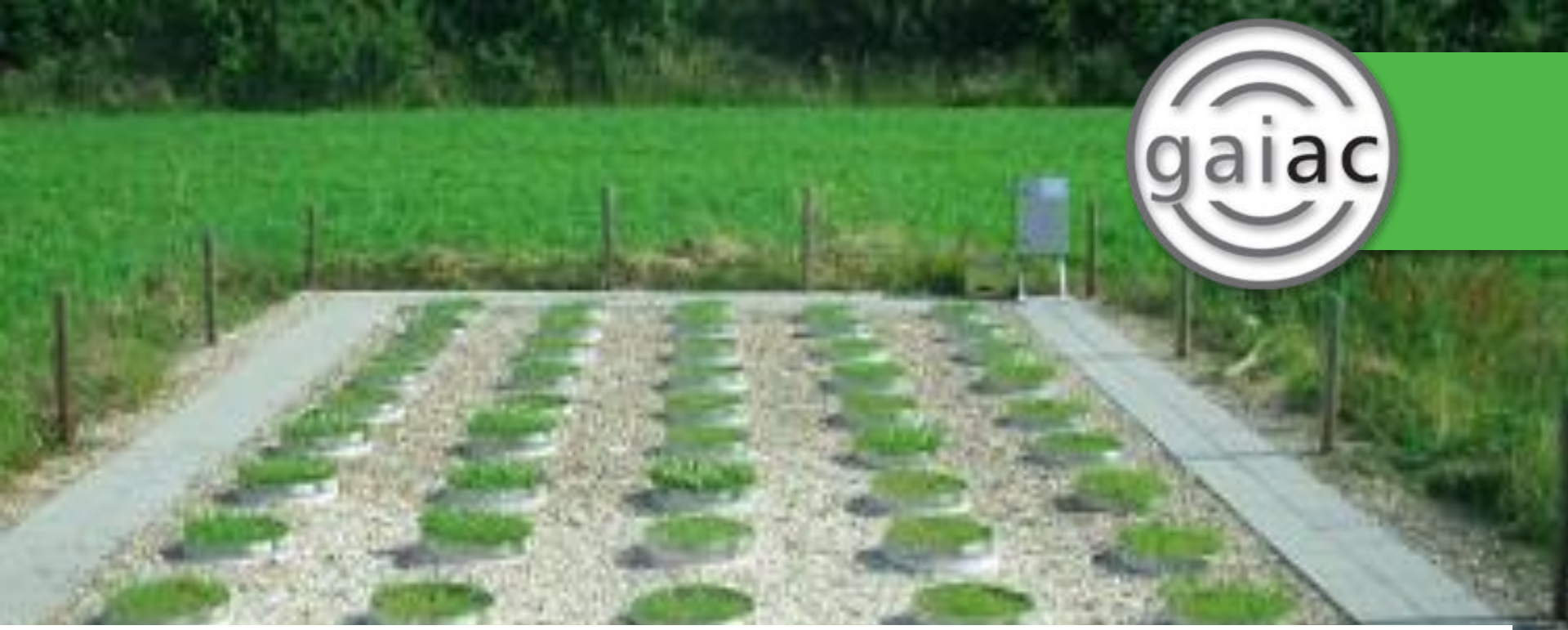

NANOMOBIL

Investigating effects of silver nanoparticles on the soil community – An outdoor TME study

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gaiac - Research Institute for Ecosystem Analysis and Assessment, Aachen, Germany

Content

Synthetic silver nanoparticles in the system soil - groundwater

POSTNOVA Leading in FFF

WP 4: Measurement technology

WP 1: **Pedosphere**
Deposition and retention behaviour in soil

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WP 2: **Biosphere**
Effects on soil and groundwater organisms

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WP 3: **Hydrosphere**
Fate and behaviour in the aquifer

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Aims of the TME study

Investigating effects of silver nanomaterials on a natural and complex soil community - focussing on the mesofauna

TME approach ▪ chronic exposure (1 yr)▪ relevant silver nanoparticles ▪ two different AgNP ▪ environmentally relevant concentrations ▪ collembolans, orbatid mites and earthworms ▪ established methods for sampling, extraction and determination

Data basis - Effect data on soil organisms

agpure – data from lab test

Mortality of earthworms

Lumbricus terrestris:	LC50 334 mg Ag/kg
Eisenia fetida:	LC50 649 mg Ag/kg

Reproduction of collembolans

Folsomia candida	NOEC > 100 mg Ag/kg

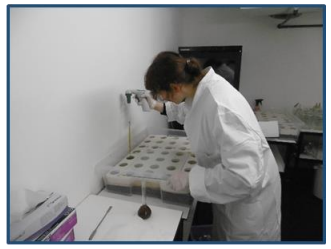
Lab pre-test on soil community - Methods

Sampling

- Natural grassland (Northern Eifel, Germany)
- 70 soil cores (5 cm diameter, 5 cm height)
- April 2016

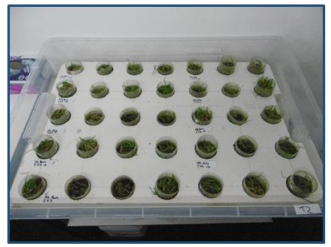
Application

- AgPURE: 5 concentrations, 3 replicates
  3.3/ 10/ 33/ 100/ 330 mg Ag/kg
- $AgNO_3$: 4 concentrations, 3 replicates
  3.3/ 10/ 33/ 100 mg Ag/kg (tox. ref.)
- Control: n = 8



