Dynamics of faecal pollution indicators in surface water draining an agricultural catchment

STADLER, P.[1,7], VOGL, W.[2], KOSCHELNIK, J.[2], EPP, M.[2], LACKNER, M.[2], OISMÜLLER, M.[1], NEMETH, L. [7], KUMPAN, M.[3], STRAUSS, P.[3], SOMMER, R.[4,5], RYZINSKA-PAIER, G.[6], FARNLEITNER, A.H.[4,6], **ZESSNER, M.[1,7]**

[1] TU Wien, Centre for Water Resource Systems ***www.waterresources.at***
[2] Vienna Water Monitoring
[3] Federal Agency for Water Management, Institute for Land & Water Management Research www.baw-ikt.at
[4] Interuniversity Cooperation Centre for Water and Health www.waterandhealth.at
[5] Medical University of Vienna, Institute for Hygiene and Applied Immunology, Water Hygiene
[6] TU Wien, Institute of Chemical Engineering, Research Group Environmental Microbiology and Molecular Ecology
[7] TU Wien, Institute for Water Quality, Resources and Waste Management

LuWQ 2015
International Interdisciplinary Conference on
Land Use and Water Quality
Agricultural Production and the Environment

Structure of presentation

Method and objectives

Test site – HOAL catchment

Monitoring results:
- **consistency/bias**
- **diurnal, event and yearly dynamics**
- **indicator capability**

Conclusion

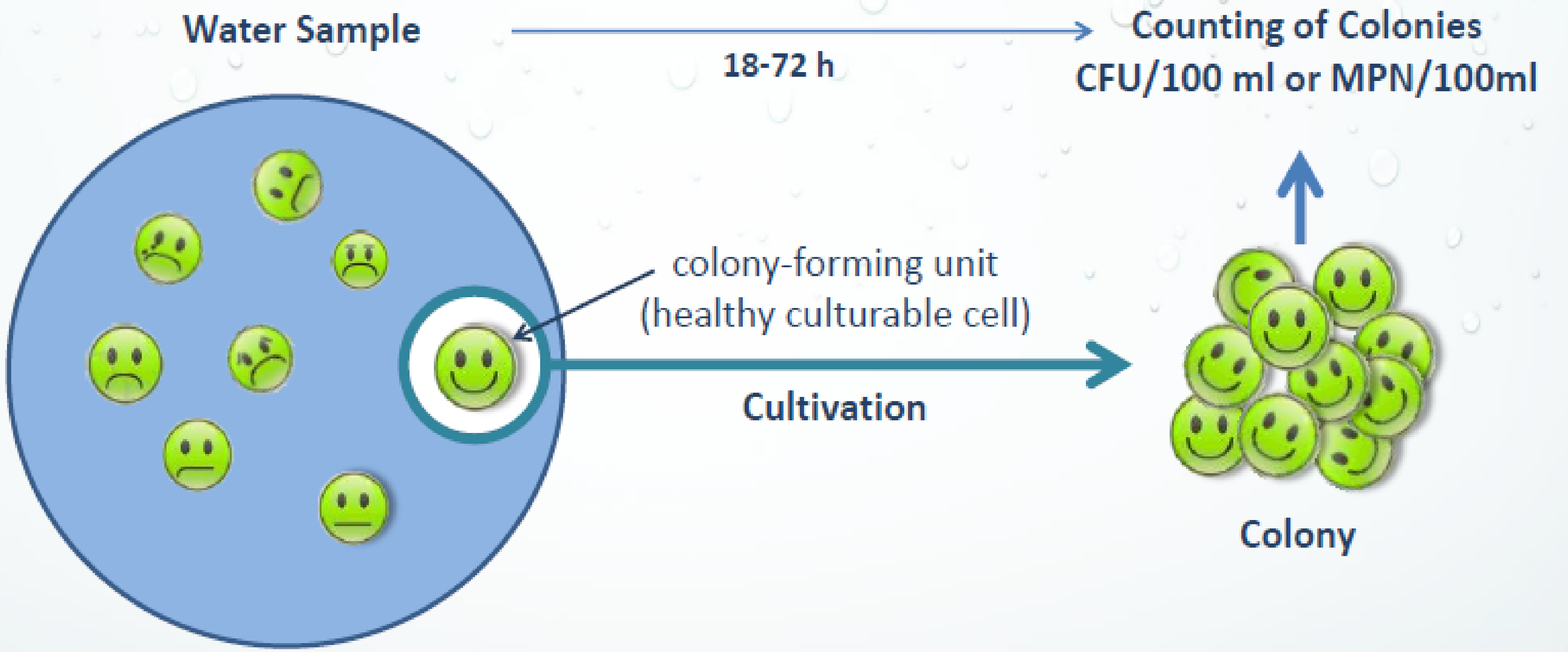
On-site detection of enzymatic activities

