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Die Ressourcenuniversität. Seit 1765.

ZIRKON

Interaction Between Tire Wear Particles and Aquatic Plants: Toxicity and Root-Mediated Transport

Europäische Union
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ESF Europäischer Sozialfonds
Freistaat Sachsen

Diese Maßnahme wird mitfinanziert durch Steuermittel auf der Grundlage des vom Sächsischen Landtag beschlossenen Haushaltes.

Workshop „Tire Wear in the Environment“ 28th November 2024

M.Sc Jennifer Dutschke and M.Sc. Anne Richter

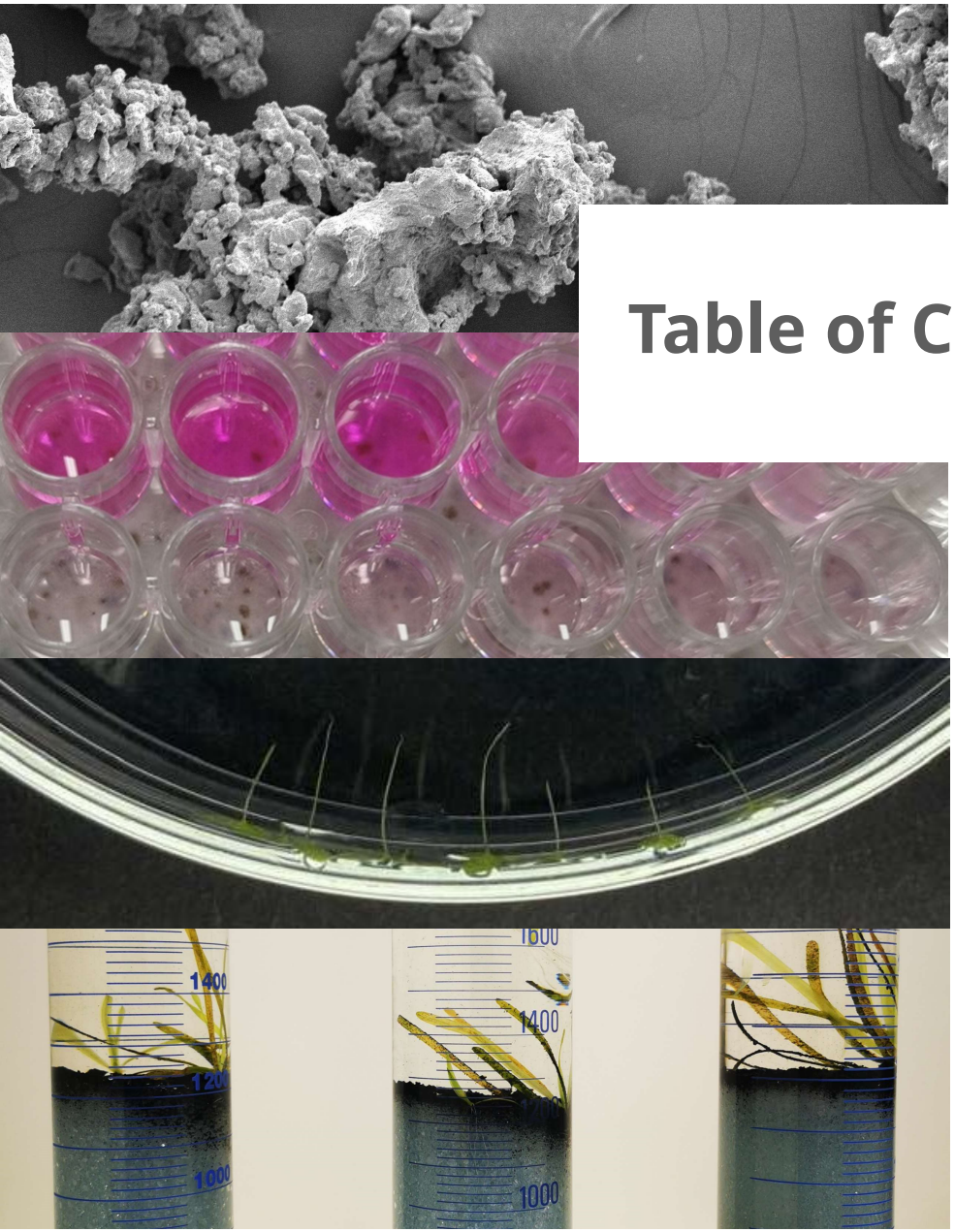

Table of Contents

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Note:
Some slides containing unpublished data have been removed from this presentation. Thank you for your understanding.

