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Anaerobic biobeds: a key part of mitigation systems for pesticide risks to freshwaters

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Participants

Dr. Ing. Björn Krause Camilo

He supervised all the practical work on the bioreactor in a PhD thesis at the Technical University in Berlin in cooperation with the Federal Environment Agency.

Dr. Stefan Lorenz

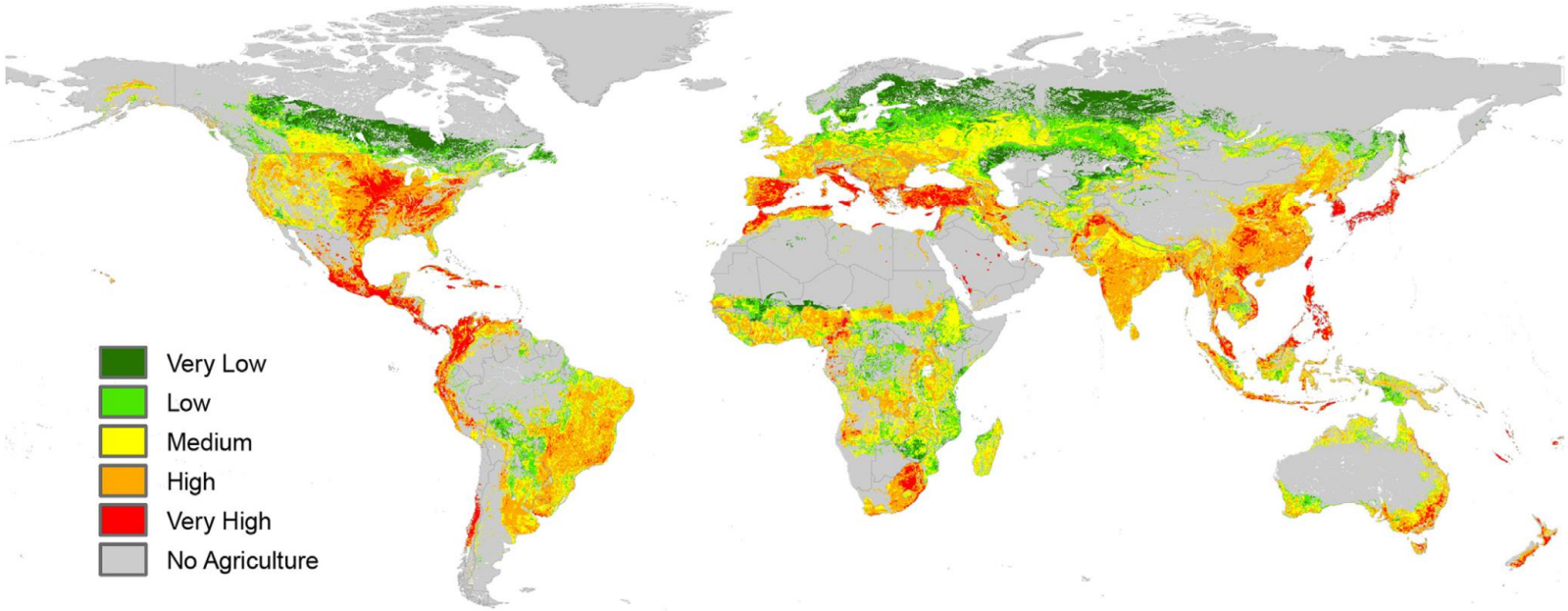
He is a scientific co worker in the "Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection" and leader of the working group aquatic ecology / small water bodies

Dr. Dieter Felgentreu

I`m the leader of the working group soil micro organisms and interested in Biobed for the microbial dissipation of ppp.

Problem?

Diffuse pollution of surface waters due to runoff, wind erosion, flow seepage, tile drainage, spray drift and atmospheric deposition are still challenging for water and landscape management. Freshwaters and particularly small water bodies are constantly threatened by the use of pesticides and fertilizers in agriculture. The risks posed by these uses have to be mitigated and reduced according to European and national regulations and directives, e.g. the Sustainable Use Directive (Directive 2009/128/EC).



