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Use of wood chips in a reactive ditch for mitigation of pesticides into receiving waters

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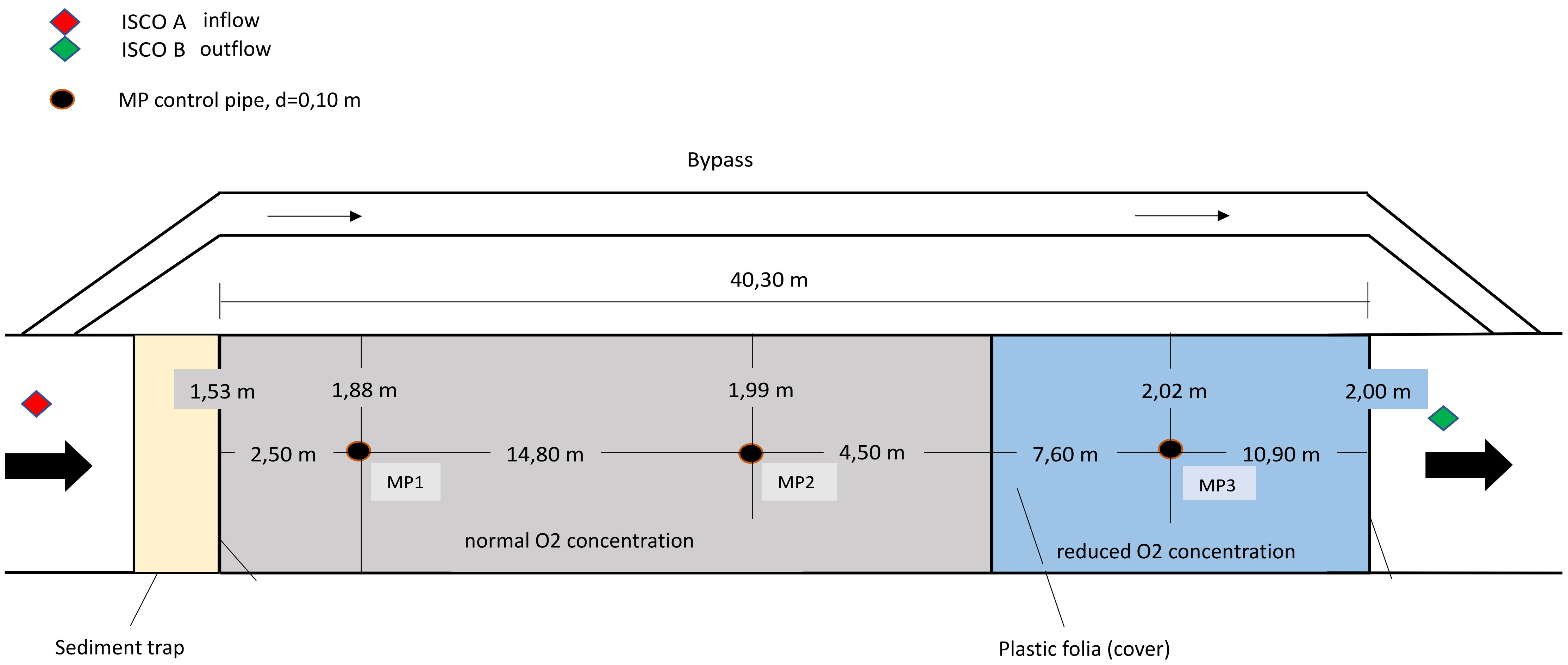
Motivation of the study

- Drainage water highly contributes to surface water contamination by pesticides
- Drainage systems cannot be closed
- End-of-pipe/Interface measures to pre-clean drainage water essential
- Retention of pesticides to enhance degradation and sorption

Objectives of the study

1. Can a Reactive Ditch System (RDS) with wood chips retain pesticides?
2. Is there a difference depending on the pesticides‘ phys-chem characteristics?
3. What are the challenges?
4. Can we provide recommendations?

