TECHNISCHE UNIVERSITÄT DRESDEN

Bundesministerium für Bildung und Forschung

INOWAS
Junior Research Group

Determination of degradation rates of organic substances in the unsaturated soil zone depending on grain size fractions of various soil types

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Influence on biodegradation

Rate and extent of biological degradation of organic substances
in unsaturated zone influenced by

Chemical and physical
properties of substances

- Water solubility
- Toxicity
- Molecular structure

Soil-specific properties

- pH-value, IEC
  Organic matter
- **Grain size distribution**

  ↓

  Pore volume,
  Distribution of pore sizes

  ↓

  Water content, oxygen supply
  Transport and storage capacity
  of water and nutrients

  ↓

  Influence on life and growth
  conditions of bacteria

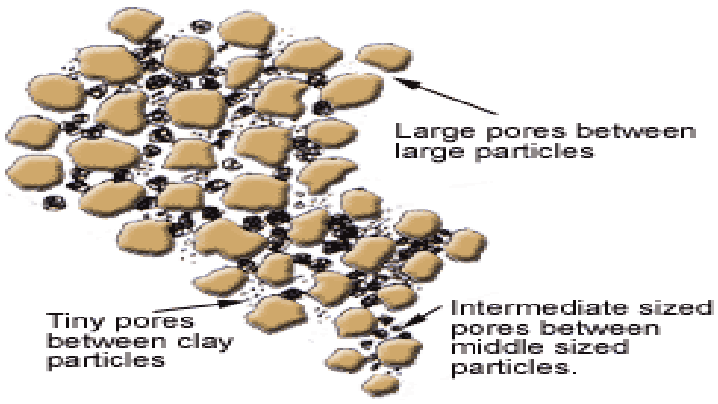
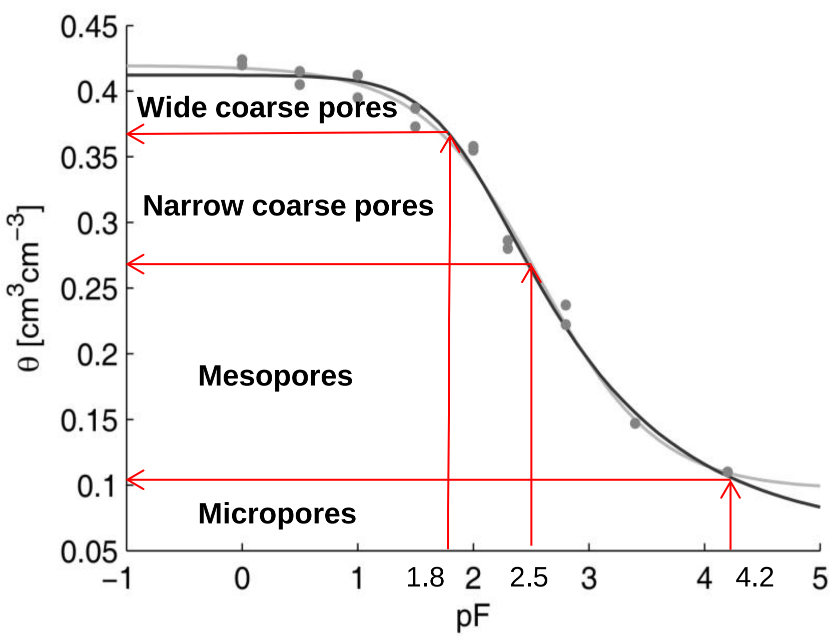


Fig. 1 Pore sizes depending on grain size

(Source: http://toolboxes.flexiblelearning.net.au)

Characterization of soil pore system

Fig. 2 Water retention curve



Source: Weynants et. al (2009); Vadose Zone Journal 8(1)

Tab. 1 Properties of different pore sizes

Pore size range	Equivalent diameter [µm]	Water tension	
		[cm WS, hPa]	[pF]
Wide coarse pores	> 50	0 – 60	< 1.8
Narrow coarse pores	50 - 10	60 - 300	1.8 – 2.5
Mesopores	10 – 0.2	300 - 15000	2.5 – 4.2
Micropores	< 0.2	> 15000	> 4.2

- Description of soil pore system and distribution of different pore sizes with soil moisture retention curve

➢ Distribution of pore sizes affects the water content, transport and storage capacity of water and nutrients as well as oxygen supply