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Overview

- Aim: Investigating the effects of tire wear on plants in road-side ecosystems
- Focus on aquatic fresh water plants → important role for infiltration of surface waters into ground water
- Design and realisation of two different experiments
  - Ecotoxicity test with *Lemna minor* (duckweed)
  - Bioturbation with *Vallisneria spiralis* (tape grass)

Tire Wear Particles

- Due to heat and friction during driving the tire material chemically changes → tire wear is different from original tire
  - Problem: where to get authentic tire wear particles (TWP) for experiments?
- Automotive company provided abraded tire particles from car and truck tires → not authentic, but available in large quantities
- For more authenticy particles were artificially aged (according DIN EN ISO 4892)
  - Aging was done in a climate chamber with variable humidity, temperatur and lighting

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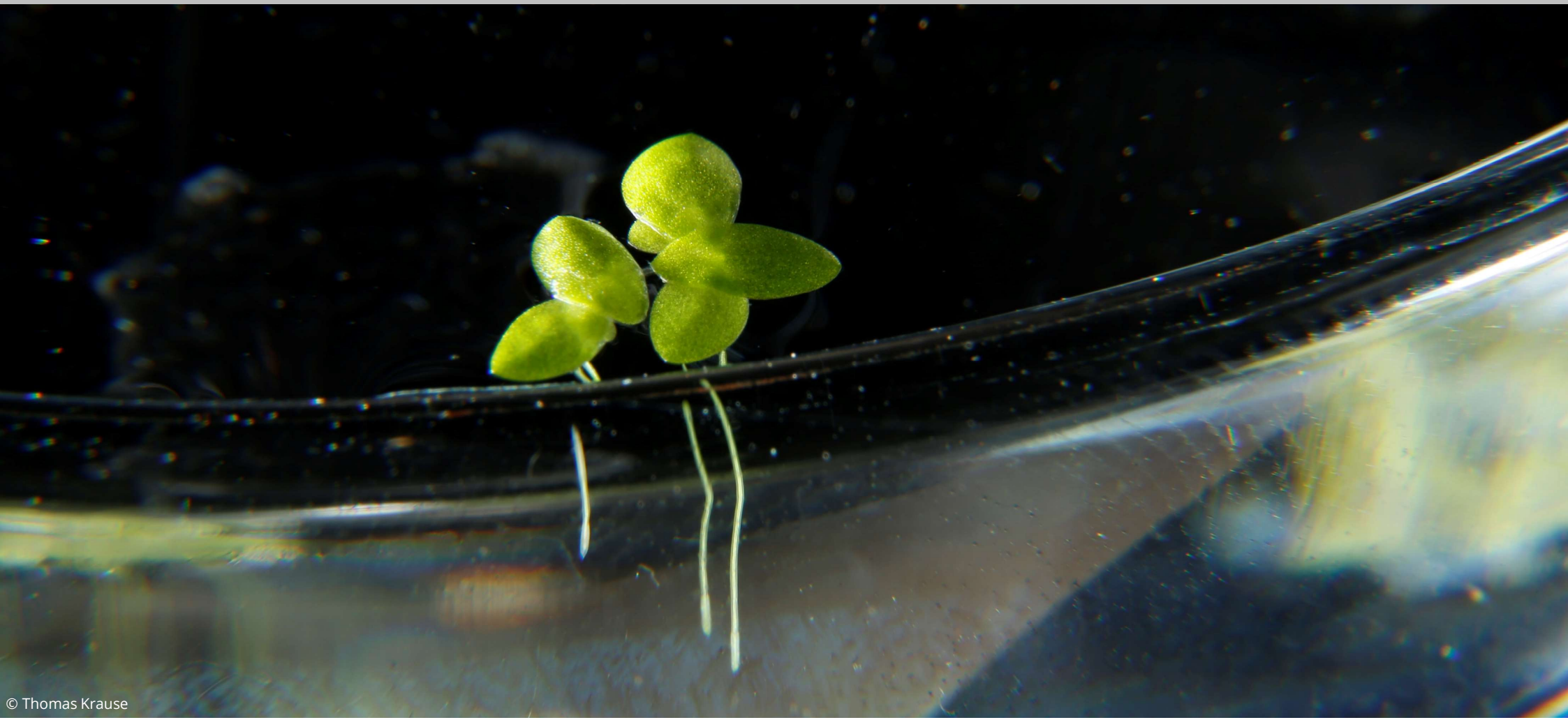
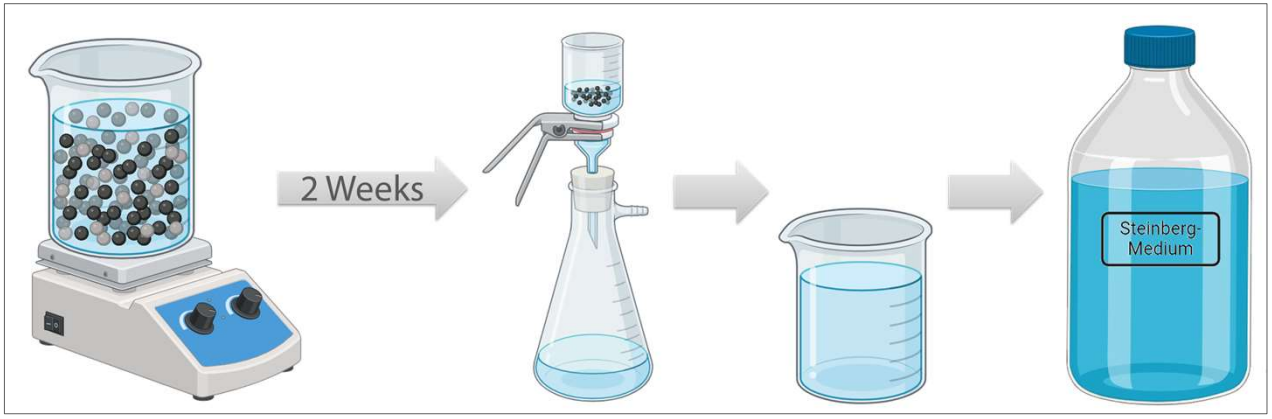
Ecotoxicity Test with *Lemna minor*