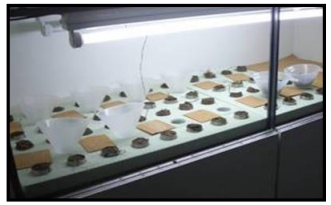
Incubation

- laboratory conditions (20° C)
- T1: 14 d, T2: 28 d



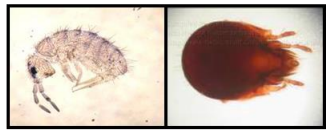
Extraction

- MacFadyen extractor, 14 d (ISO 23611-2)
- temperature and moisture gradient

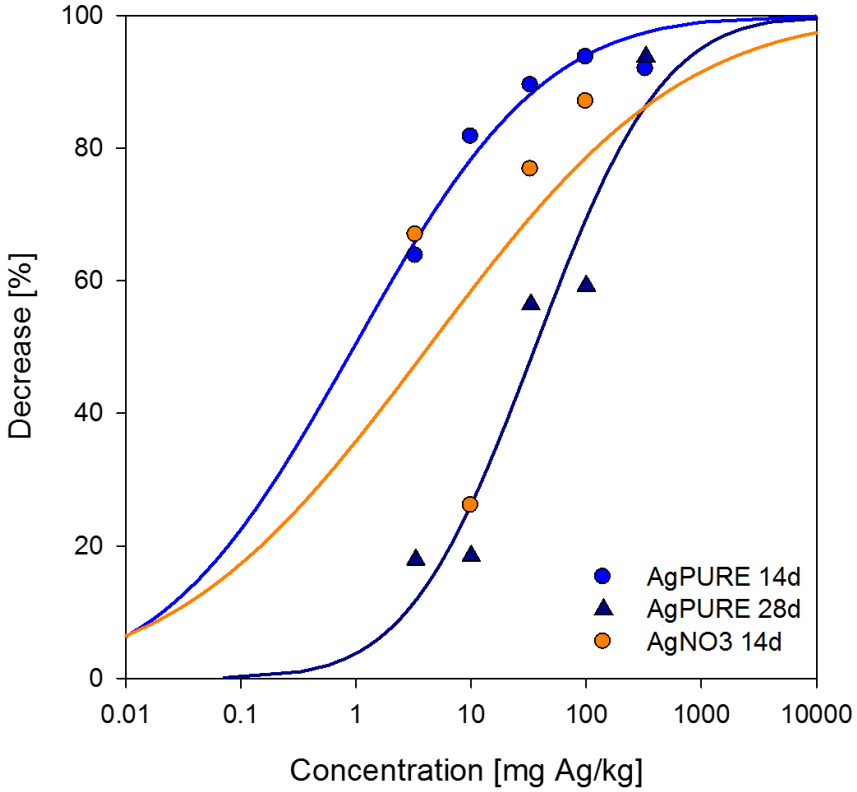


Determination

- Collembola and Oribatida
- Counting and determination to species level



Collembolans – effects on total number



	after 14 days		
Treatment	EC50 [mg Ag/kg]	NOEC [mg Ag/kg]	LOEC [mg Ag/kg]
AgPURE	0.96	3.3	10
$AgNO_3$	4.26	33	100
	after 28 days		
Treatment	EC50 [mg Ag/kg]	NOEC [mg Ag/kg]	LOEC [mg Ag/kg]
AgPURE	36.1	100	330
$AgNO_3$	n.d.	33	100

Oribatid mites

- Decreased number in silver treatments after 14 days, but no clear dose-response relationship for agpure

TME outdoor study – Test design

Silver nanoparticles

- **agpure W10** (ras materials GmbH, ø 10 nm)
- **PVP coated AgNP** (Silver (10 wt%) nanopowder, NanoAmor, ø 20 nm, Stock #: 7023HZ)

Reference substance

$AgNO_3$ as reference (only highest test concentration)

Test concentrations

- **1 mg Ag/kg**
- **10 mg Ag/kg**

Replicates

- 10 control TME
- 5 replicates per silver treatment

Application method

- Spray application on the soil surface
- Sprinkler irrigation directly after application