Reactive Ditch System



Plastic folia on ditch bottom

Characteristics of the Reactive Ditch System

Mean surface area of wood chips 3-42 cm²

Salt tracer experiment

Detention time mean	5.9 h
Hydraulic efficency	0.76
Short circuiting	0.73

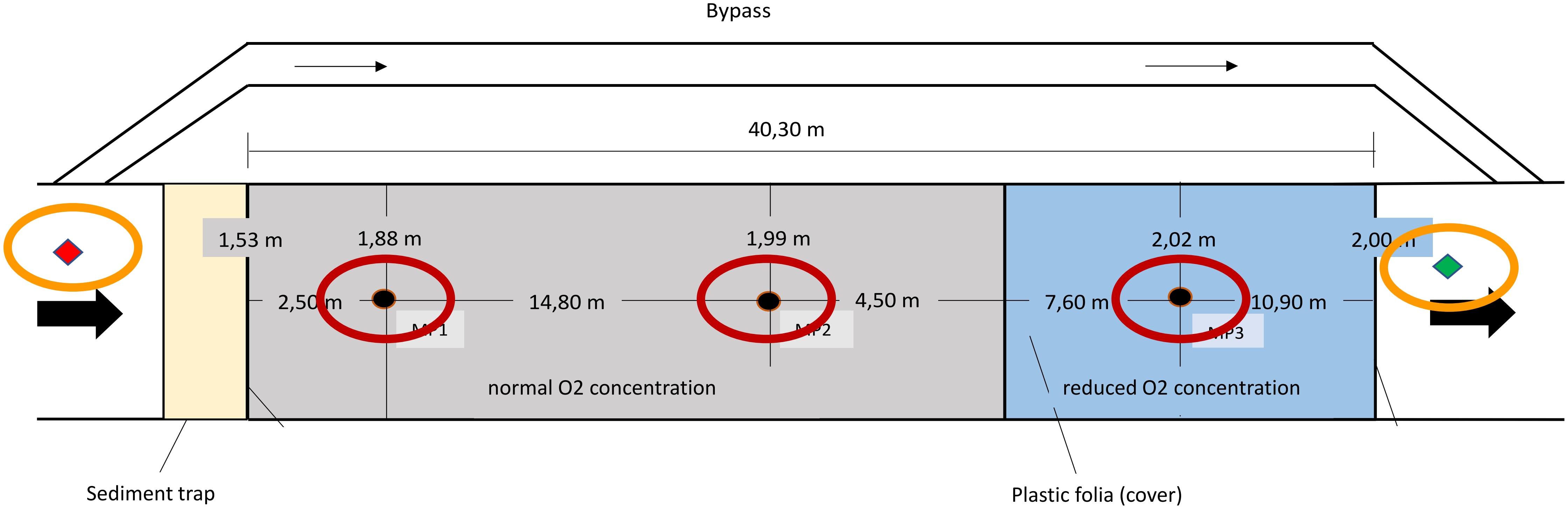
Decreasing water level along RDS

Sampling scheme

ISCO A inflow
ISCO B outflow
MP 1-3

Daily mixed samples
Weekly grab samples

Sampling period: I Jan-June 2021