Ecotoxicity Test with *Lemna minor*

- **Test organism**: *Lemna minor* (Duckweed)
  - Advantages: fast growing, worldwide distribution, established model organism for toxicity tests, standardized cultivation and test procedures (DIN EN ISO 20079)
- **Problem:** Duckweed swims on the surface of water, but most tire wear particles sink to the ground
  - Solution: Use of leachates from aged tire wear particles

- **Leaching:**
  - Particles were shaken in water for 2 weeks
  - 2 scenarios + control group
    - Control (K) (TWP-)
    - S4: 100 mg/L TWP
    - S5: 500 mg/L TWP



Generation of leachates for ecotoxicity testing (Figure created with BioRender).

Ecotoxicity Test with *Lemna minor*

Experimental Set-up

- Experiment conducted in aquariums in a climate chamber (constant conditions)
- 16 plants were placed in taped glass dishes with 150 mL of Steinberg Medium
- Duration = 15 days (sampling on day 1, 4, 8 and 15)
- Two different kinds of vessels:
  - **Observation vessels**
    - No plants removed, 4 replicats per scenario constantly observed → determination of growth rate
  - **Withdrawal vessels**
    - Plants removed for measurements, 4 replicats per scenario and day were sacrificed
- During each sampling stress markers were measured

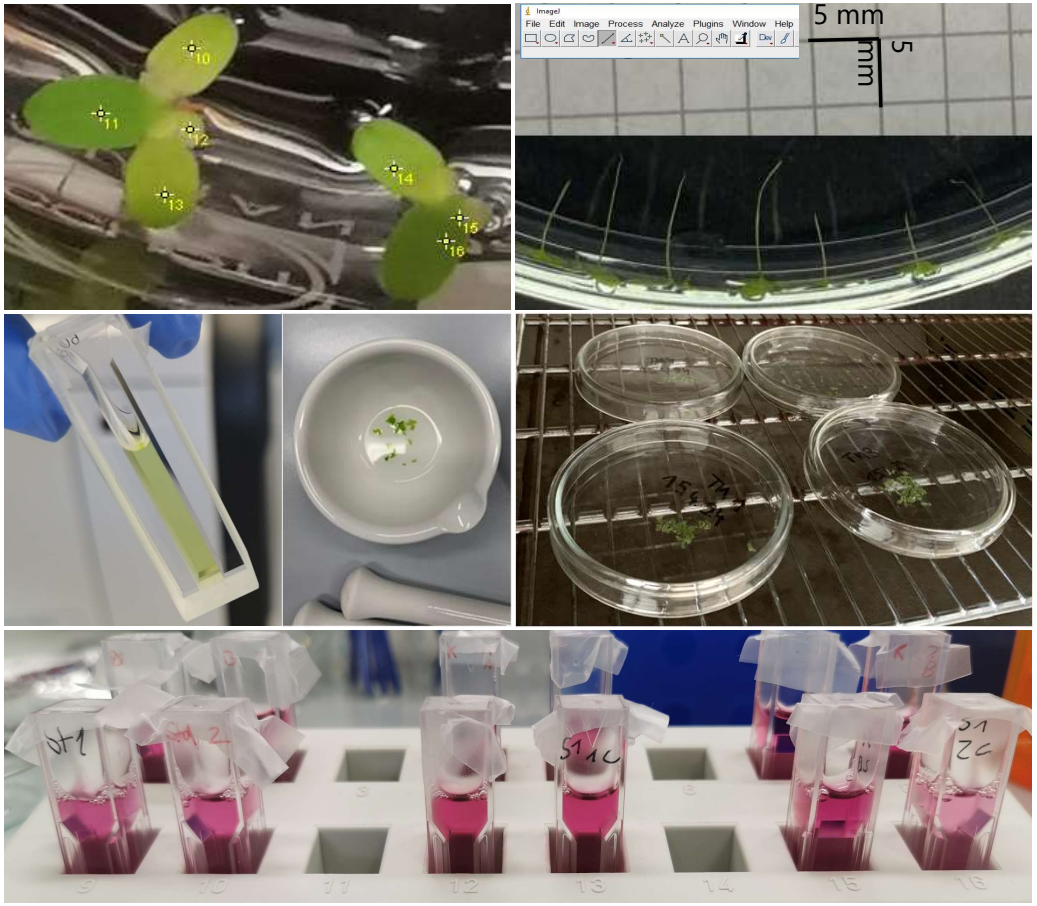
Oberservation vessel over the course of the experiment.