Global risk of insecticide entries in freshwaters; from Ippolito et al. 2014, Env Poll 198:54-60

Freshwaters and particularly small water bodies



(photo by S. Lorenz)

Wash-off and wash-out of intensively applied artificial or natural fertilizers result in increased loads of nutrients in surface waters, particularly of nitrogen and phosphorous. These increases can lead to freshwater eutrophication which may change natural communities, and may enhance algae associated toxin concentrations or oxygen depletion. Additionally, pollution with pesticides and thereof particularly herbicides can affect single aquatic species, food chains or even entire aquatic communities and their resilience.

Mitigation systems

Vegetated riparian buffer strips can effectively mitigate the risks associated with pesticide and fertilizer use for small water bodies in agricultural landscapes (photo by S. Lorenz).

We observed a constant but only slight turnover towards pesticides with lower water body distance requirements over time when no buffer strips were present.

Mitigation systems

Picture from the construction site of a "biobed" in a floating system (photo by B. Krause Camilo[1]).

Suitable tools for the decontamination of drainage water, wash water or runoff water are aerob working biobeds.

Under anaerobic conditions, biobeds support denitrification as major nitrate mitigation process. However, anaerobic conditions in biobeds are in general disadvantageous for the mitigation of the pesticide agents.

Part of the Aquisafe II Project

The Aquisafe II project is focused on reduction of diffuse pollution in surface waters by decentralized measures to mitigate negative impacts of contaminants on drinking water production. The aim of work package V in the Aquisafe II project is to determine efficient conditions and designs for the attenuation of selected pesticides in mitigation system.

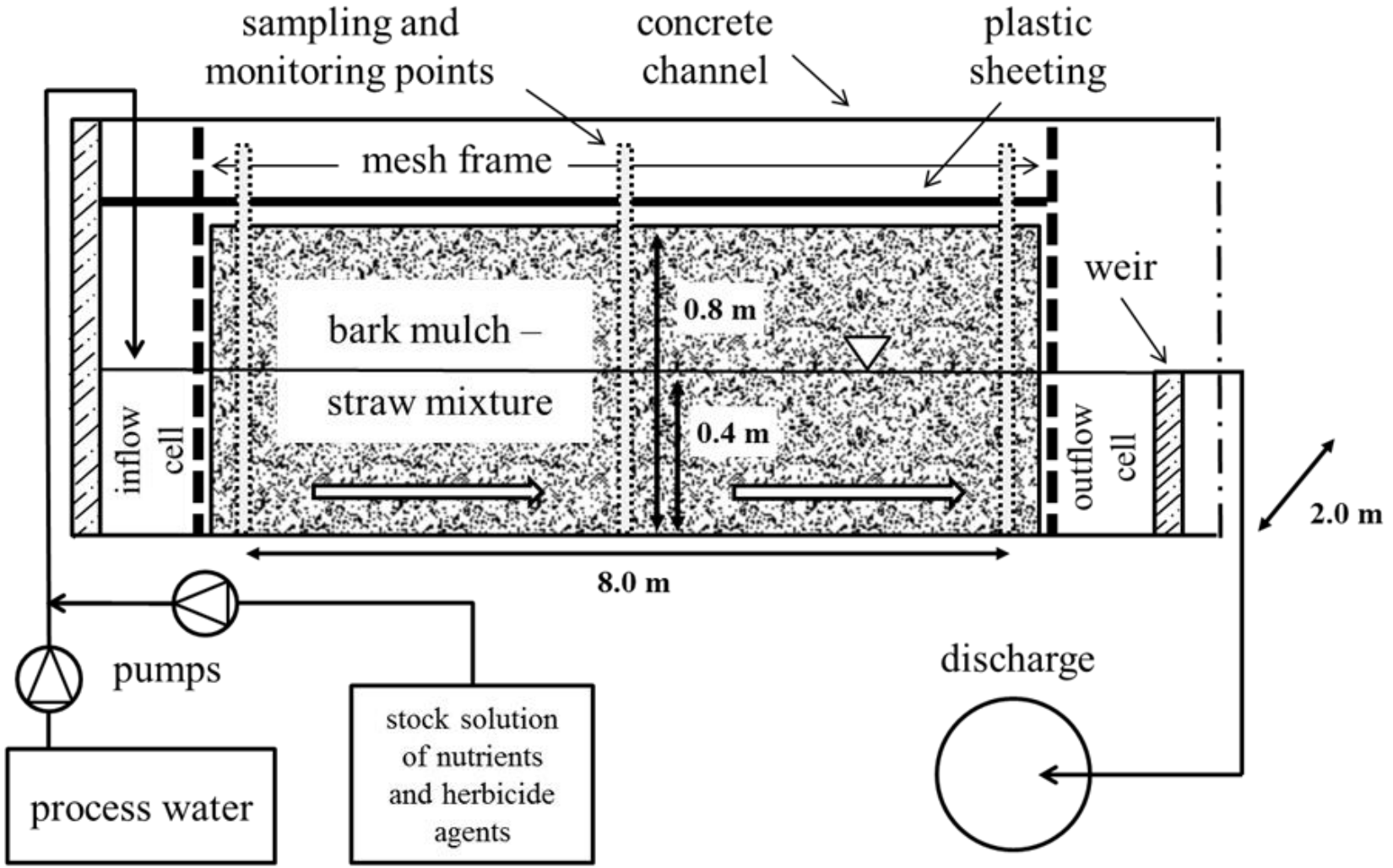
The Aquisafe II project was designed and has been conducted by partners in Germany (KompetenzZentrum Wasser Berlin (KWB), Umweltbundesamt (UBA), Institut für Landschaftsökologie und Ressourcenmanagement der Universität Gießen (ILR)), in France (Ste d'Environnement d'Exploitation et de Gestion de Travaux (S.E.E.G.T.), Syndicat Mixte Environnement Goëlo l'Argoat (SMEGA)) and in the United States of America (Center on Earth and Environmental Science, Indiana University-Perdue University of Indianapolis). It has been financed and supervised by Veolia eau, France.