II Nov 2021-March 2022



Impressions of the Reactive Ditch System

Inflow

View from inflow

View from outflow

Outflow

In situ parameters

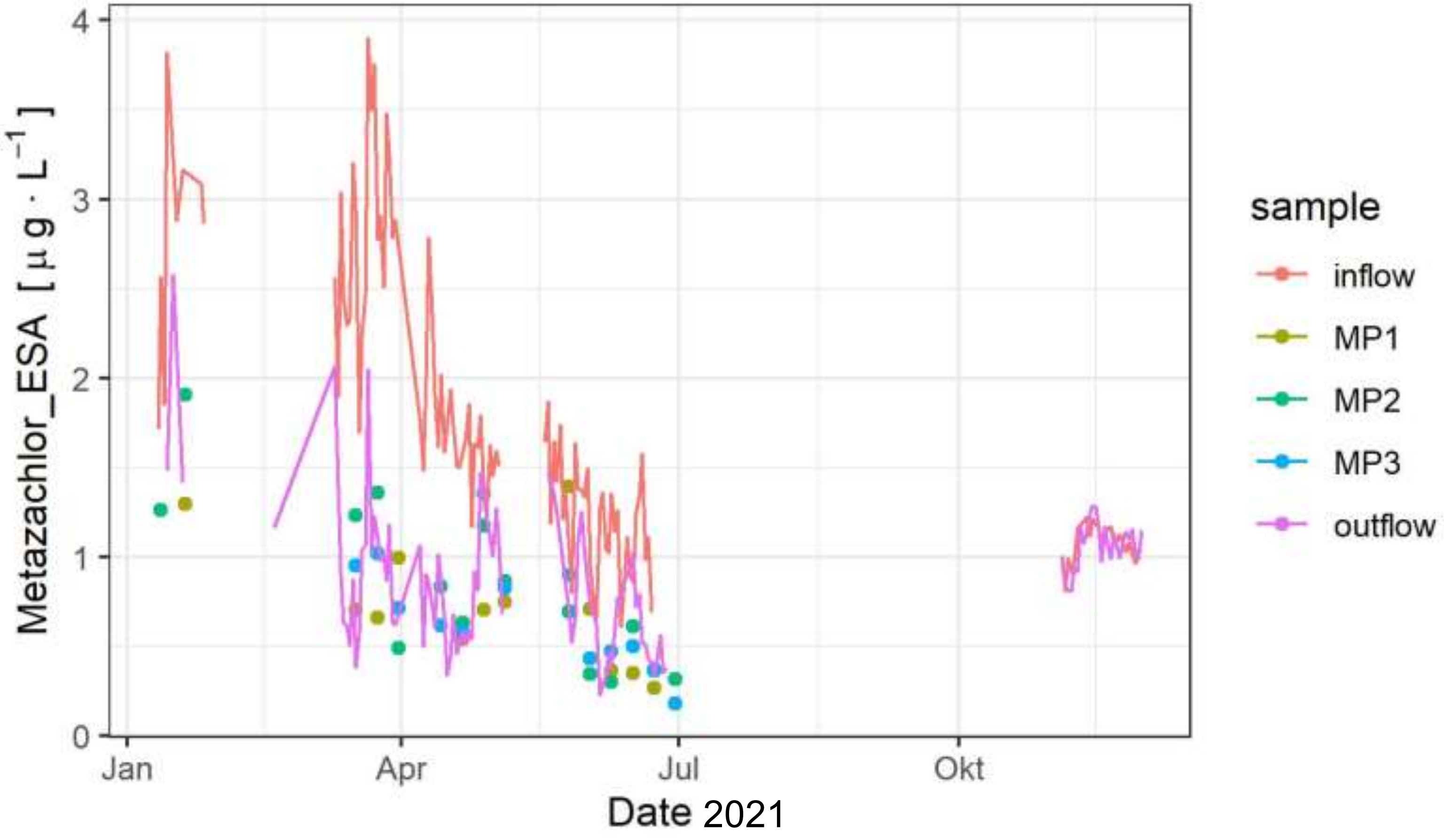
pH values:
at 6.8-7.4 at all sampling points

Temperature:
seasonality at inflow/MP1/outflow
constant at ca. 7°C in MP2/MP3

Dissolved oxygen content:
decreased along RDS inflow 11 mg/L→MP3 2 mg/L
decrease from May to July → higher temperatures, lower flow