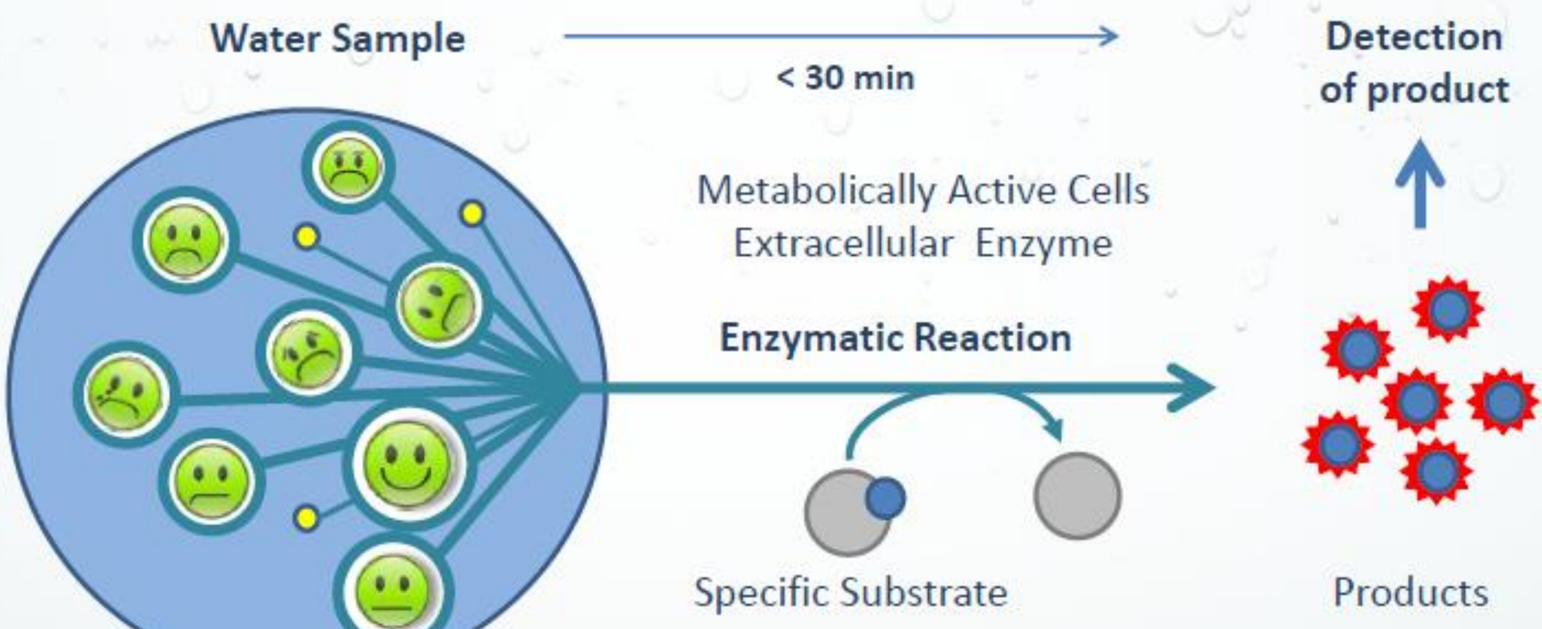
- as a rapid surrogate for microbiological pollution monitoring of water resources.
- short measuring intervals
- potentially significant information for a health related water quality assessment.

Four tested devices

(2 ColiMinder VWM – Austria and 2 BACTcontrol MicroLan - Netherlands)

- are designed for the rapid detection of fecal contamination by means of specific enzymatic activity (beta-D-glucuronidase - GLUC) determination in water and water resources.


Water Sample
18-72 h
Counting of Colonies
CFU/100 ml or MPN/100ml
colony-forming unit
(healthy culturable cell)
Cultivation
Colony


Water Sample
< 30 min
Detection
of product
Metabolically Active Cells
Extracellular Enzyme
Enzymatic Reaction
Specific Substrate
Products

Potential applications

Early warning systems

e.g.: drinking water and food related bathing waters

Process control

WWTP

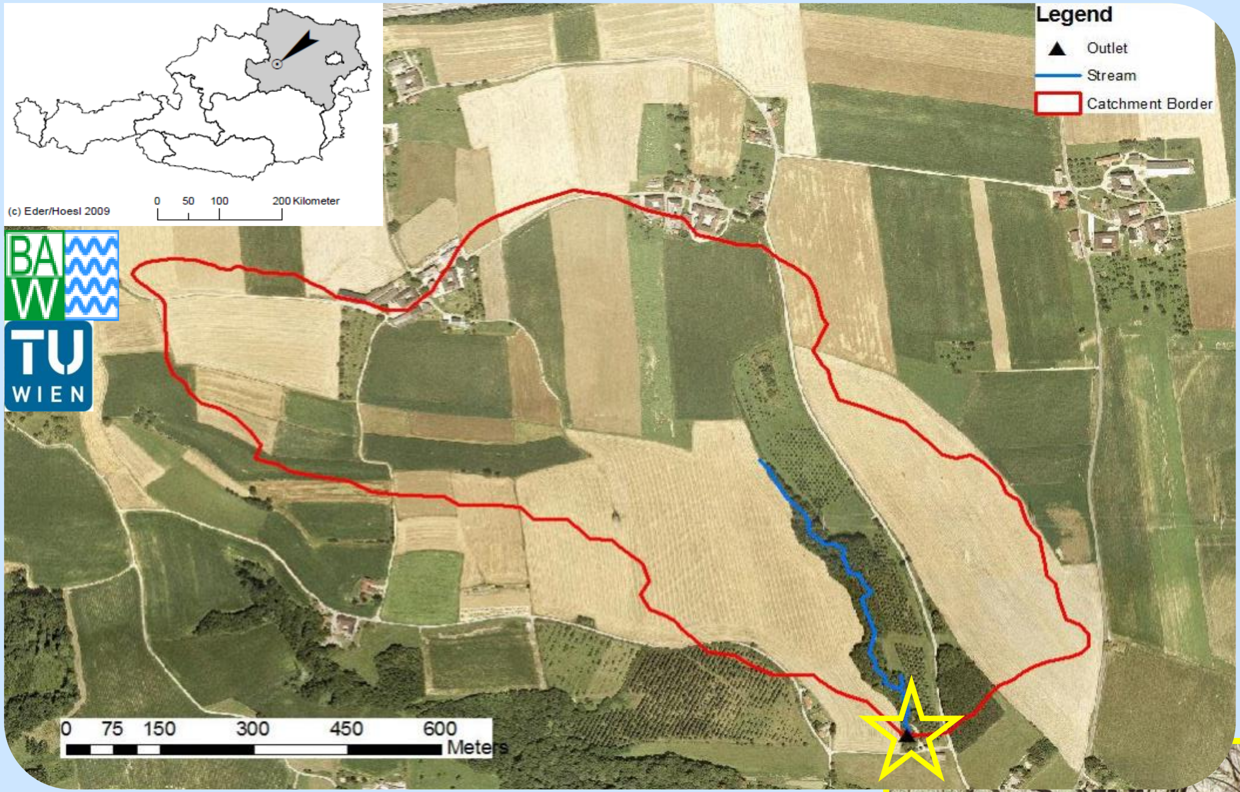
Objective of this study

Stream draining an agricultural used catchment

Long term field testing under demanding conditions

- **Technical realization** of automated, on-site and near real time enzymatic activity measurements for surface water quality monitoring
- **concistency** of on-site GLUC measurements (2 independent constructed designs)
- **Indicator capability** of on-site measured enzymatic activity for potential fecal contamination of stream water (standard microbiological assays)
- **Seasonal trends and event dynamics** of enzymatic activity in stream water

Experimental catchment (Hydrological Open Air Laboratory - HOAL)