The experimental studies of work package V were conducted at the European Center for Aquatic Simulations, which is operated by UBA and located in Berlin.

Motivation and design of the Aquisafe II project is comprehensively described in the project proposal (Matzinger et al. (2009)) and in Périllon and Matzinger (2010).

Construction of the bioreactor

Dr.-Ing. Björn Krause Camilo, bkrausecamilo@gmail.com



Reduction of nitrate and herbicides in drainage waters - First experiences with non-aerobic bioreactors at macro scale

The bioreactors (8.0x2.0x0.4m), with bark mulch and straw were examined for 1.5 years for their potential to attenuate one of the commonly used herbicide agents **bentazon**, **atrazine** or **isoproturon** (20 to 50 µg/L) and **nitrate** (NO_3^-; 100 mg/L) under realistic conditions [short hydraulic residence times (HRT), seasonally changing temperatures].

Straw and bark mulch are readily available organic carbon sources, which support effective and efficient denitrification at short hydraulic residence times in the temperature range between 9 and 21°C.
The short hydraulic residence times ranged from 0.4 (500 L/h) to 2.5 days (100 L/h).

Results I

- **Bentazon** is too persistent and mobile to be considerably reduced under high flow conditions.

- **Atrazine** can be substantially reduced in drainage waters (15 to 48% (10 to 22 mg m^{-3} day^{-1}) at HRT of 0.4 days and 52 to 98% (7 to 10 mg m^{-3} day^{-1}) at HRT of 2.5 days in the temperature range of 9 to 21°C).

- **Isoproturon** seems to be effectively reduced by degradation to metabolites under denitrifying (suboxic) condition (36 to 77% (11 to 21 mg m^{-3} day^{-1}) at HRT of 0.5 days and 0 to 49% (0 to 2 mg m^{-3} day^{-1}) at HRT of 2.0 days in the temperature range of 5 and 21°C.