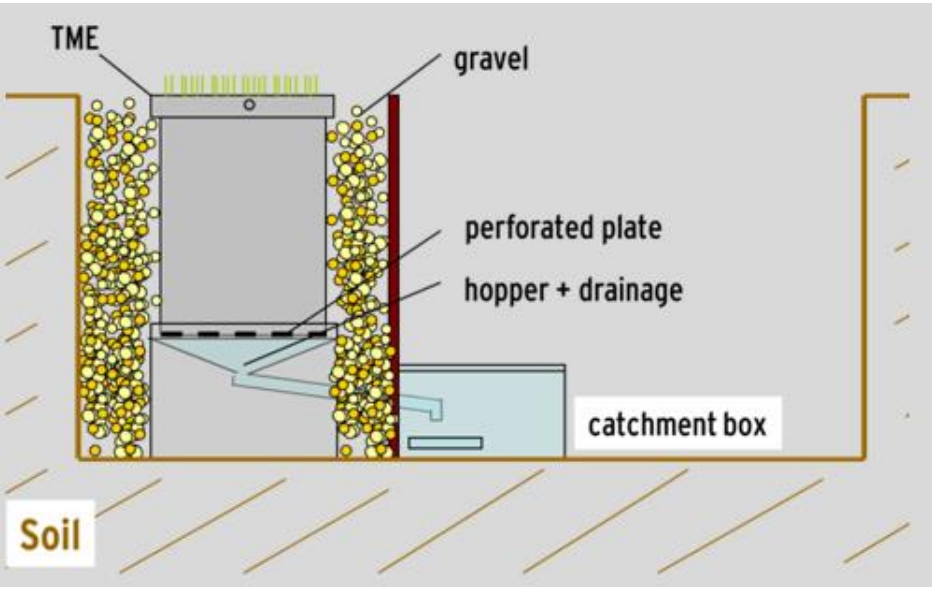
TME outdoor study – Time schedule

	Action	Date
	**Coring of soil cores** TME (ø 46cm, 40 cm high) in undisturbed, natural grassland (Northern Eifel, Germany) **Insertion of soil cores** into the test facility (Aachen, Germany)	18.05.2016
	**Application** Spray application on the soil surface	01.06.2016
	**Sequential sampling of microarthropds in soil cores and pitfall traps (5 times)** after 14 days after 28 days after 3 months after 6 months after 12 months	 15.06.2016 29.06.2016 31.08.2016 01.12.2016 31.05.2017
	Destructive sampling of earthworms in different soil layers via manual sorting (one sampling at the end of the study)	31.05.2017

TME outdoor study – Measurement of percolate water

Sampling of percolation water in two separate TME (1yr)

Treated with 10 mg Ag/kg of agpure or AgPVP



TME outdoor study – Endpoints

Microarthropods (5 observation times):

- Collembolan species/ taxa (40 taxa) in soil cores
- Collembolan species/ taxa (40 taxa) in pitfall traps
- Oribatid mite species/taxa (20 taxa) in soil cores

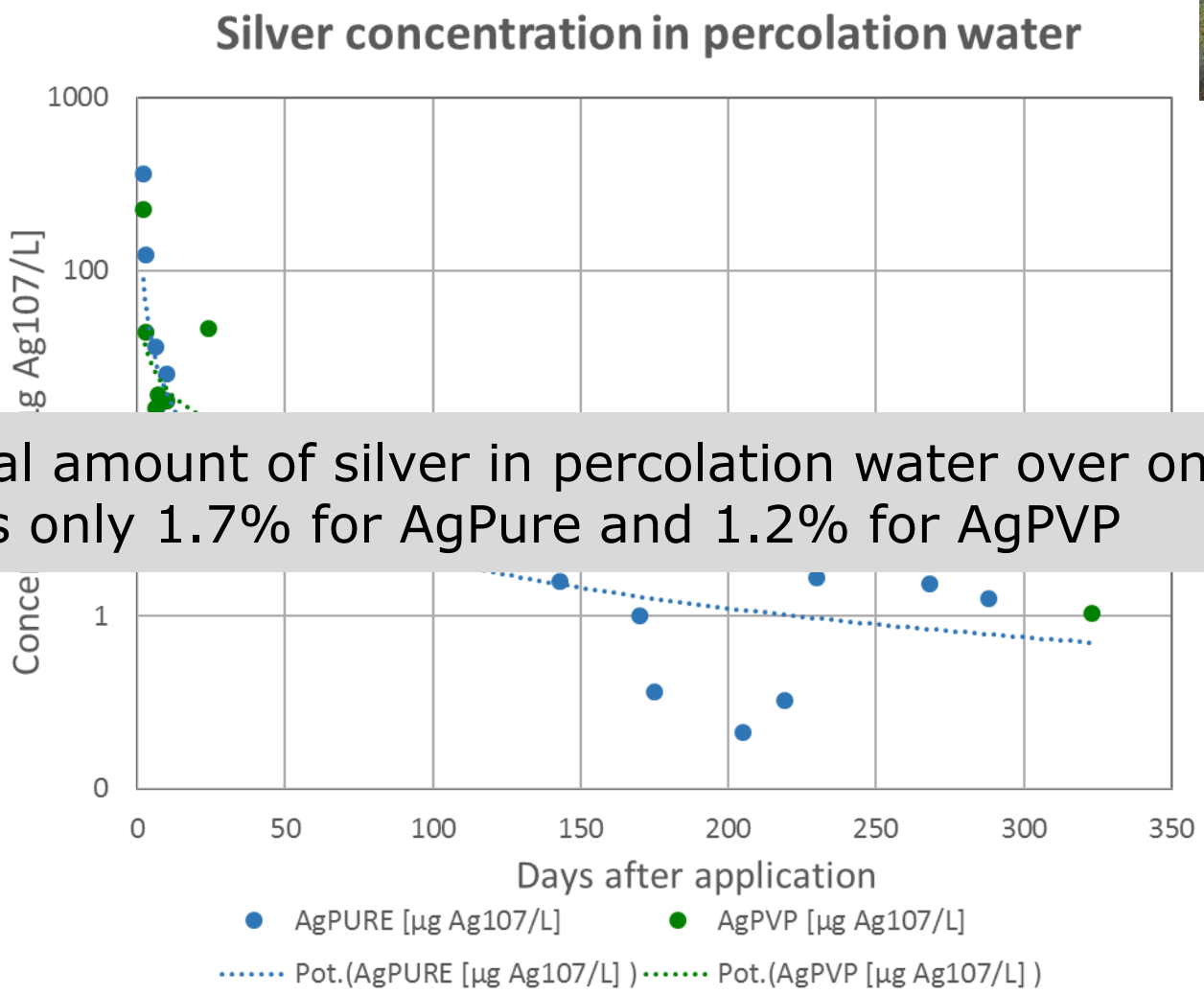
Earthworms (after 1 year):