Experimental set-up for one scenario.

Ecotoxicity Test with *Lemna minor*

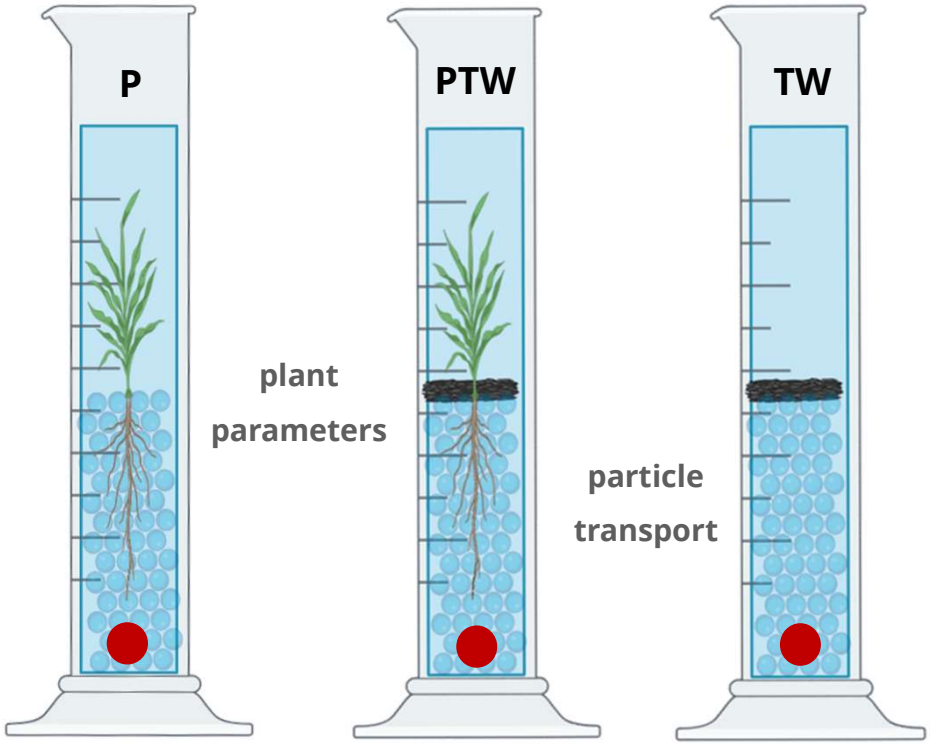
Stress markers

- Morphological/Physiological
  - Frond number → growth rate
  - Root length
  - Chlorophyll content
  - Dry weight
- Biochemical
  - Catalase activity
- Further measurements
  - pH, temperature, conductivity



