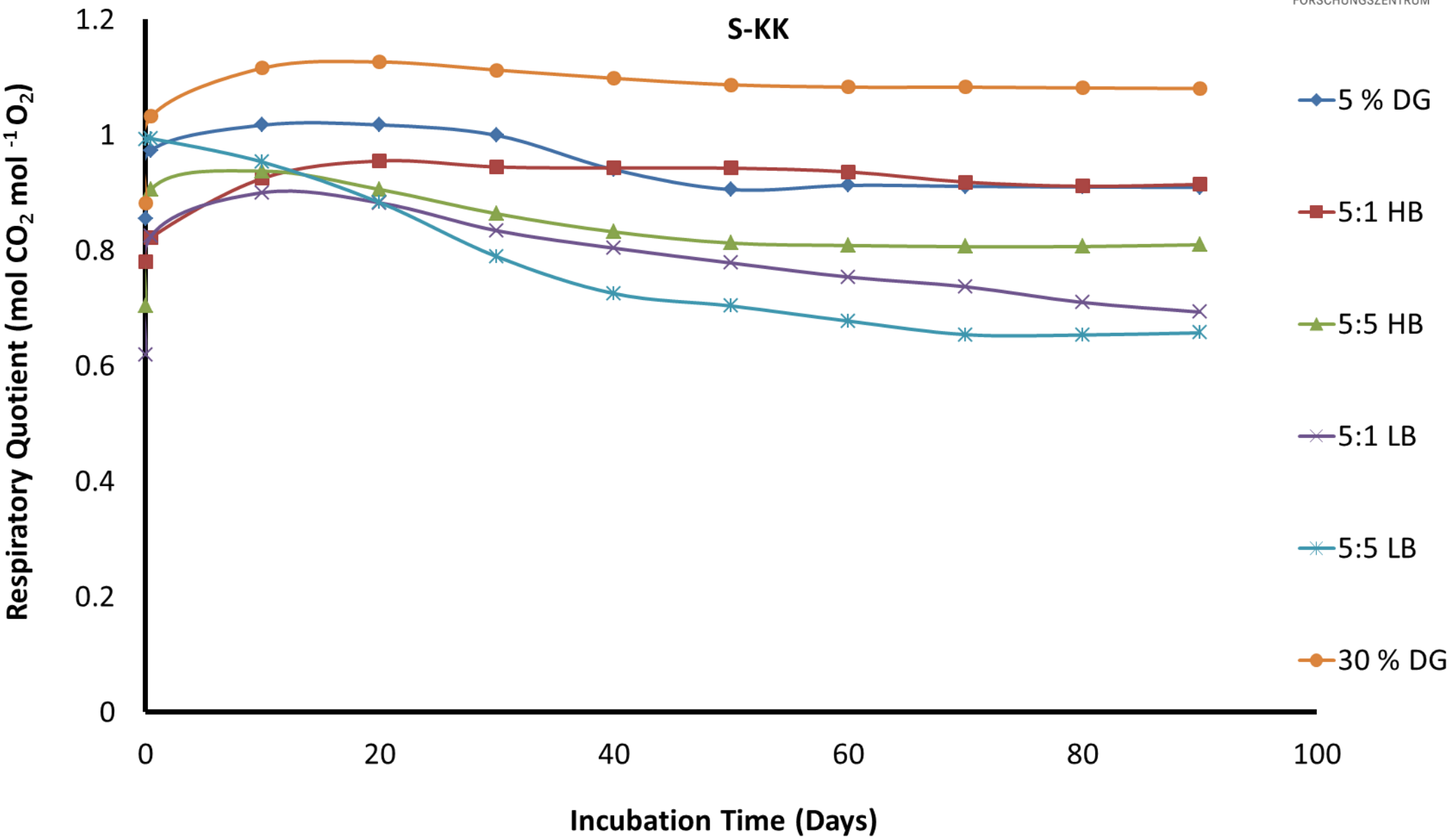

Proposed Hypothesis :

- Chemisorption of respired CO_2 to biochar surface (Thies et. al., 2009) .
- O_2 consumption by nitrifying bacteria (Dilly , 2001) .
- Precipitation of CO_2 as mineral carbonates (Kuzyakov,2006).
- Conversion of gaseous CO_2-C into chemoautotrophic microbial biomass (Hart et. al., 2013).
- At a certain threshold, compounds from biochar could potentially become microbiologically toxic (Clough et. al., 2010).

Which of these scenarios is the driving mechanism for reduced CO_2 release from biochar and digestate amended soils is yet to be resolved.

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Future Tasks derived from incubation study :

- ❑ Analyze the kinetics based on (using double pool model)
- ❑ Writing publication
- ❑ Identify the most suitable biomixture for investigating the fundamental processes i.e sorption-desorption , degradation and transport behaviour of toxicants through biofilter materials.

Tasks	Year 1				Year 2				Year 3			
	1	2	3	4	1	2	3	4	1	2	3	4
Arrangement of amendment materiales , radiolabelled herbicides and Incubation experiment												
Degradation study of radiolabelled pesticides and batch sorption-desorption experiment												
Set up of an unsaturated column system to study the leaching behaviour of pesticides with Br^- as a conservative tracer and application of suitable model to validate the lab results												
Installation of pilot biofilter system to study the leaching & degradation behaviour of radiolabelled herbicides												
Writing of papers/PhD thesis												

A LOT OF KNOWN AND UNKNOWN IS UNKNOWN !