- Earthworm species/taxa (6 taxa) in different soil layers

Percolation water (two separate TME):

- Silver concentration in percolation water over 1 yr

TME outdoor study – Results percolation water



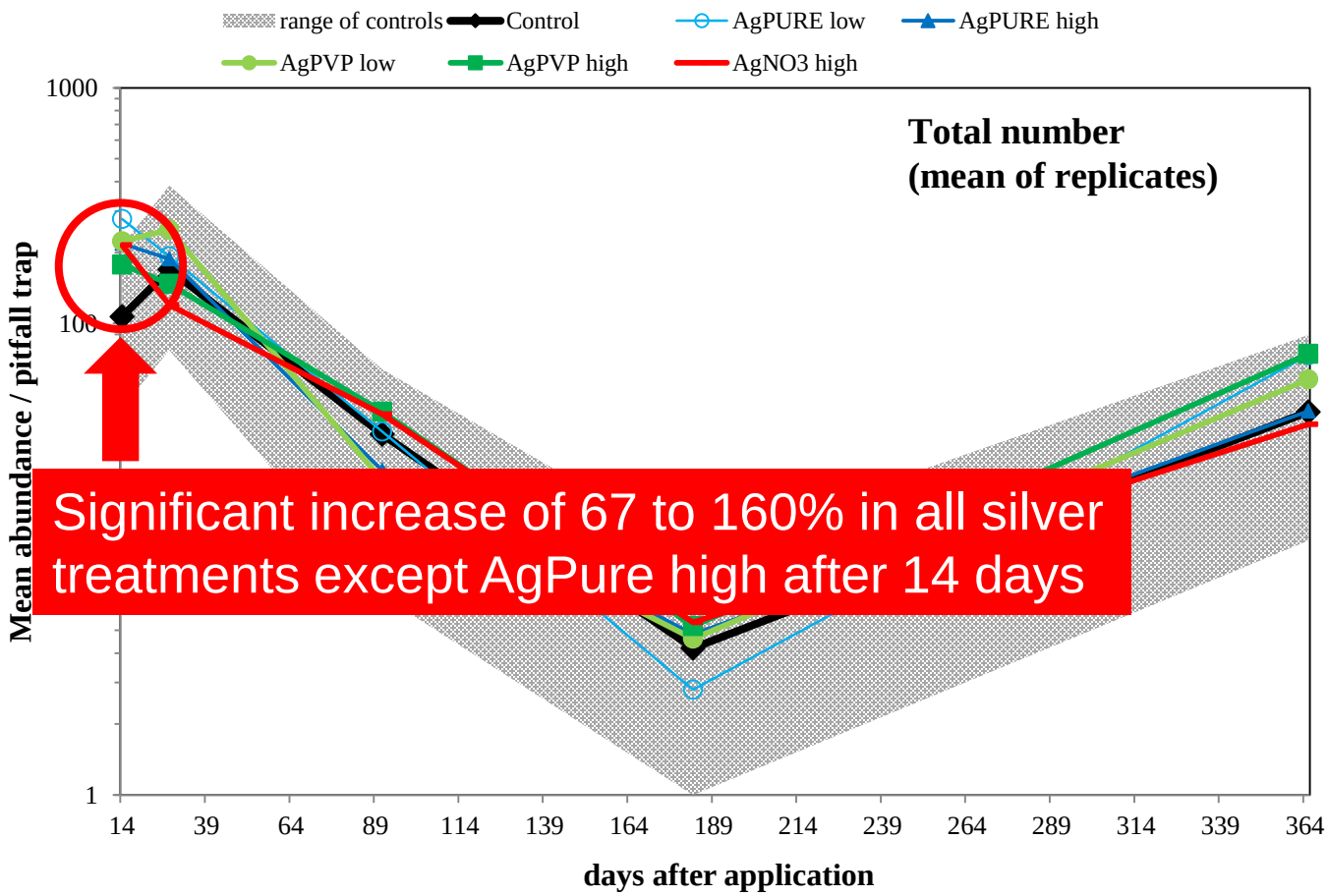
Total amount of silver in percolation water over one year was only 1.7% for AgPure and 1.2% for AgPVP