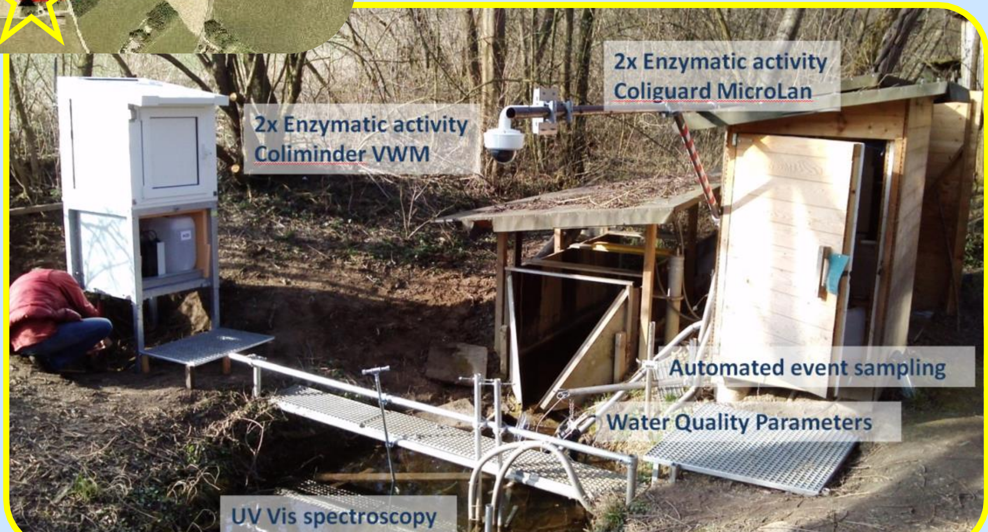
66 ha
620 m stream

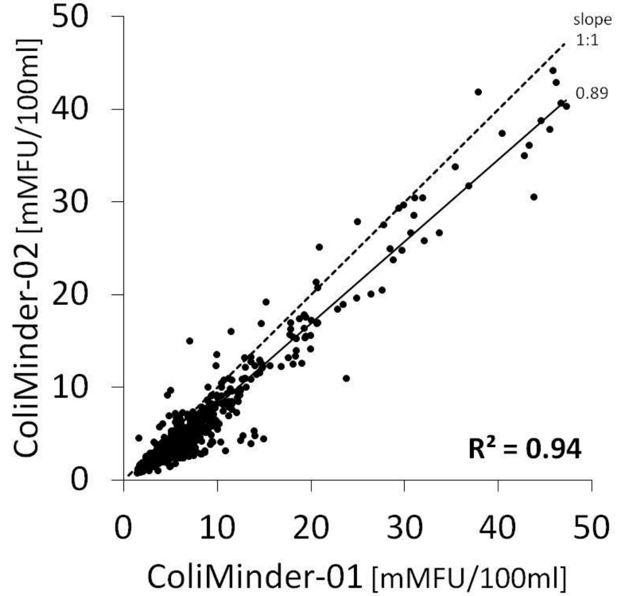
87% arable land
Manure application

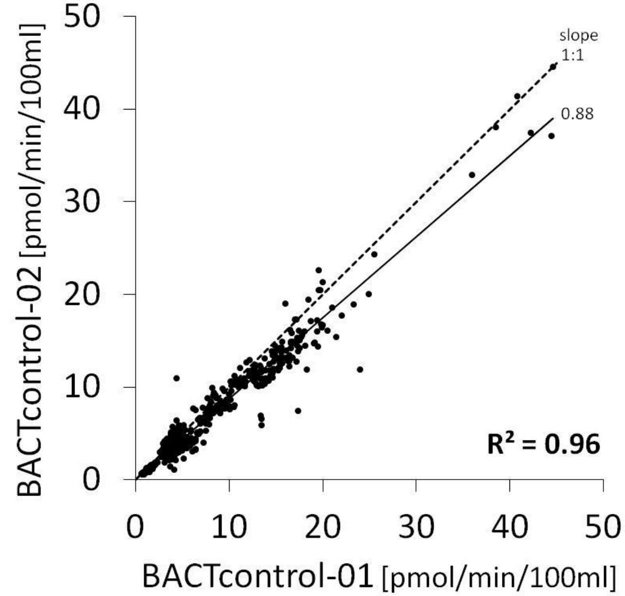
High dynamics in discharge, sediment transport and bacterial contamination

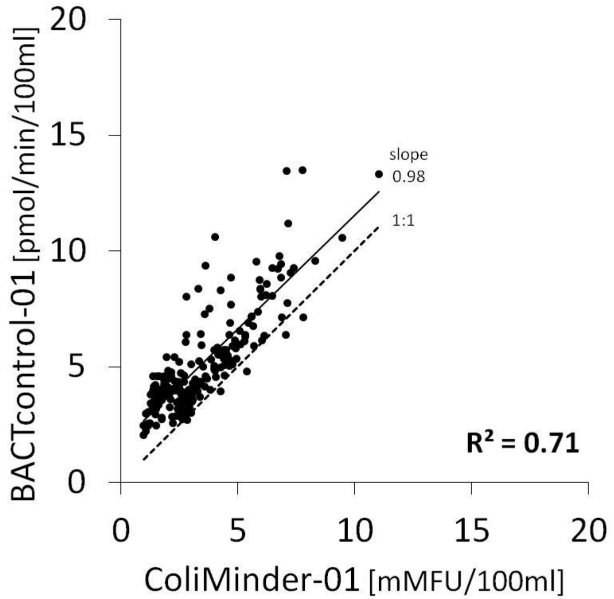
Discharge
mean: 4.2 l/s
max: 655 l/s
min: 0.3 l/s

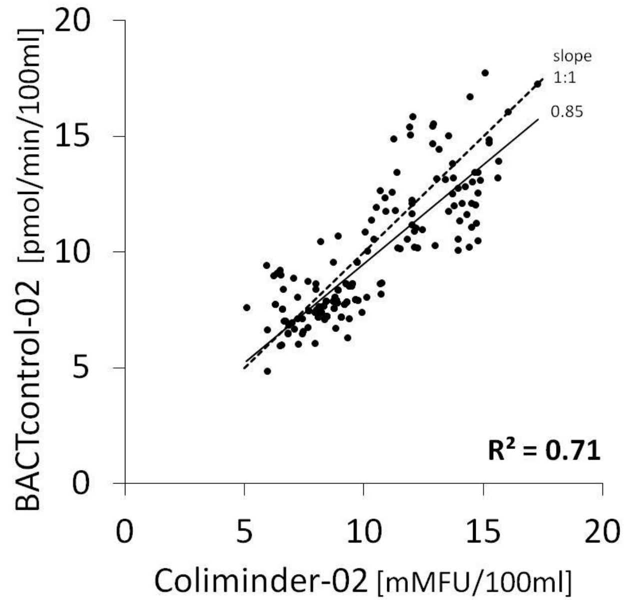
E. coli [MPN/100ml]
peak: 11 300
min: 4.1