- Straw and bark mulch are readily available organic carbon sources, which support effective and efficient denitrification at short hydraulic residence times (8 to 82% (3 to 30 g-nitrogen m^{-3} day^{-1}) at HRT of 0.4 days (500 L/h) and 72 to 100% (5 to 8 g-nitrogen m^{-3} day^{-1}) at HRT of 2.5 days (100 L/h) in the temperature range between 9 and 21°C).

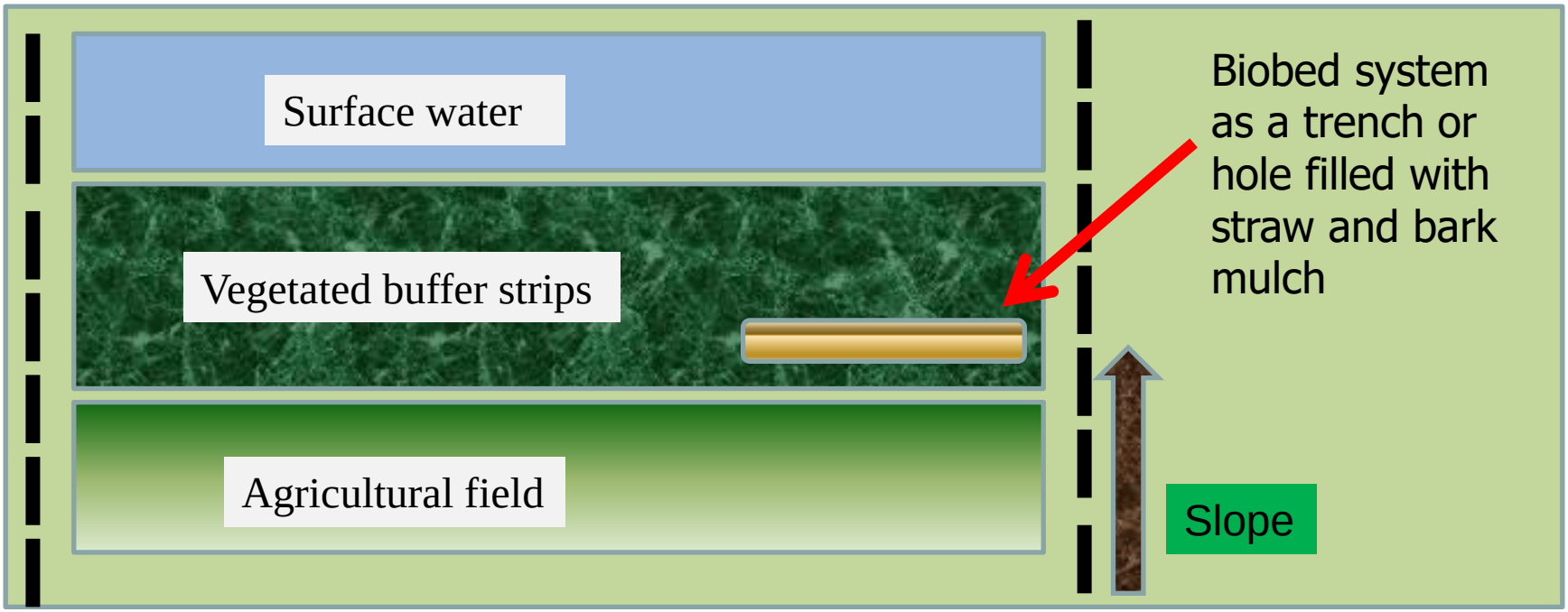
Results II

Design, operation and sizing of the bioreactor need to be adapted to present conditions at the desired site to prevent or, at least, to minimize possible negative effects, such as discharge of oxygen-free water, dissolved organic carbon, nitrite and hydrogen sulphide into receiving waters and N_2O into the atmosphere.

In conclusion, the studied design provides a valuable and effective tool in the set of best management practices in agriculture to attenuate nitrate and atrazine as well as isoproturon in drainage waters.

Future applications

The innovative mitigation system proposed here will combine the positive effects of vegetated buffer strips and anaerobic biobeds. These biobeds may be restricted e.g. to the end of erosion rills in order to absorb the main load of runoff water.




Thank you
for your attention!