State of the art and resulting objectives

- Batch experiments with unsteady state conditions
- Better biodegradation with soil that has smaller particles e.g. Zhang and Bouwer (1997)

Tab. 2 Degree of saturation for optimal biodegradation

source	saturation [%]	soil type
Pramer, Baratha (1972)	53 - 71	Silty loam
Dibble, Bartha (1979)	28 - 95	Medium sandy loam
Dupont et al. (1991)	70 - 93	Medium silty sand
Briglia et al. (1992)	58 - 82	Sandy loam
Sims et al. (1993)	30 - 98	Medium sandy loam
Okeke et al. (1996)	70 - 100	Sandy loam
Rice et al. (2000)	83 - 100	Sandy clay loam

↳ Determination of the correlation between the grain size fractions respectively pore sizes, water content, oxygen supply and the biodegradation rate of infiltrated organic substances in column experiments

Experimental setup

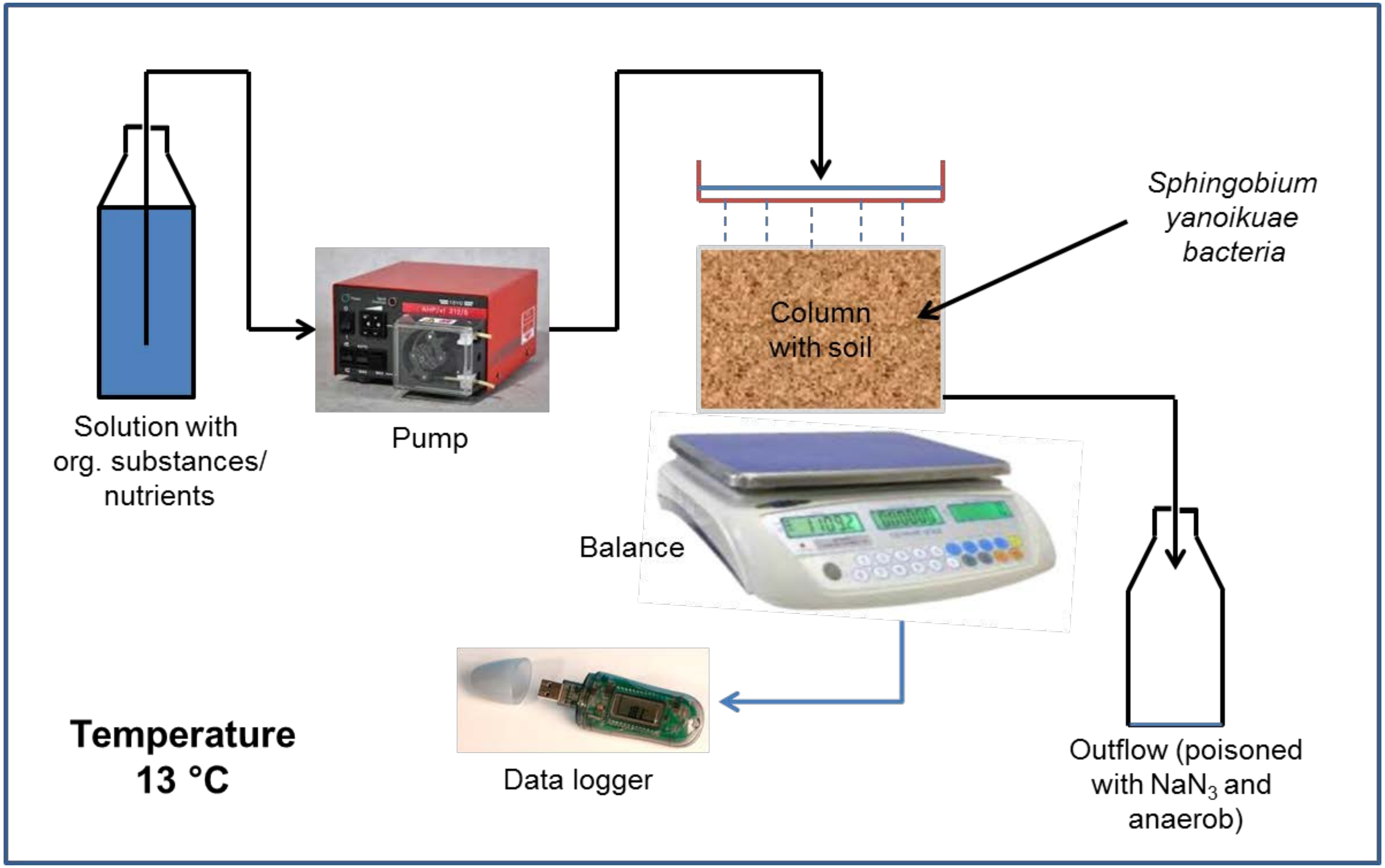


Fig. 2 Experimental setup

Used grain size fractions

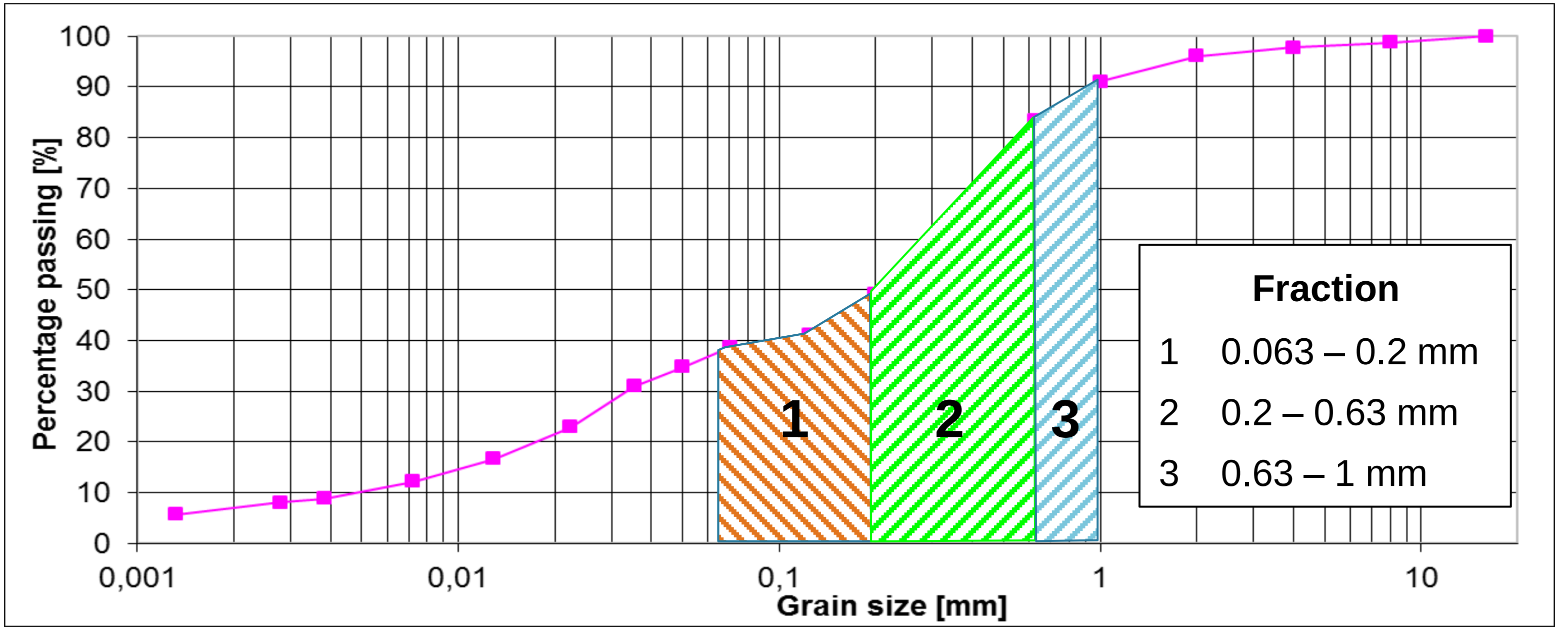
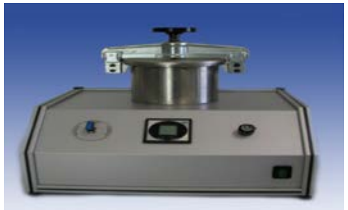


Fig. 3 Grain size distribution curve and used fractions

- Determination of pore volume with air pyknometer



(Source: UGT GmbH)

- Determination of water retention curve/pore sizes with HYPROP system (evaporation method according to Wind (1966) and Schindler (1980))

(Source: UMS GmbH)