TME outdoor study – Results

Direct effects on earthworm behaviour after application in all silver treatments

TME outdoor study – Results

Collembolans in pitfall traps



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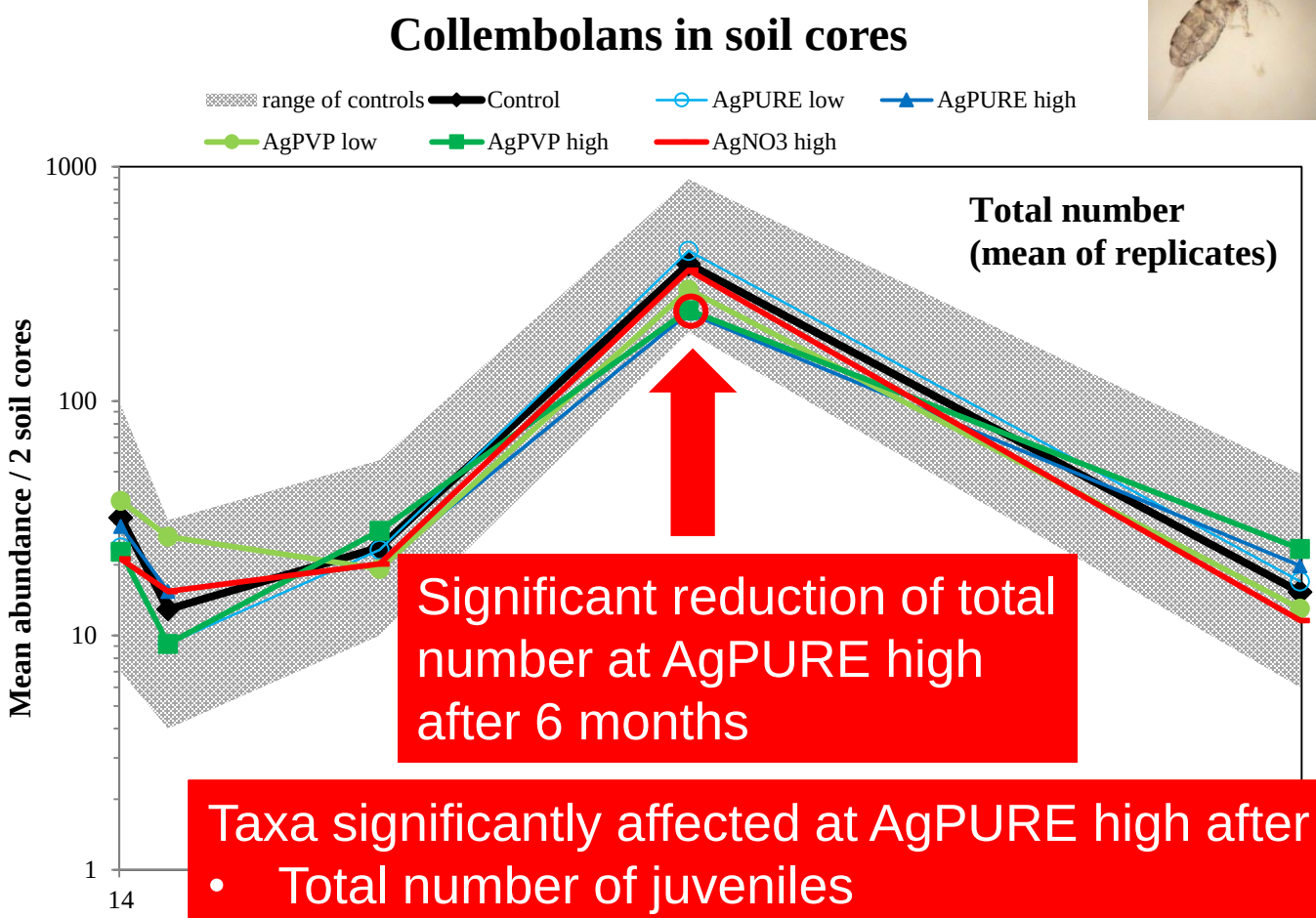
TME outdoor study – Results