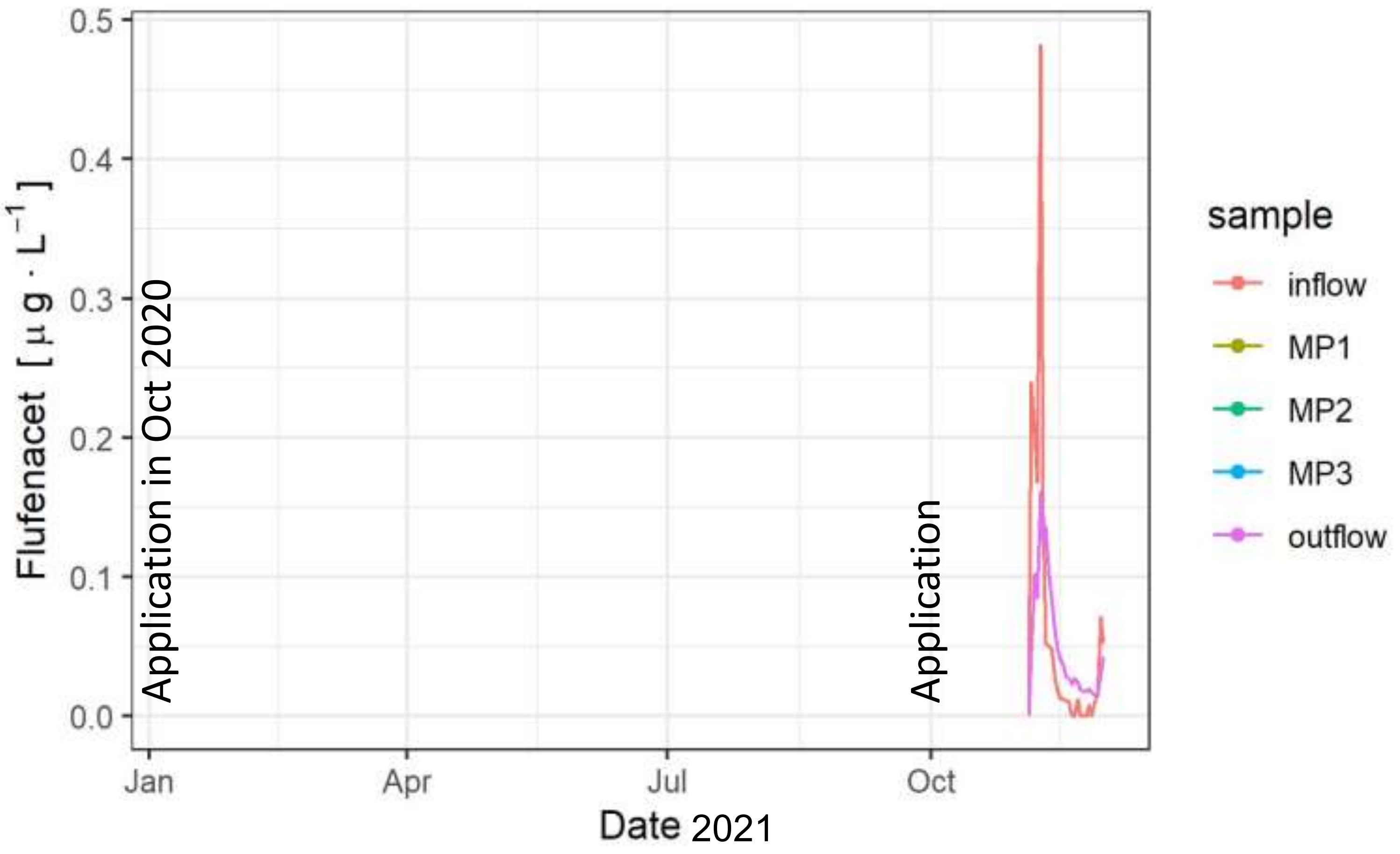
Retention of Metazachlor-ESA

K_f=0.26 ml g^{-1}



Retention in spring, but reduction in summer/winter due to low O_2?