Selection of organic substances

- Pre-tests with *Sphingobium yanoikuae and* different organic substances (glucose, yeast extract, peptone, starch, oxalic acid, salicylic acid and mixes of those)

➢ Search for a solution of organic substances which can be culture medium for *Sphingobium yanoikuae*

Tab. Concentrations of used organic substances in the solutions [g/l]

	Soultion 1	Solution 2
Glucose	1	1
Yeast extract	0.5	
Peptone	0.5	
Starch	0.5	
Oxalic acid		0.5
Salicylic acid		0.5

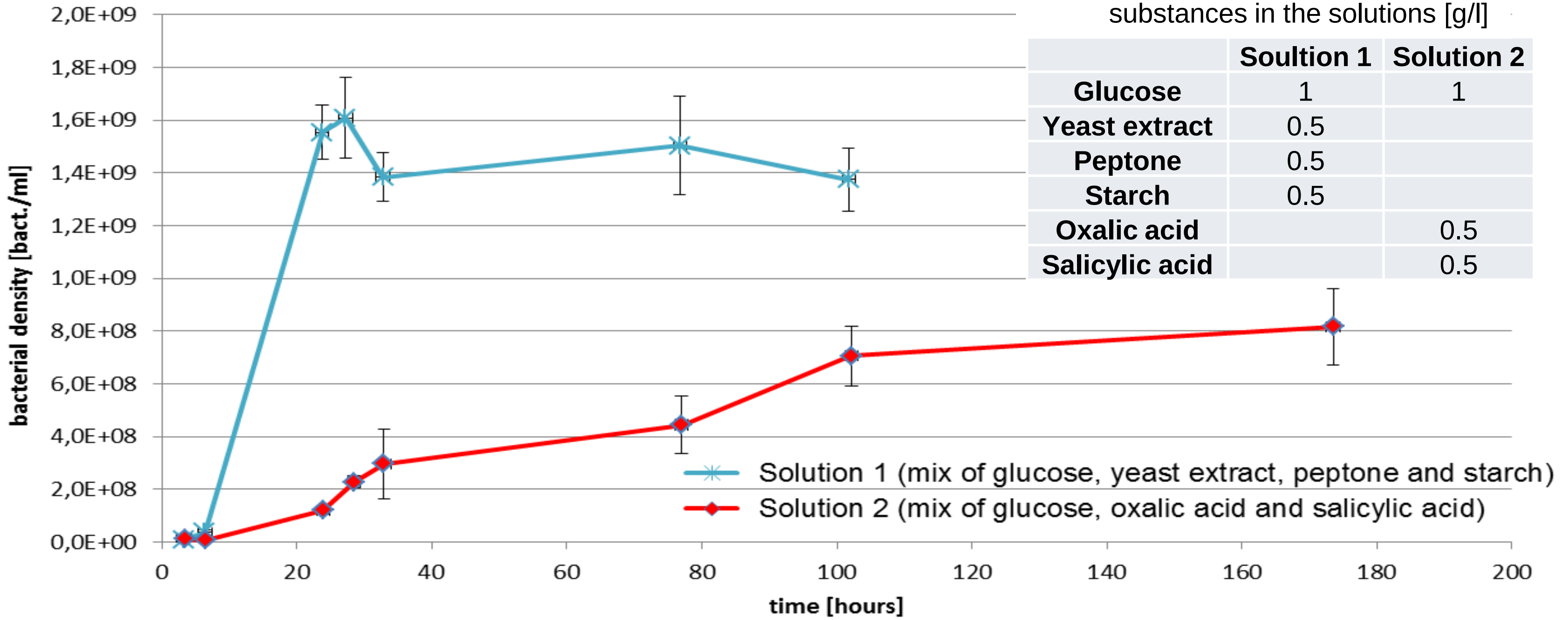


Fig. 4 Growth curve for Sphingobium yanoikuae bacteria in solutions with different mixes of organic substances