Bioturbation with *Vallisneria spiralis*

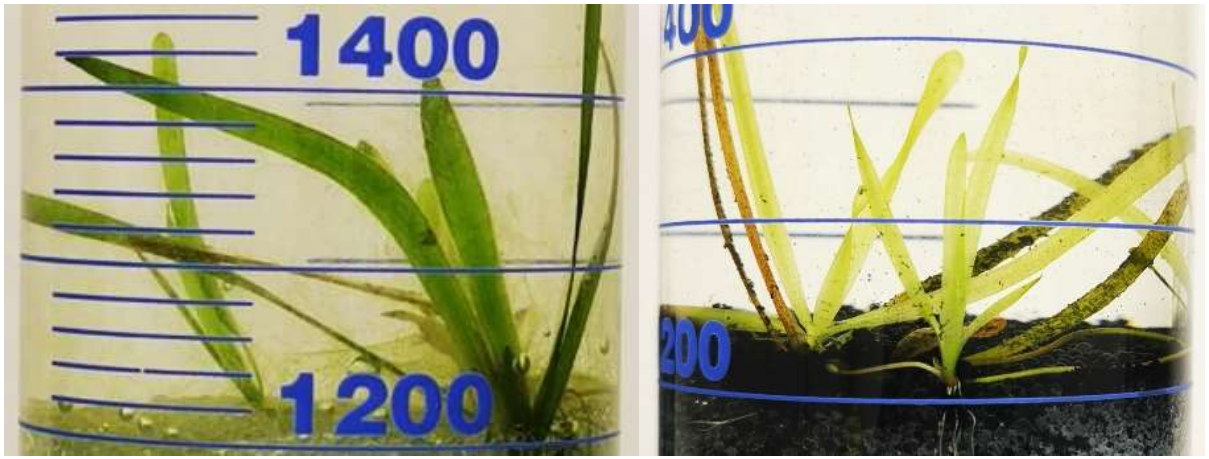
- **Test organism**: *Vallisneria spiralis* (tape grass)
- **Aim:** Investigation of the transport of TWP by plant roots
- **Experimental set-up**
  - 3 scenarios, 50 days
  - 2-liter glass cylinder, root area darkend
  - Fertilizer pellet at the bottom to stimulate root growth
  - Parent plant was placed and left to settle, then TWP were introduced
- **Hypothesis (particle transport)**
  - Parent plant forms offshoots which then move TWP through the substrate



Scenarios for Bioturbation experiment, 3 replicates each, substrate: glass beads (d= 1-2 mm); c_{TWP} = 1 g/ kg substrate; ~ 500 mg/ L medium) (vgl. Wagner et al. 2018).

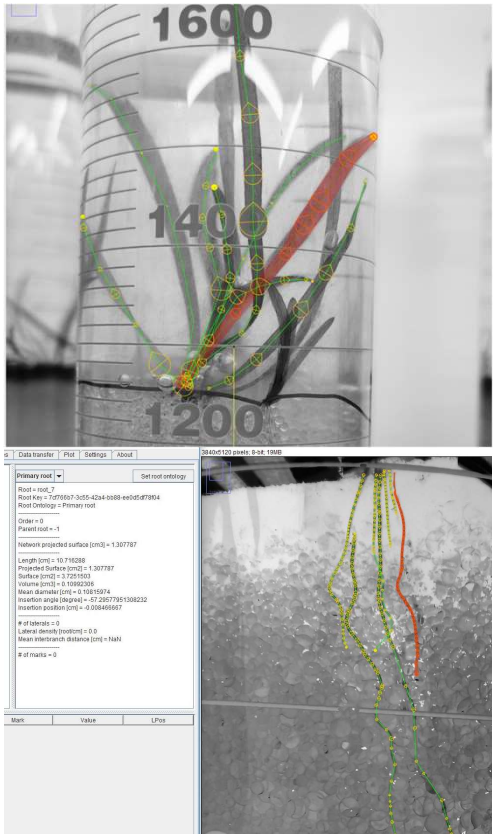
Bioturbation with *Vallisneria spiralis*

- **Plant Growth - General Observations**
  - Plants exposed to TWP (c_{TWP} = 1 g/ kg substrate; ~ 500 mg/ L medium) produced fewer offshoots and the leaves faded in color over time
  - TWP appeared to reduce algae growth



Bioturbation with *Vallisneria spiralis*

- **Plant Parameters – Root and Leaf Length**



Meassurement of root and leaf length in ImageJ (SmartRoot)

TWP adhering to roots.

References

- Rozman, Ula; Turk, Tilen; Skalar, Tina; Zupančič, Marija; Čelan Korošin, Nataša; Marinšek, Marjan et al. (2021): An extensive characterization of various environmentally relevant microplastics - Material properties, leaching and ecotoxicity testing. In: The Science of the total environment 773, S. 145576. DOI: 10.1016/j.scitotenv.2021.145576.
- Wagner, Stephan, et al. "Tire wear particles in the aquatic environment-a review on generation, analysis, occurrence, fate and effects." Water research 139 (2018): 83-100.