Retention of Flufenacet

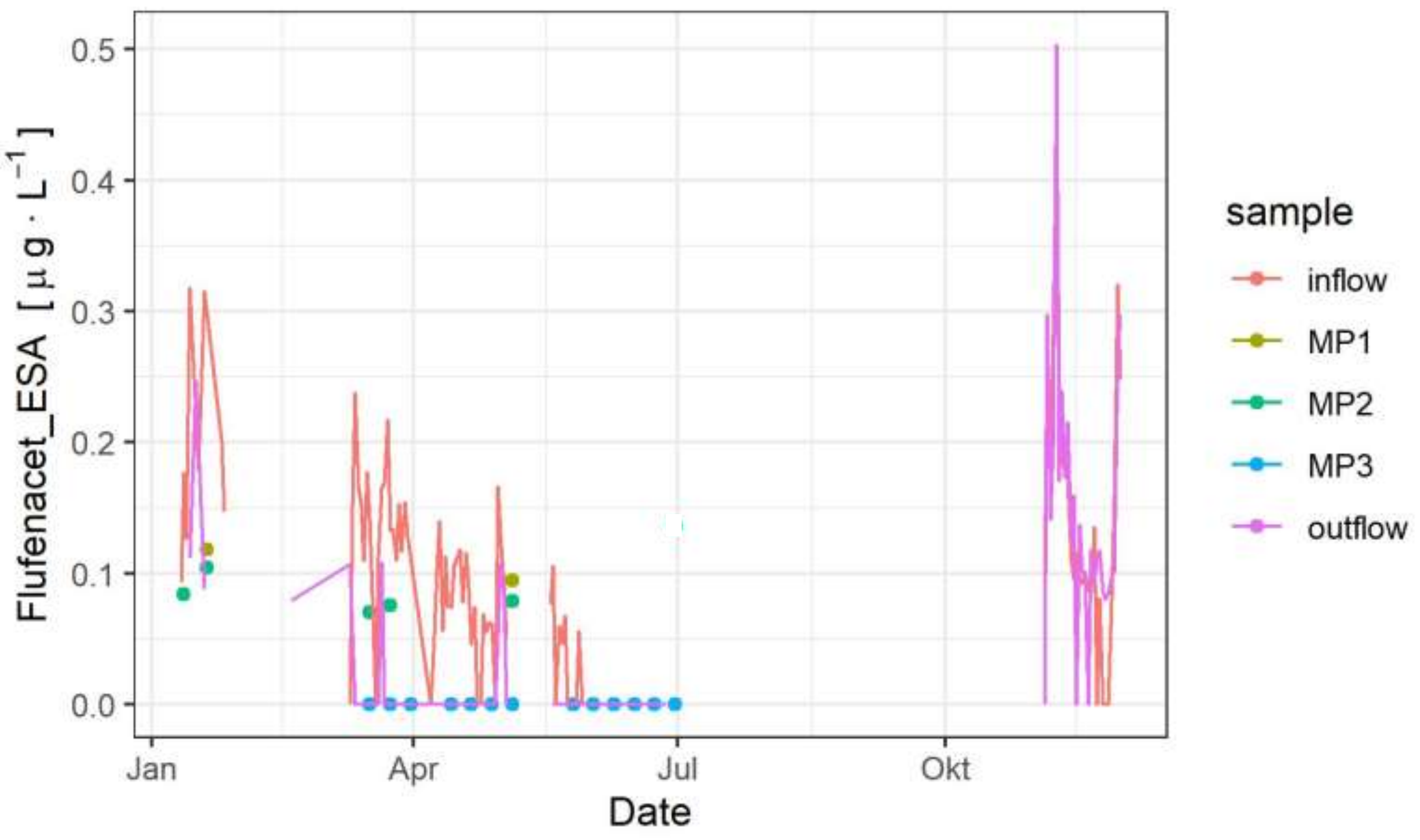


K_f=4.38 ml g^{-1}

Conc.<LOQ in winter/spring

Peaks in autumn reduced