> Choosing of solution with a mix of glucose, oxalic acid, salicylic acid

First results – pore size distribution

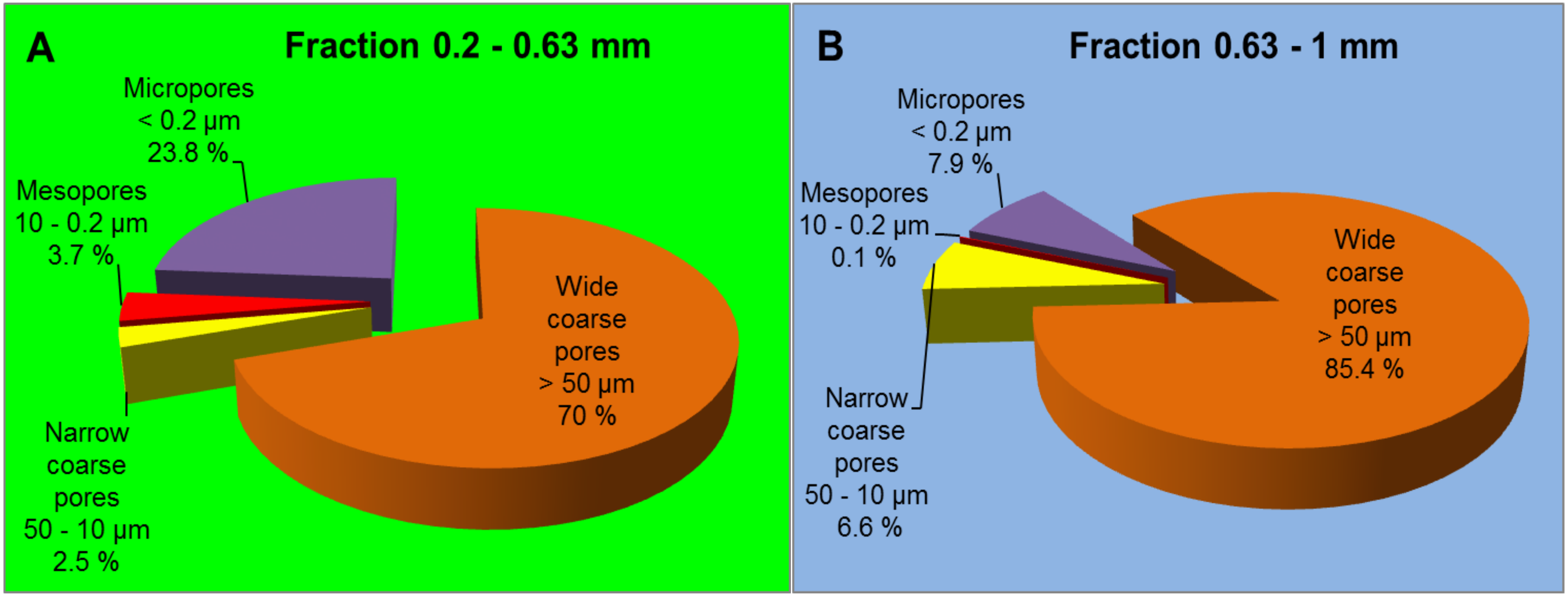


Fig. 5 Distribution of pores sizes in grain size fraction 0.2 – 0.63 mm (A) and 0.63 – 1 mm (B)

- Differences in proportion of wide coarse and micropores

  > Different water contents, transport and storage capacity of water and nutrients, oxygen supply

> What is the optimal water/oxygen ratio for bacteria ?