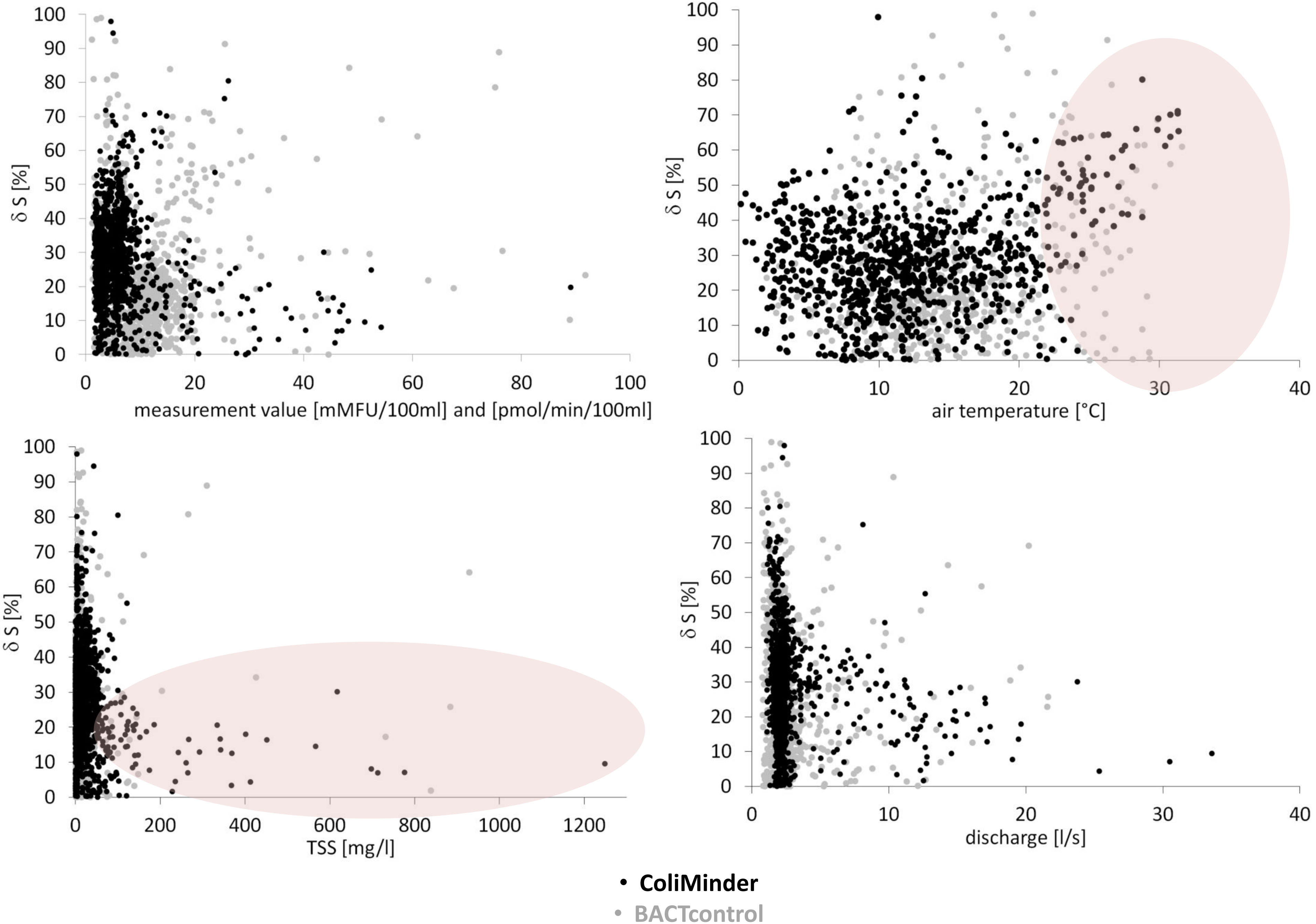








n>200 , p-value<0.001

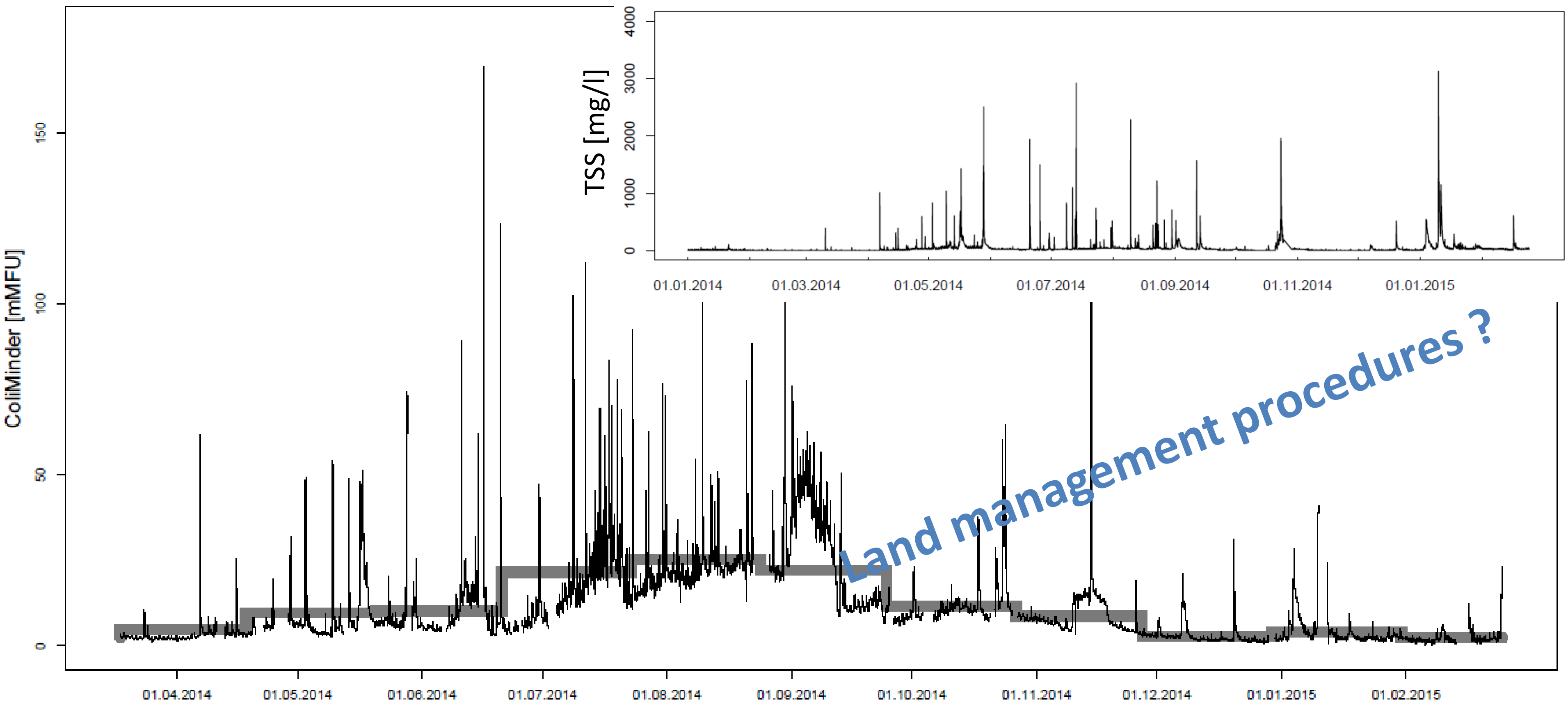

δ S [%]
measurement value [mMFU/100ml] and [pmol/min/100ml]
δ S [%]
air temperature [°C]
δ S [%]
TSS [mg/l]
δ S [%]
discharge [l/s]
• ColiMinder
• BACTcontrol

Seasonal dynamics

Maximum GLUC values during summer month (June-September)