Retention of Flufenacet-ESA

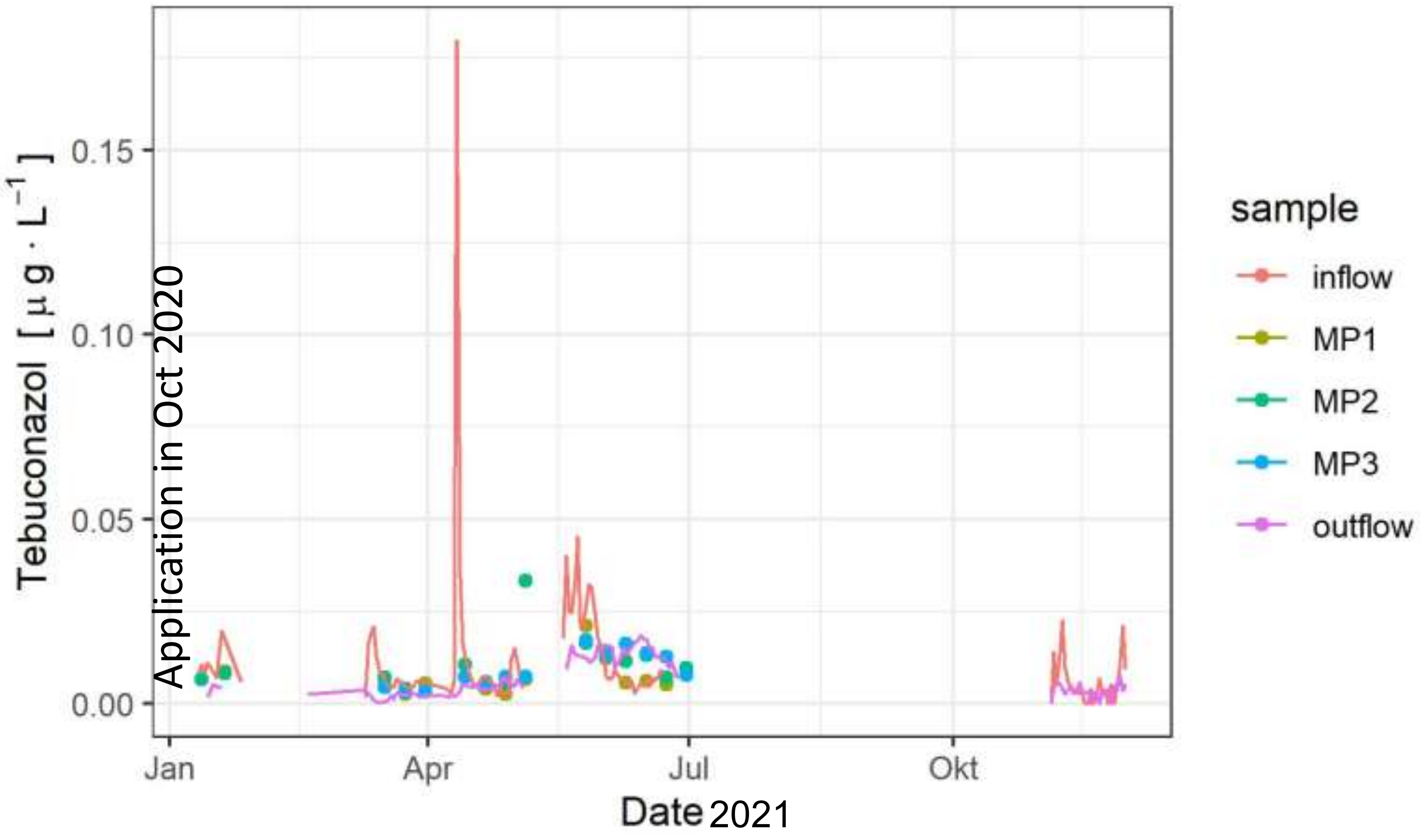


K_f=0.12 ml g^{-1}

Transformation of „fresh“ flufenacet in RDS or remobilization after dryness?