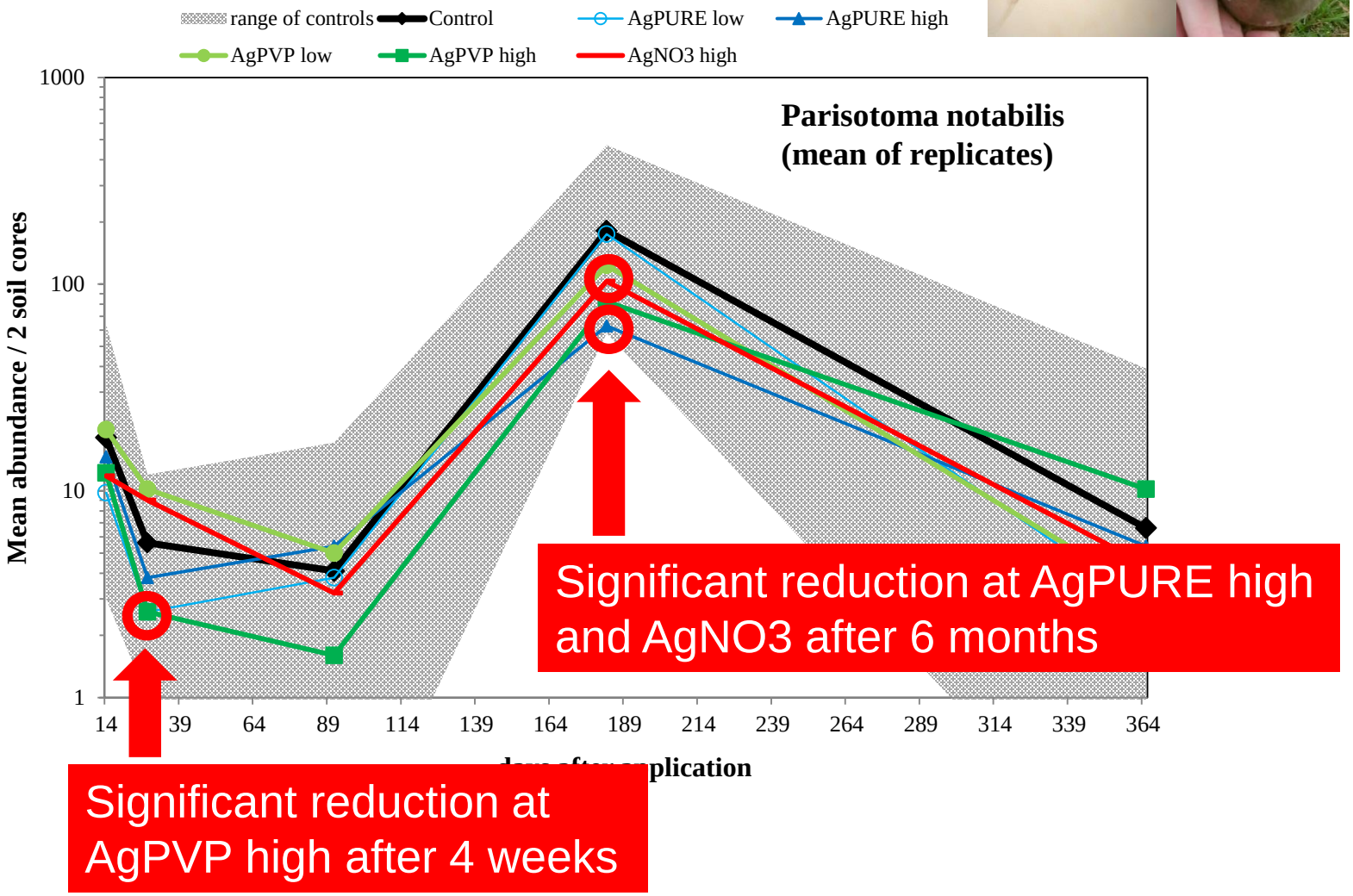


Significant reduction of total number at AgPURE high after 6 months

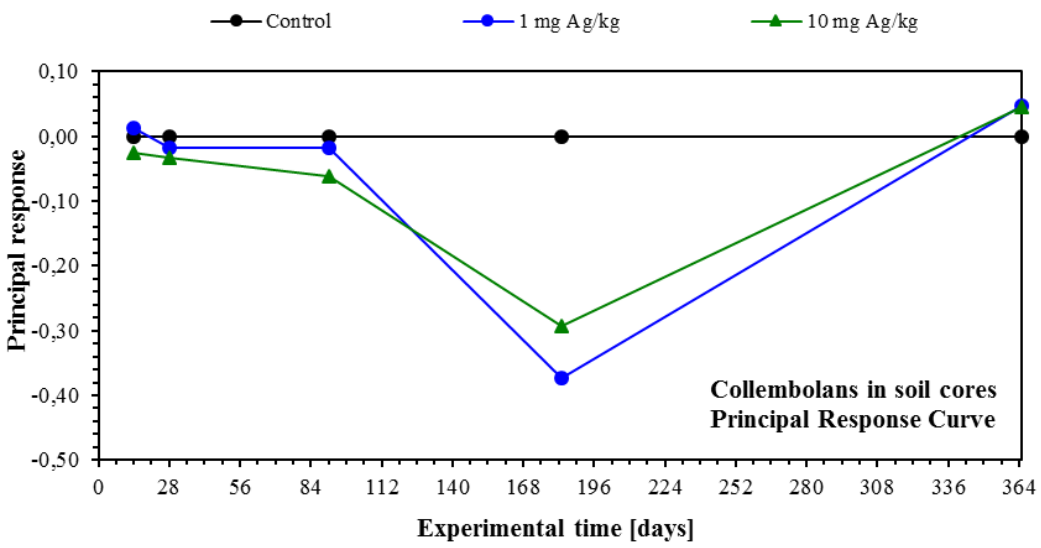
Taxa significantly affected at AgPURE high after 6 month:

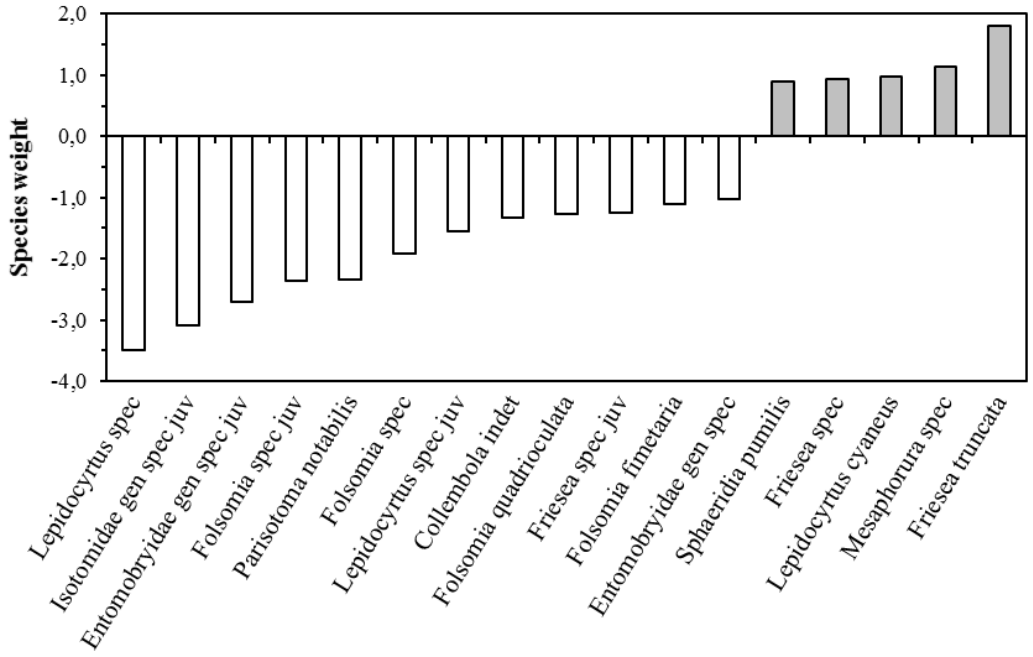
- Total number of juveniles
- Total number of Entomobryomorpha
- *Folsomia* spec. juveniles
- *Lepidocyrtus lanuginosus*
- *Parisotoma notabilis*

TME outdoor study – results



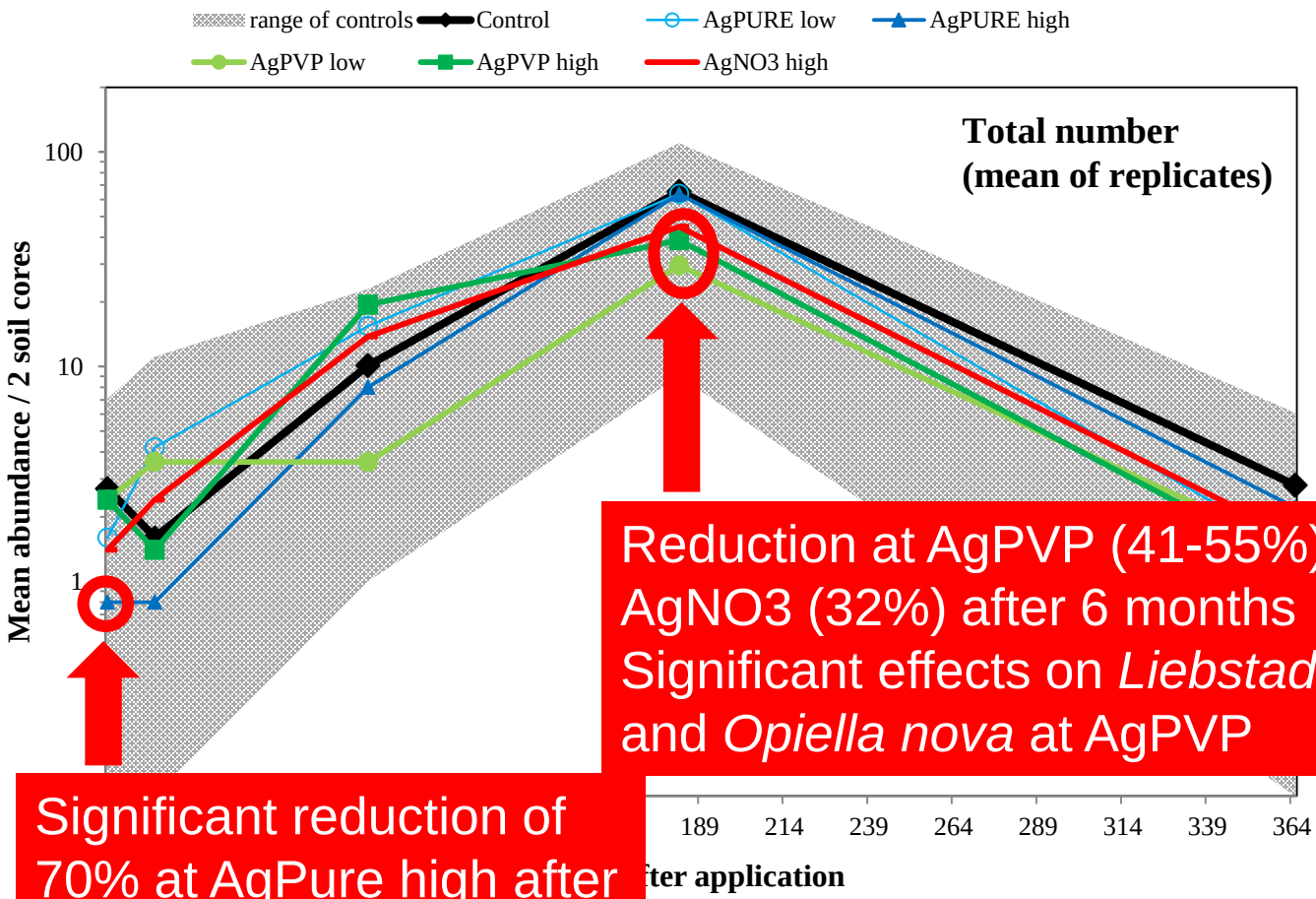
TME outdoor study – Community response





TME outdoor study – results

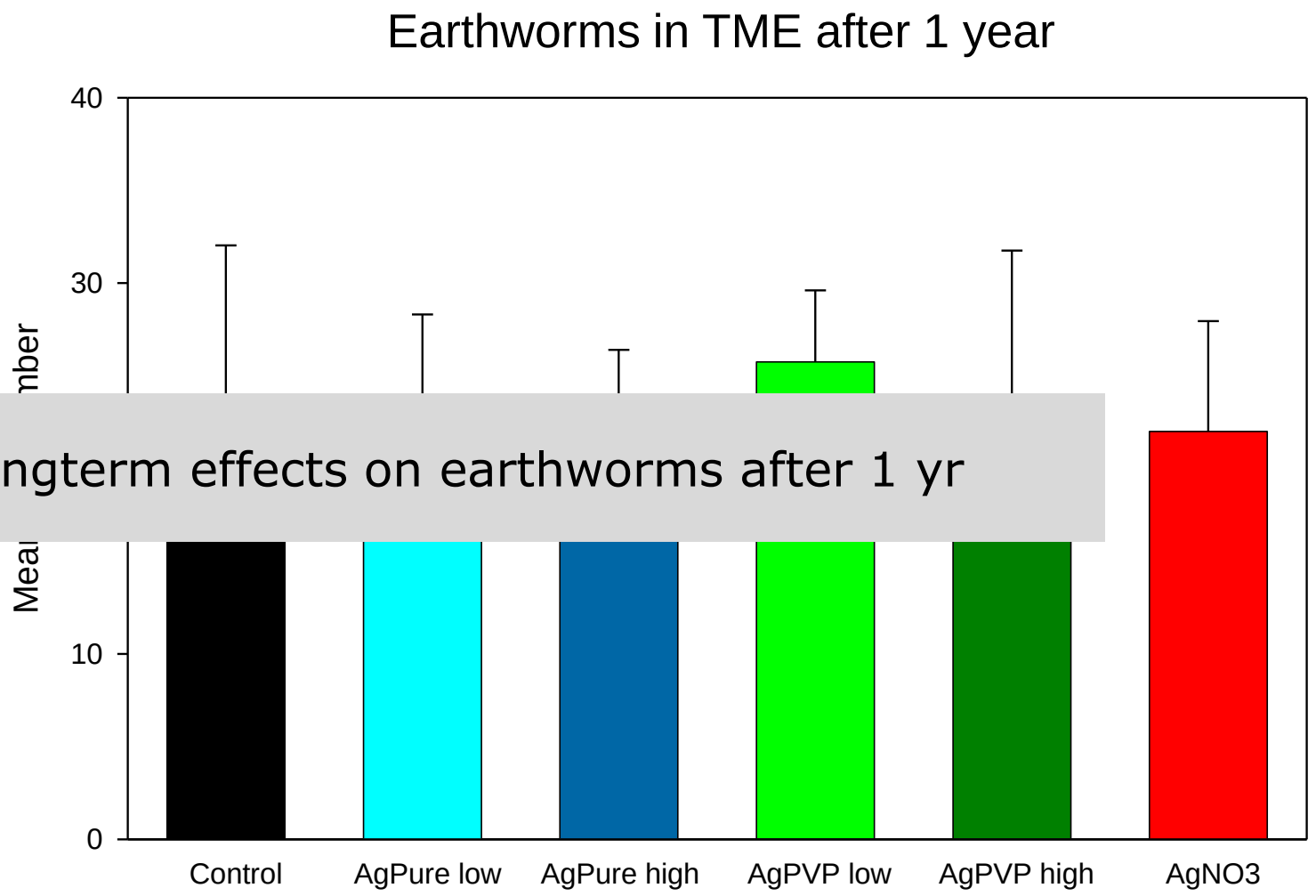
Oribatid mites in soil cores



Reduction at AgPVP (41-55%) and AgNO3 (32%) after 6 months
Significant effects on *Liebstadia similis* and *Opiella nova* at AgPVP

Significant reduction of 70% at AgPure high after 2 weeks

TME outdoor study – results



No longterm effects on earthworms after 1 yr

TME outdoor study – Summary

- Detection of silver in the percolation water of AgNP treated TME, but total amount was only 1.2 to 1.7%
- Direct effects on earthworm behaviour and increased mobility of collembolans on the TME surface (significant increase in pitfall traps after 14 days)
- Long-term effects after 6 months on collembolans in soil cores and oribatid mites in soil cores
- No indications of long-term effects on earthworms after 1 yr

TME outdoor study – Conclusions

- Long-term effects of silver nanoparticles on the soil mesofauna could be demonstrated
- Especially the juveniles among the collembolans were the sensitive groups
- Lab test with single species as representatives were not able to predict the long-term effects

Many thanks to…

- Our partners in the NanoMobil project
- My colleagues involved in the project

- The BMBF for sponsoring the project

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