First results – infiltration and saturation

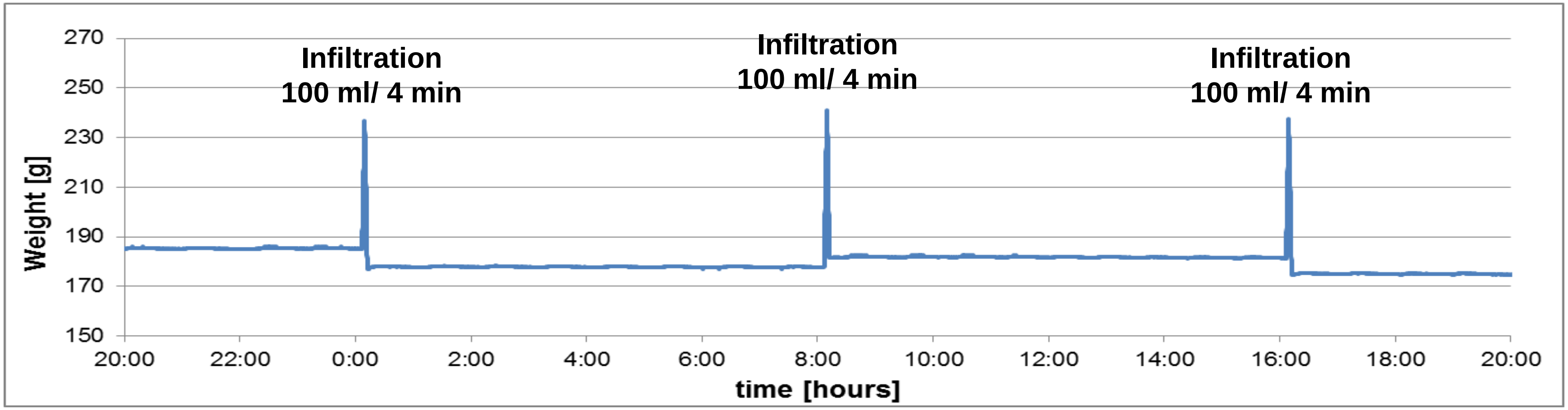


Fig. 6 Changing of water content due to 3 infiltrations over 24 hours in the soil with grain size fraction 0.63 – 1 mm

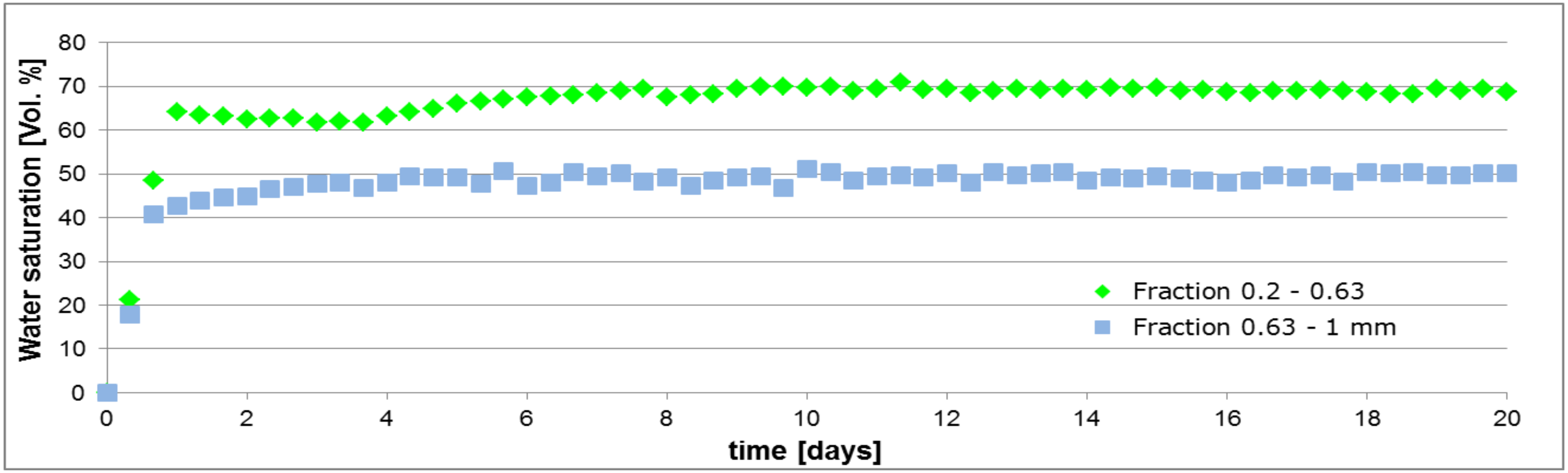


Fig. 7 Soil saturation

First results – DOC and oxygen

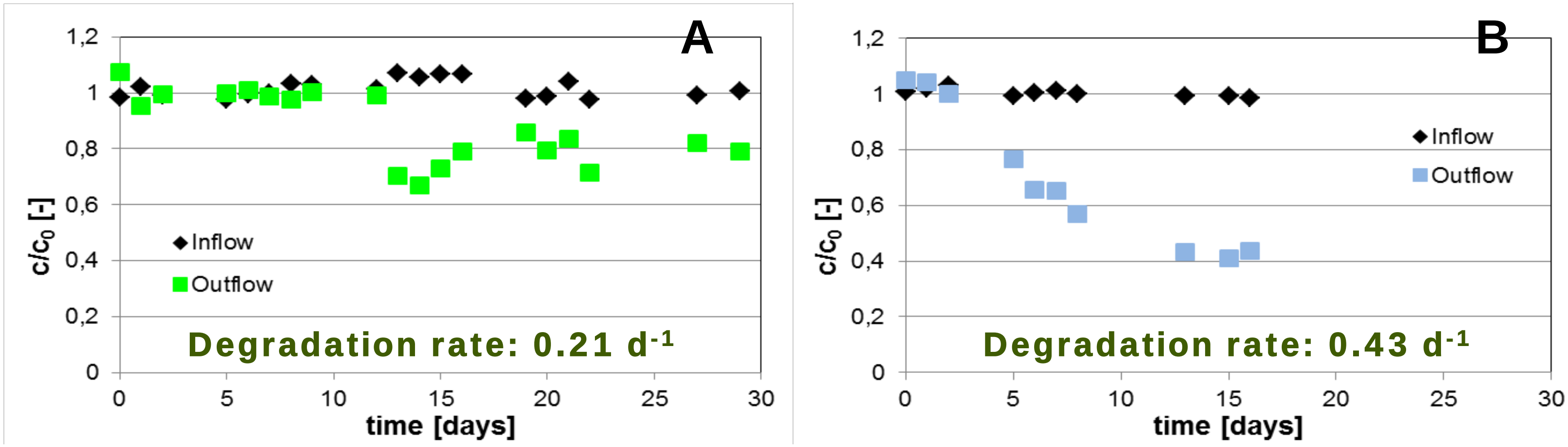


Fig. 8 DOC for fraction 0.2 – 0.63 mm (A) and 0.63 – 1 mm (B)

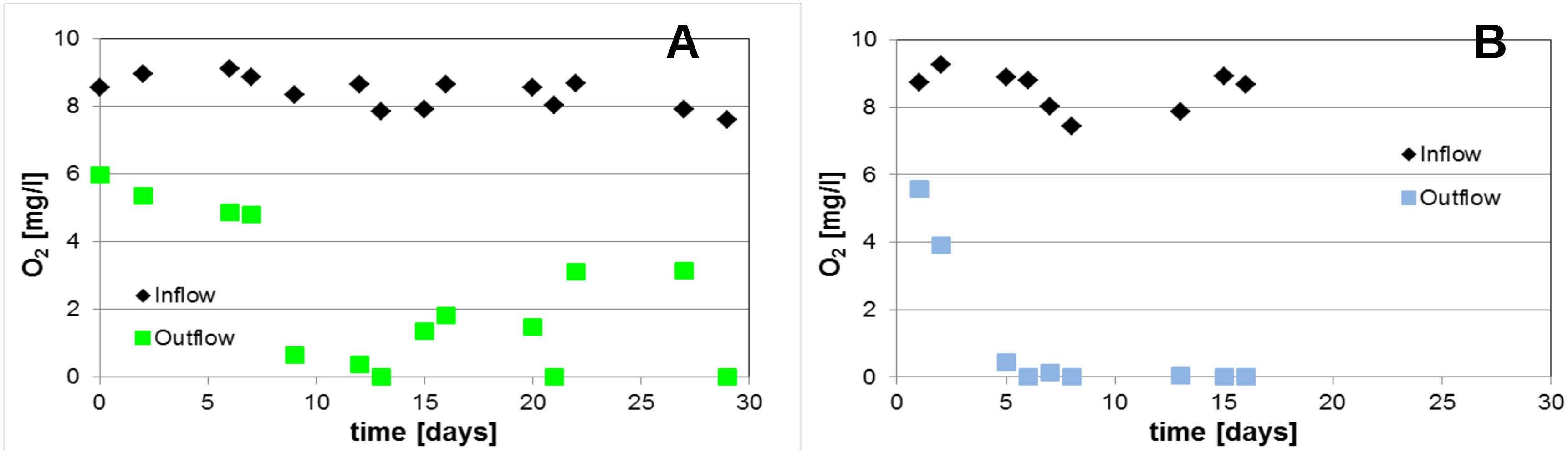


Fig. 9 Oxygen content for fraction 0.2 – 0.63 mm (A) and 0.63 – 1 mm (B)

Summary and outlook

- One of the first column experiments to the influence of pore sizes on the biodegradation

- Higher saturation in soil with smaller grain size fraction

- **Higher degradation rate in soil with bigger grain size fraction**

  ↳ Replenishment of nutrients and oxygen has higher influence on degradation than water content

Outlook:

- Continuing with fraction 0.063 – 0.2 mm to confirm results

- Repetition of experiments to confirm results

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