Retention of Tebuconazole

K_f=12.7 ml g^{-1}



Peaks are smoothened

Challenges and recommendations

For scientists:

- Flow velocity measurements not posssible at our construction →important for load calculations
- Avoid interaction with shallow groundwater → mass balance
- Is a remobilization after dry period likely?

For Practioners:

- Good stearing unit/bypass essential → too high or too low water levels
- Take care of the kind of wood chips → clogging of the front area by sediments, very fine wood material (bark), biofilm (?)
- Wood chips should be more or less covered with water → fast degradation
- Outflow barrier increases involved RDS volume

Conclusion & Outlook

First attempt in this field for pesticides

- Potential for pesticide retention
- Quantification of efficiency here not possible (no loads)
- K_f has no clear impact on retention
- No overview of microbiology in RDS despite of MPs→ only in water samples aerobic/anaerobic
- Main challenge is handling of hydraulic conditions

Next attempt:

- Exchange of wood chips
- Barrier at the outflow
- More measurements
- Including microorganism-DNA sequencing

Thanks for your attention!

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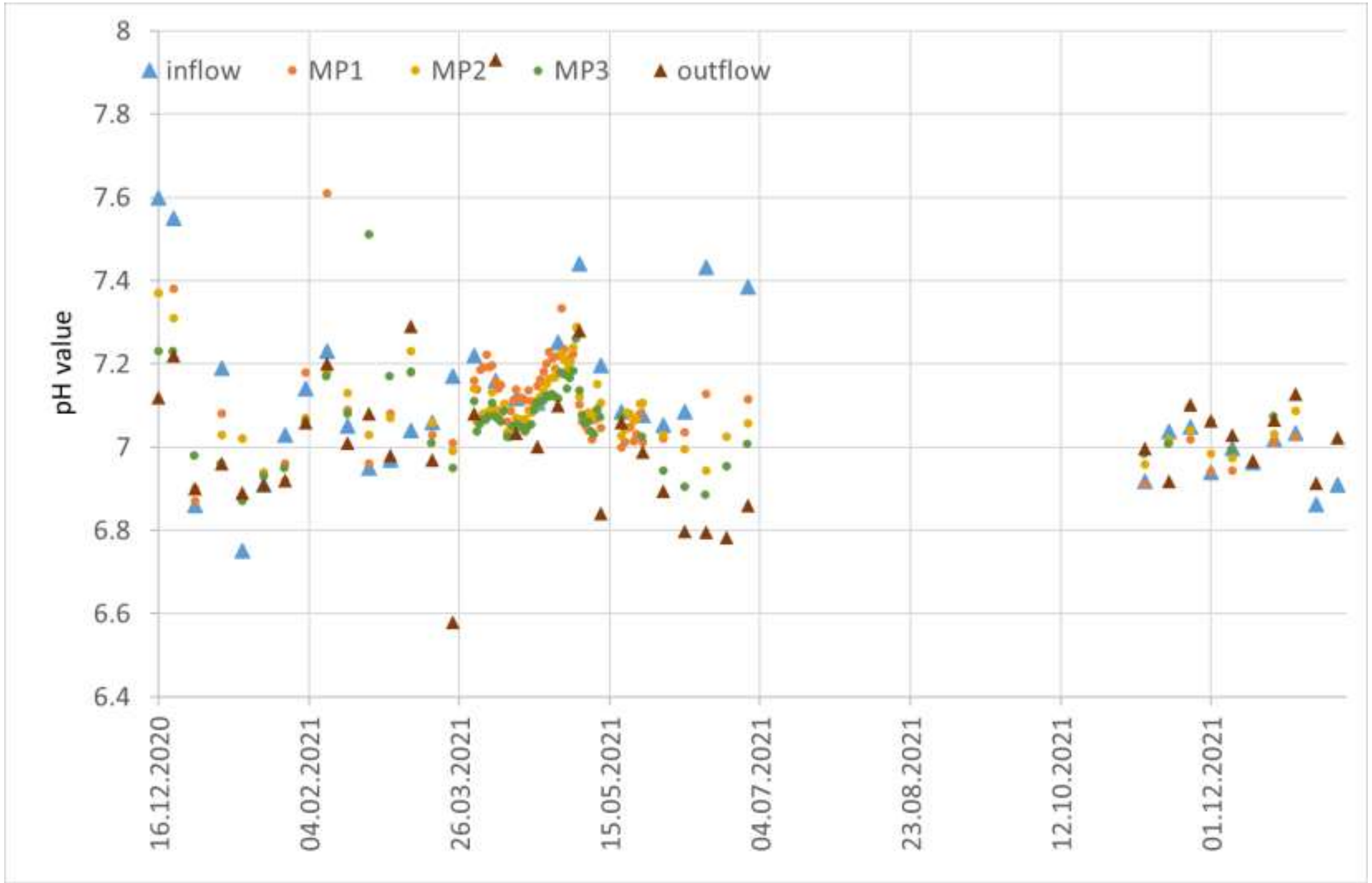
Lee Burbery/New Zealand