Minimum GLUC values in late winter (February – March)

Fits well with data from monthly grab samples (3 years, cultivation based standard assays)

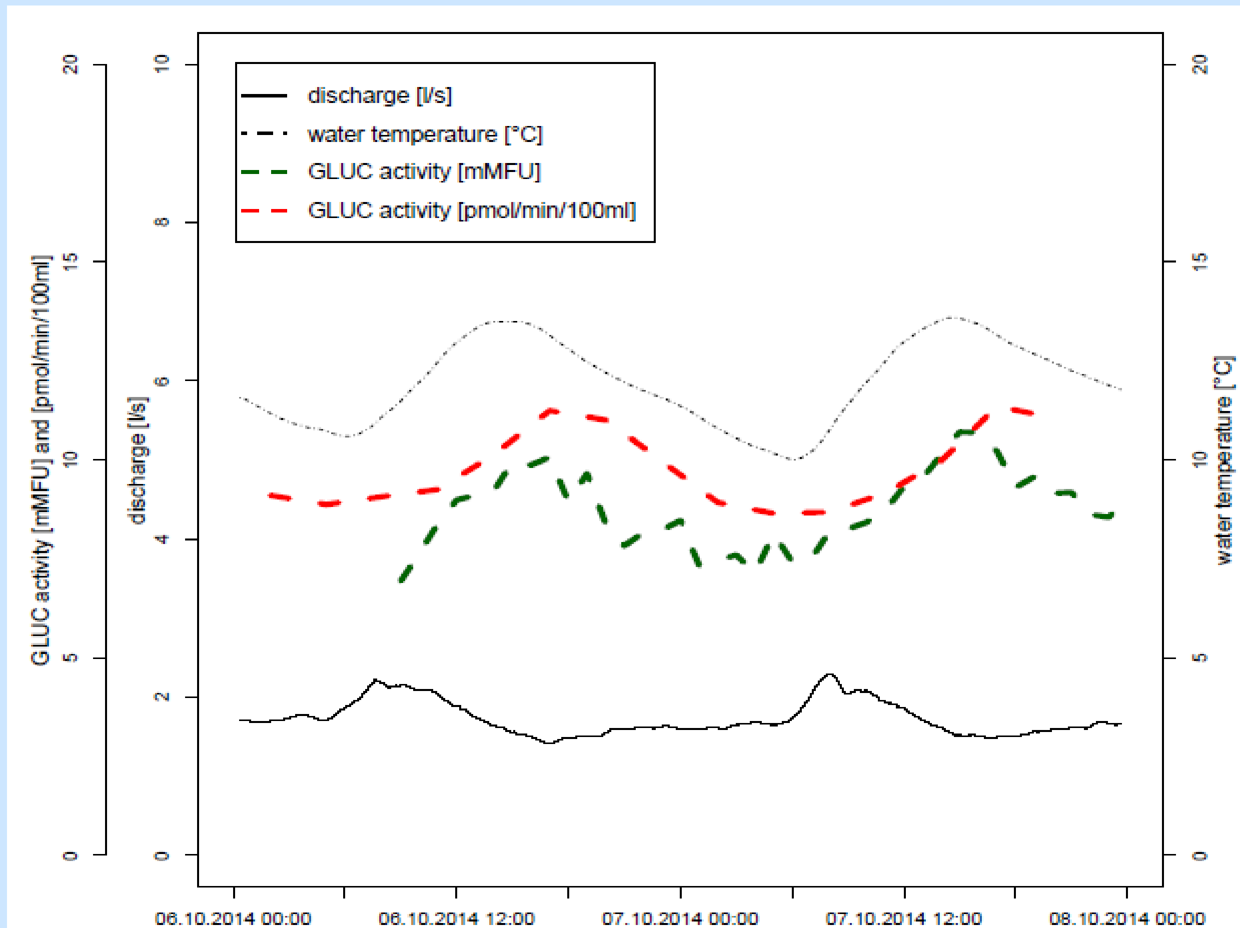


Diurnal dynamics

During dry weather periods with abundant daily temperature oscillation

Maximum GLUC activity in the late afternoon and minimum values in the early morning.

Antithetic to the daily discharge dynamics and lagging behind the daily course of water temperature

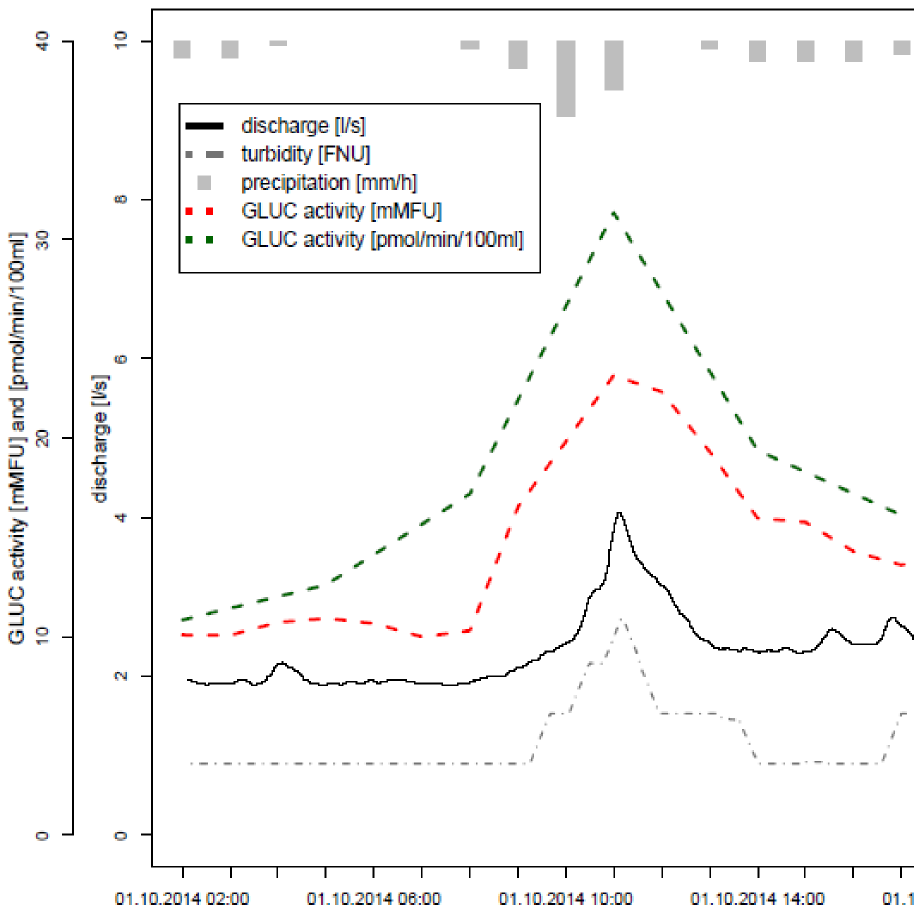


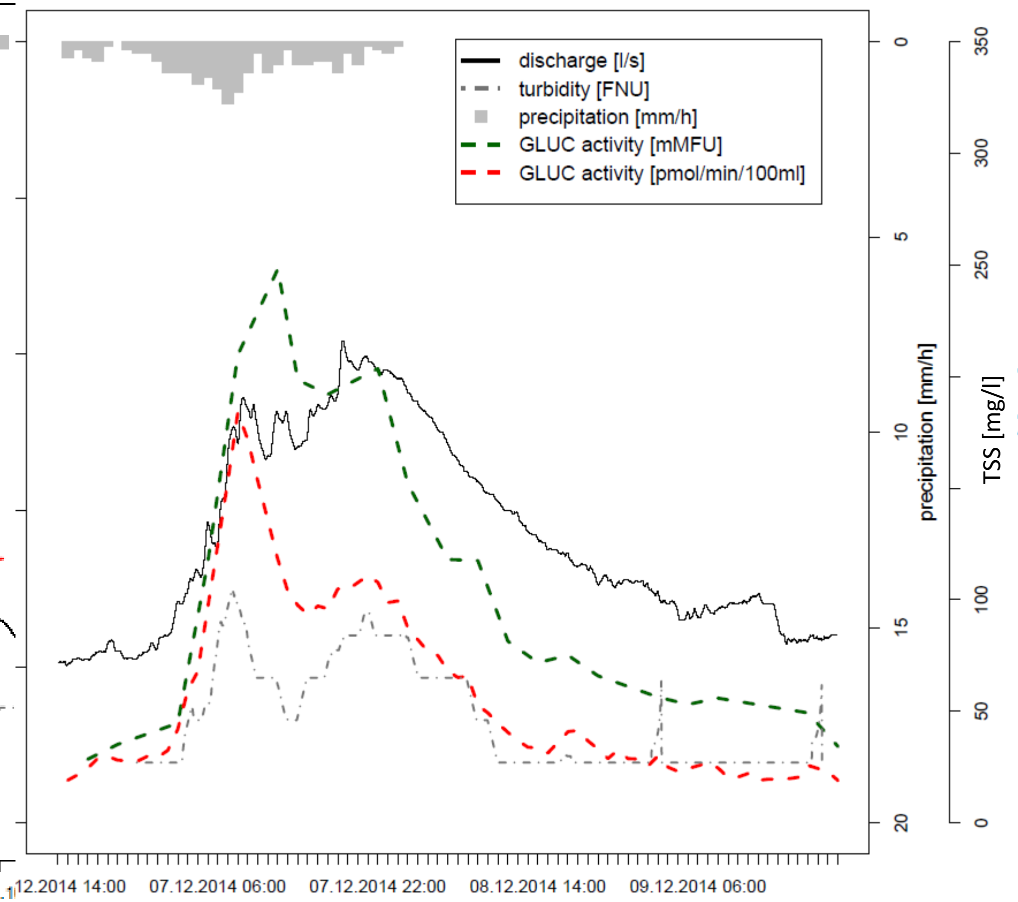
Event dynamics

Indication of potential fecal contamination

GLUC values follow and reflect hydrological conditions

GLUC peaks must not be aligned with discharge/ turbidity maximum





Indicator capability for microbiological standard assays

R^2	**GLUC activity** [mMFU/100ml]	***E. coli*** [MPN/100ml]	**Discharge** [l/s]	**EC** [µS/cm]	**TSS** [mg/l]	**Water temp.** [°C]	**Air temp.** [°C]
GLUC activity [mMFU/100ml]	*n=54*	0.52	0.38	0.47	0.39	0.12	0.00
E. coli [MPN/100ml]	0.52	*n=54*	0.62	0.68	0.51	0.14	0.18
Discharge [l/s]	0.38	0.62	*n=54*	0.57	0.73	0.29	0.29
EC [µS/cm]	0.47	0.68	0.57	*n=54*	0.74	0.08	0.19
TSS [mg/l]	0.39	0.51	0.73	0.74	*n=54*	0.15	0.06
Water temp. [°C]	0.12	0.14	0.29	0.08	0.15	*n=54*	0.71
Air temp. [°C]	0.00	0.18	0.29	0.19	0.06	0.71	*n=30*

Conclusion

Automated and rapid enzymatic activity determination is applicable for surface water monitoring

GLUC measurements followed and reflected the hydrological- and microbiological conditions of the stream during the test period

Dynamics of enzymatic activity in stream water were captured on diverse time scales

Not a quantifying proxy for microbiological standard assays

A valuable complementary parameter for water quality assessment

Ongoing research

Impacts of land management procedures

Driving processes behind dynamics

BAW

ICC Water & Health

MEDIZINISCHE UNIVERSITÄT WIEN

TU WIEN

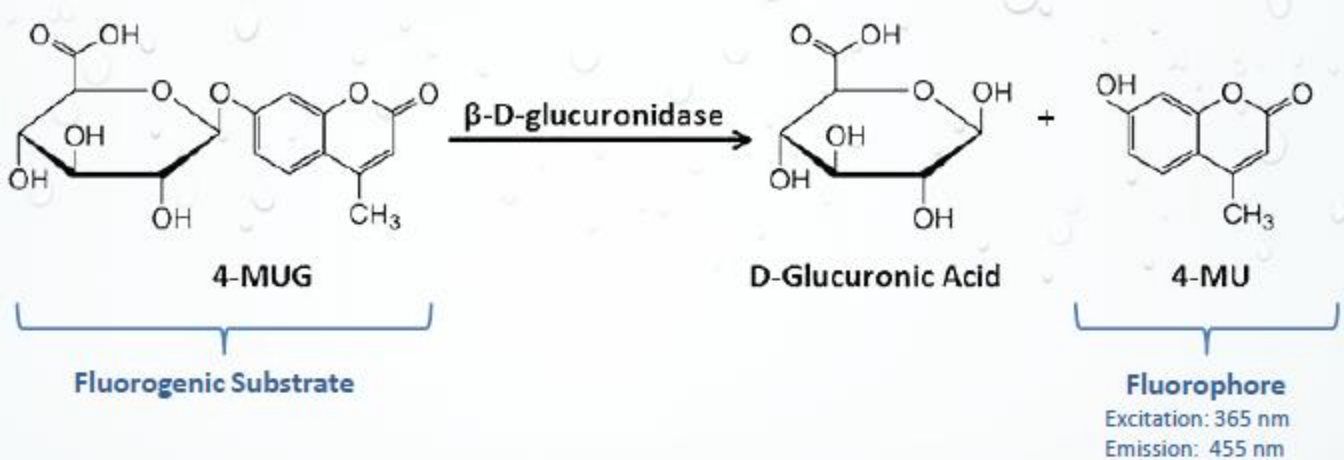
Vienna Doctoral Programme on
Water Resource Systems
www.waterresources.at

VWM
vienna water monitoring
SOLUTIONS

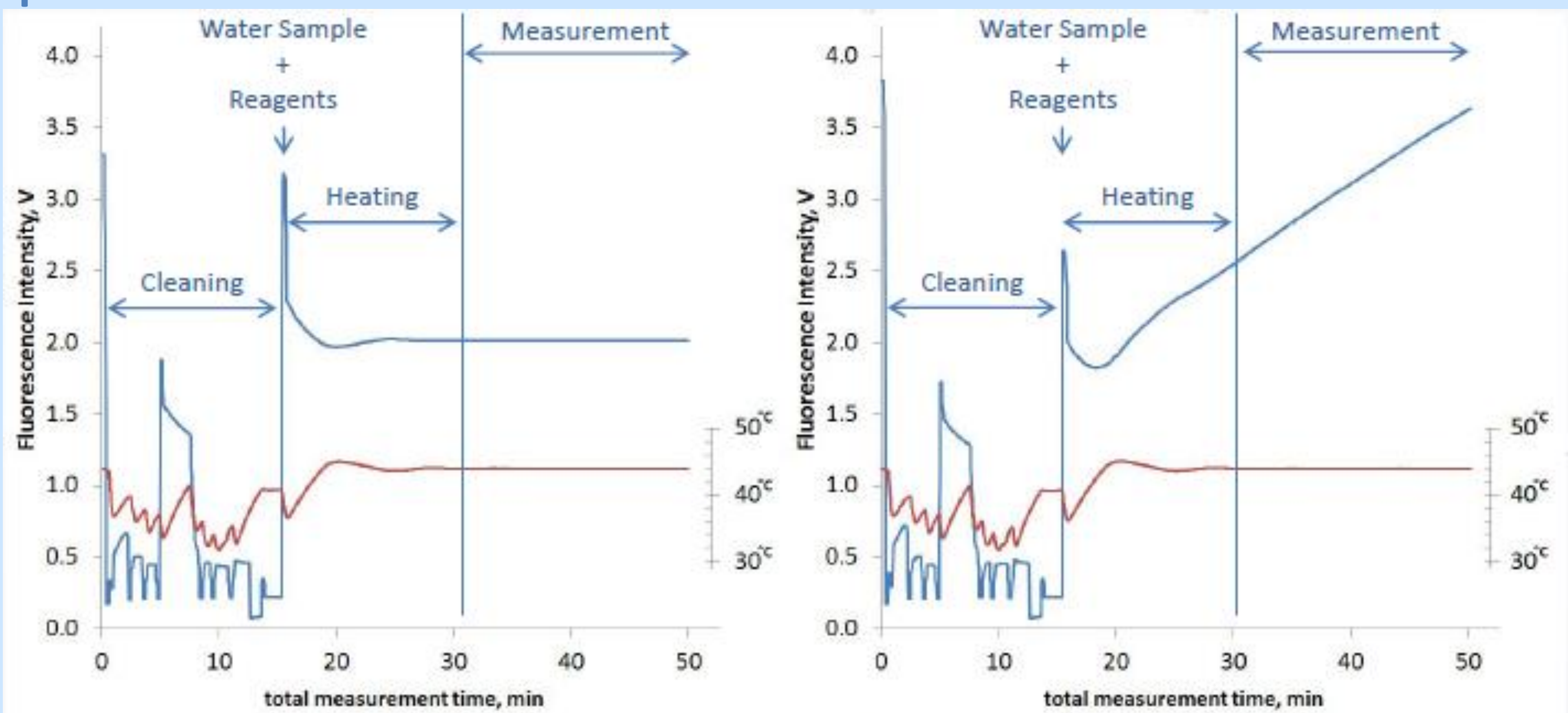
Thank you !

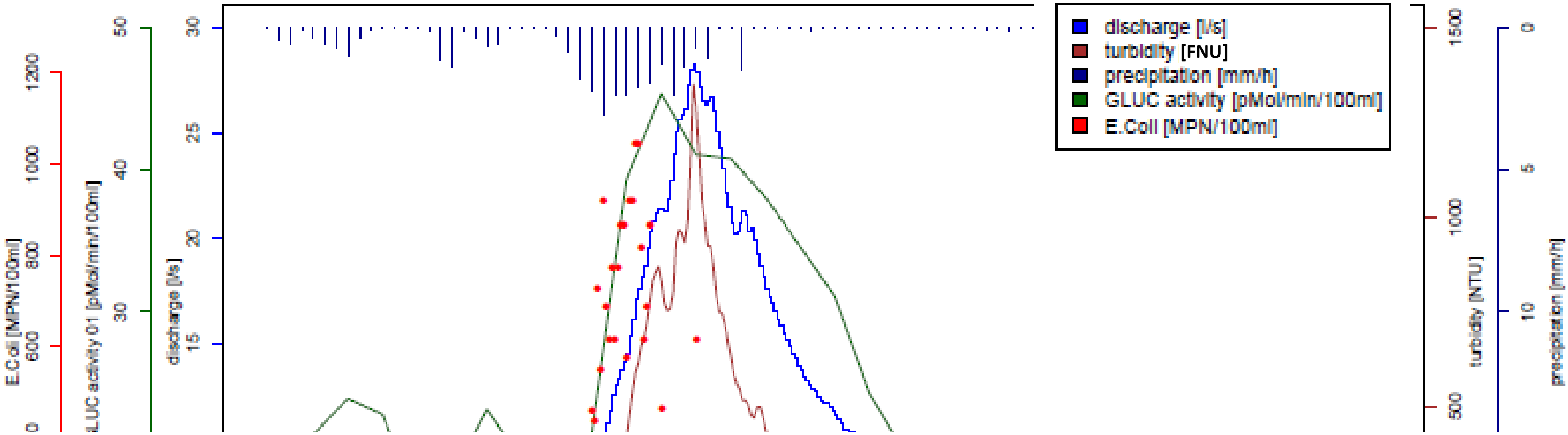


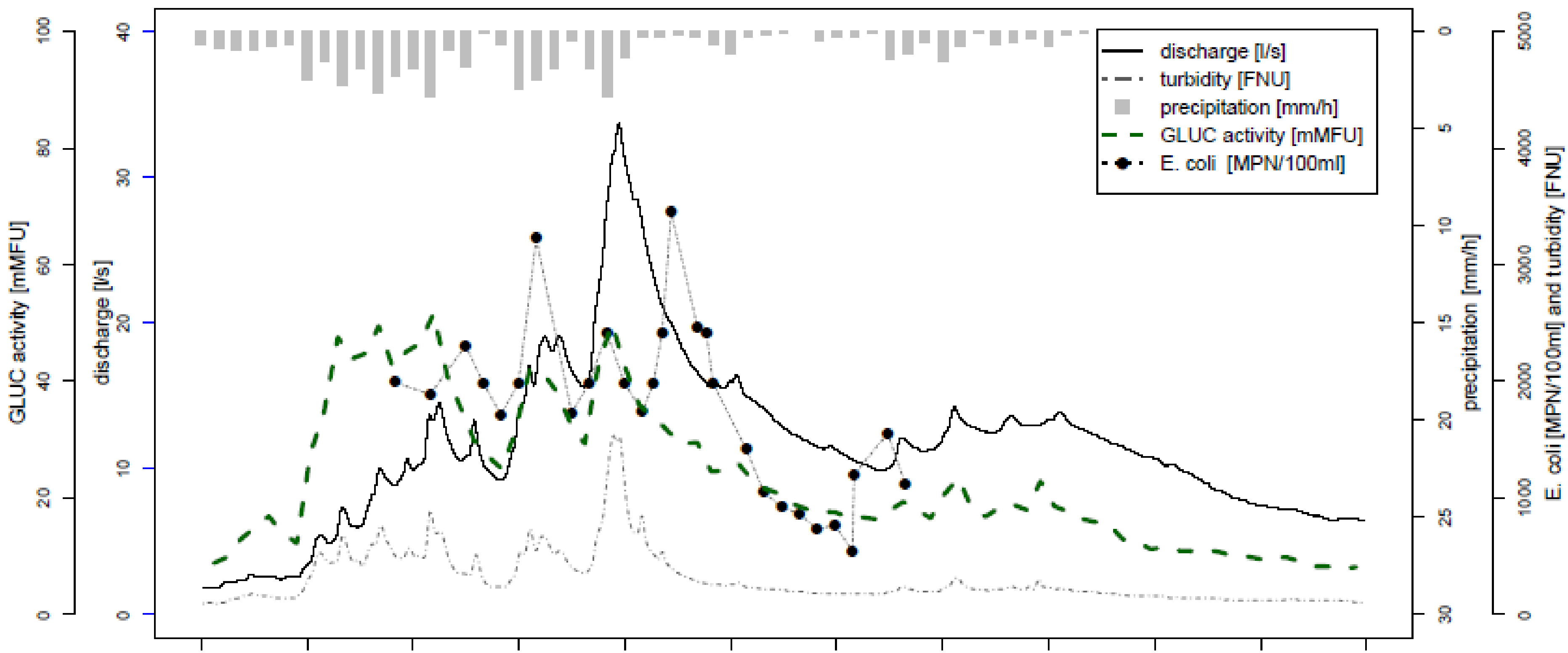


Enzymatic hydrolysis of non-fluorescent substrate leads to **accumulation of highly fluorescent product**




discharge [l/s]
turbidity [FNU]
precipitation [mm/h]
GLUC activity [pMol/min/100ml]
E.Coli [MPN/100ml]
E.Coli [MPN/100ml]
GLUC activity 01 [pMol/min/100ml]
discharge [l/s]
turbidity [NTU]
precipitation [mm/h]


discharge [l/s]
turbidity [FNU]
precipitation [mm/h]
GLUC activity [mMFU]
E. coli [MPN/100ml]
GLUC activity [mMFU]
discharge [l/s]
precipitation [mm/h]
E. coli [MPN/100ml] and turbidity [FNU]