pH values



Similar pH range for all points

Theoretical hydrological detention time based on measurements

Tabelle 8: Ergebnisse der theoretischen hydraulischen Verweilzeit (HRT) und der Fließgeschwindigkeits- (v) und Abflussmessungen (Q) mit dem jeweiligen Wasserstand an MP4.

Datum	Wasserstand [cm]	v [m/s]	Q [l/min]	HRT [h]
27.01.2021	17,50	0,0040	42,91	6,43
10.02.2021	15,00	0,0025	20,00	13,80
17.02.2021	24,00	0,0048	70,02	5,00
24.02.2021	22,30	0,0031	32,77	8,37
03.03.2021	15,50	0,0018	14,63	19,51
10.03.2021	12,50	0,0020	14,56	16,18

Different stages of degradation

0-9 cm under plastic cover	9-15 cm dry zone	15-45 cm fluctuating water levels	45-50 cm water saturation

Hydraulic parameters based on tracer experiment

Tabelle 10: Berechnete Hydraulische Parameter des reaktiven Grabens (RG) nach Daten der Tracerdurchgangskurve. Gesättigtes Volumen des RG (Vs), mittlerer Abfluss (Q), Porosität des Graben-Mediums (n), theoretische hydraulische Verweilzeit (HRT), mittlere Verweilzeit (τ), hydraulische Effizienz (λ), Short-Circuiting (S) und Morill-Dispersion-Index (MDI).

Sensor	Vs [m³]	Q [l/s]	n	HRT [h]	τ [h]	λ	S	MDI
3630	21,26	0,70	0,70	5,90	5,89	0,76	0,73	2,49
3620	21,26	0,70	0,70	5,90	7,14	0,94	0,76	2,38

$$\mathrm{HRT} = \frac{V_s n}{Q}$$

Mit:

V_s = Gesättigtes Volumen [m³]

n = Porosität des Füllmediums 0.7

Q = Abfluss [m³/h]

$$\tau = \int_0^\infty t \cdot E(t)dt$$

With tracer experiment

Mit:

t = Zeitpunkt der Messung [h]

E(t) = Wahrscheinlichkeitsdichtefunktion [h⁻¹]

dt = Messintervall [h]

Colors of wood chips at the end of the reactor after 2 years

0-9cm under plastic cover | 9-15cm dry zone | 15-45cm fluctuating water levels | 45-50 cm water saturation

Distribution of wood chip sizes

Tabelle 6: Größendefinierung der einzelnen HHS-Kategorien und ihr geschätzter, durchschnittlicher Anteil am gesamten Füllmedium.

HHS-Kategorie	Anteil am Füllmedium [%]	mittlere Oberfläche [cm^2]	mittleres Volumen [cm^3]
I	1,17	35,15	9,53
II	12,46	16,86	3,24
III	30,19	10,79	1,58
IV	56,18	4,94	0,53

Microbiology

For scientists: