



# Problem 7: Worms

Reporter: Team Switzerland

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Earthworms change the mechanical properties of soil and make the soil more porous. Investigate this process and introduce quantitative parameters.

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**Earthworms** change the mechanical properties of soil and make the **soil more porous**. Investigate this process and introduce quantitative parameters.

→ over time: measure and analyze the variation in porosity

# Digestive system of a worm



mouth

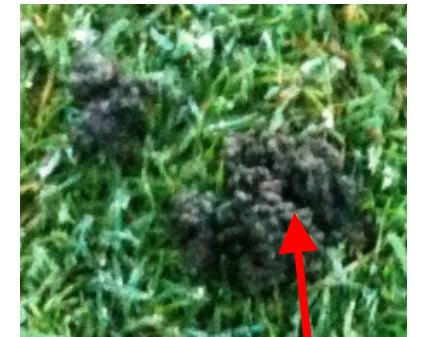
pharynx

esophagus

crop


gizzard

intestines

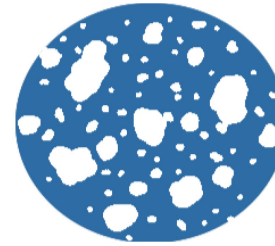


castings

# Mechanical Properties of Soil

Composition: soil = solids + liquids + gases 

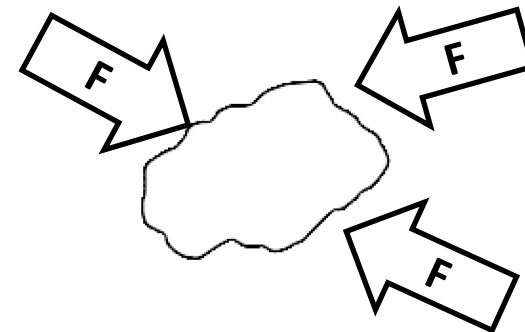
Porosity:  void spaces per total volume



Compaction:  soil per total volume

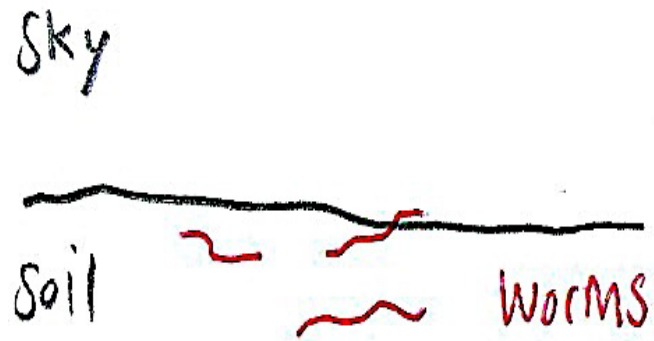


Strength:  resistance to deformation



**impact of worms in soil**

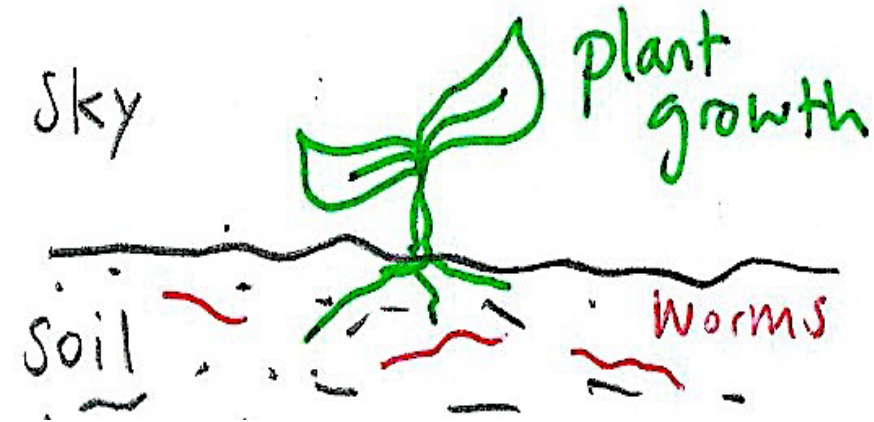
# Phenomenon



dig tunnels

eat and digest soil

leave castings

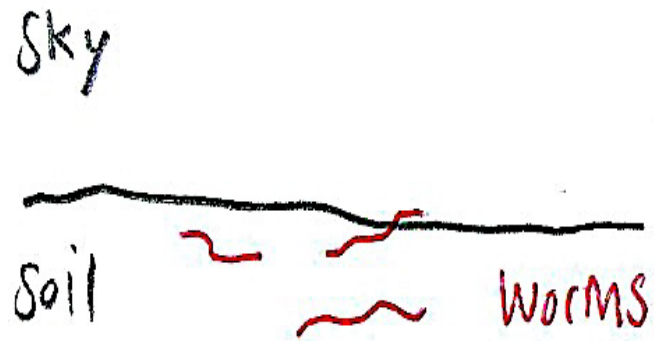


→ more pores, more air flow

→ rearranging soil

→ add nutrients

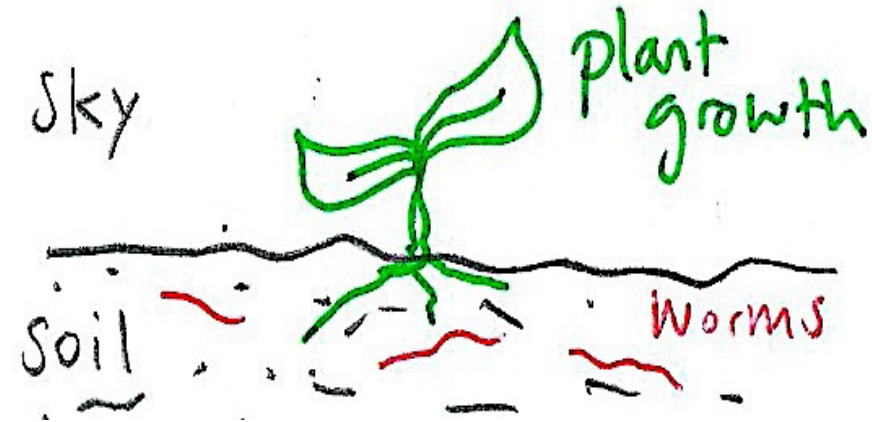
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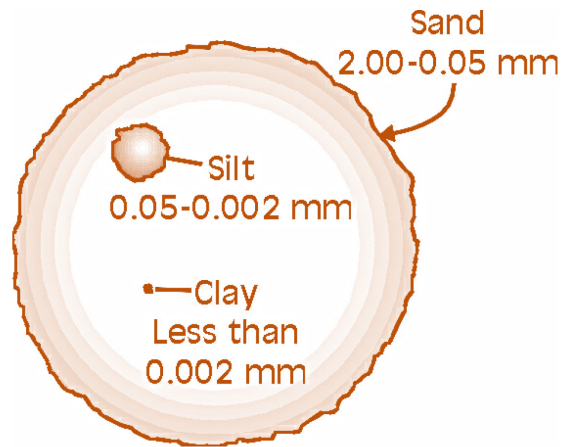
→ **more pores**, more air flow

→ rearranging soil

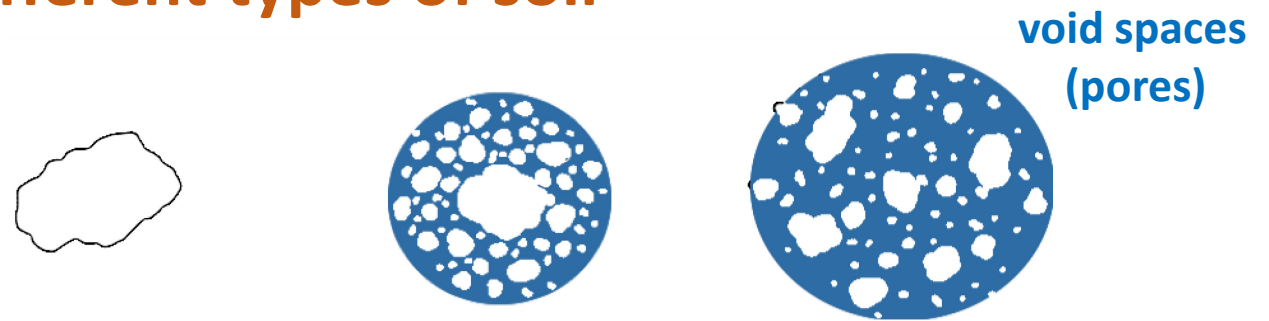
→ add nutrients

# Definition of Porosity

## soil particles



## different types of soil



$$\text{Porosity} = \frac{\text{volume of pores between particles}}{\text{total volume}}$$





# Method 1: Measuring porosity of soil

$V_S$  = volume of solids

$V_p$  = volume of pores

$V_T = V_S + V_p$  = total volume

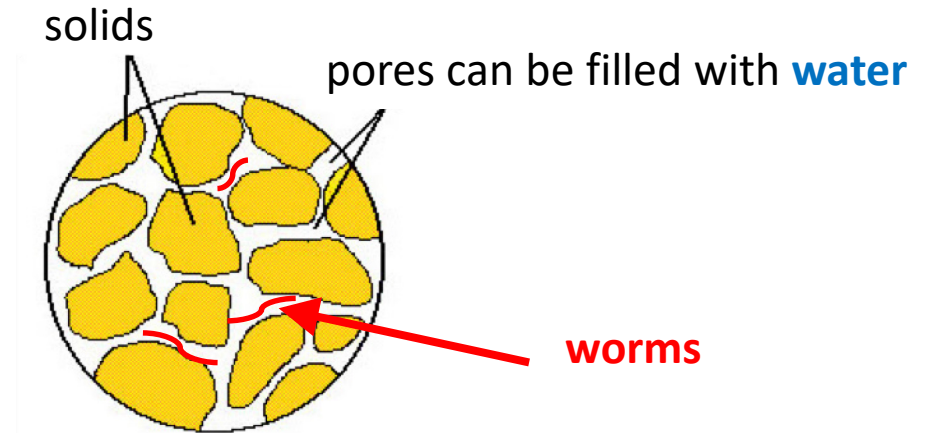
$$P = \frac{V_P}{V_T} = \text{porosity}$$

$$P = \frac{V_L}{V_T}$$

$V_L$  = volume of **water** it can hold

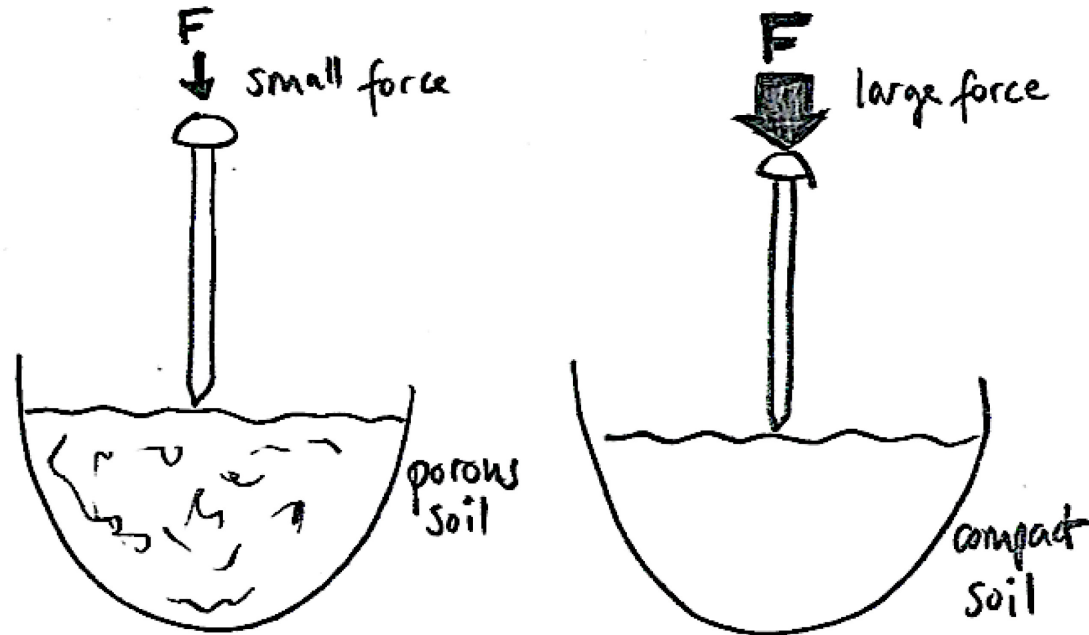
$$P = \frac{V_L + V_W}{V_T}$$

$V_W$  = volume of **worms**

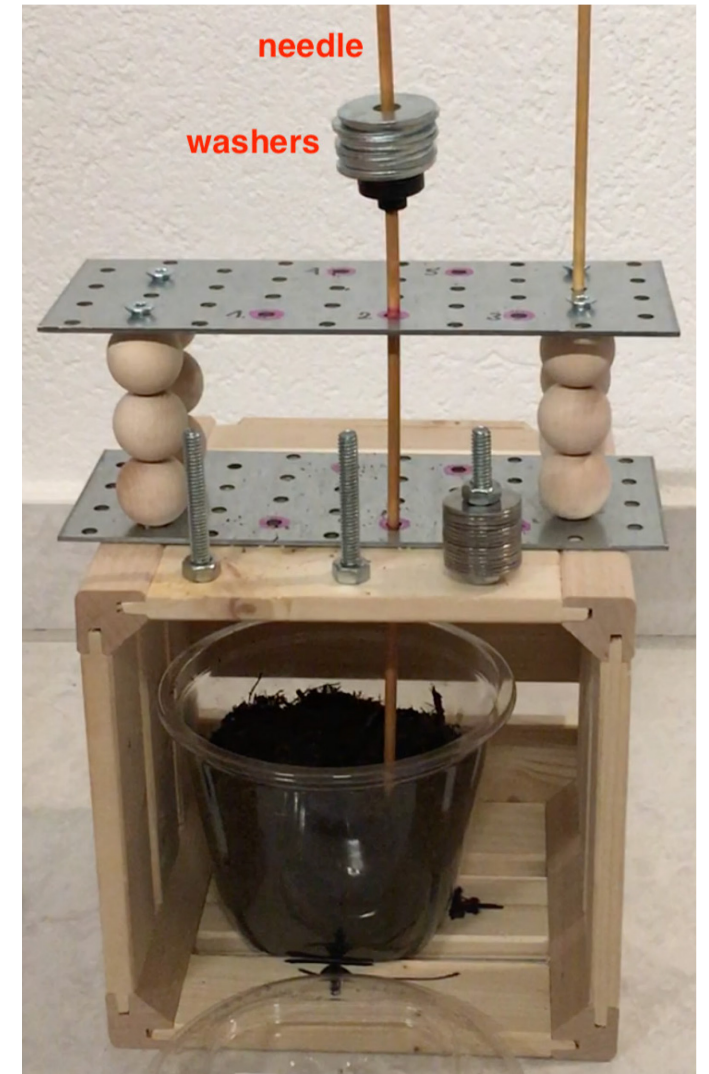


# Method 2: Measuring porosity of soil

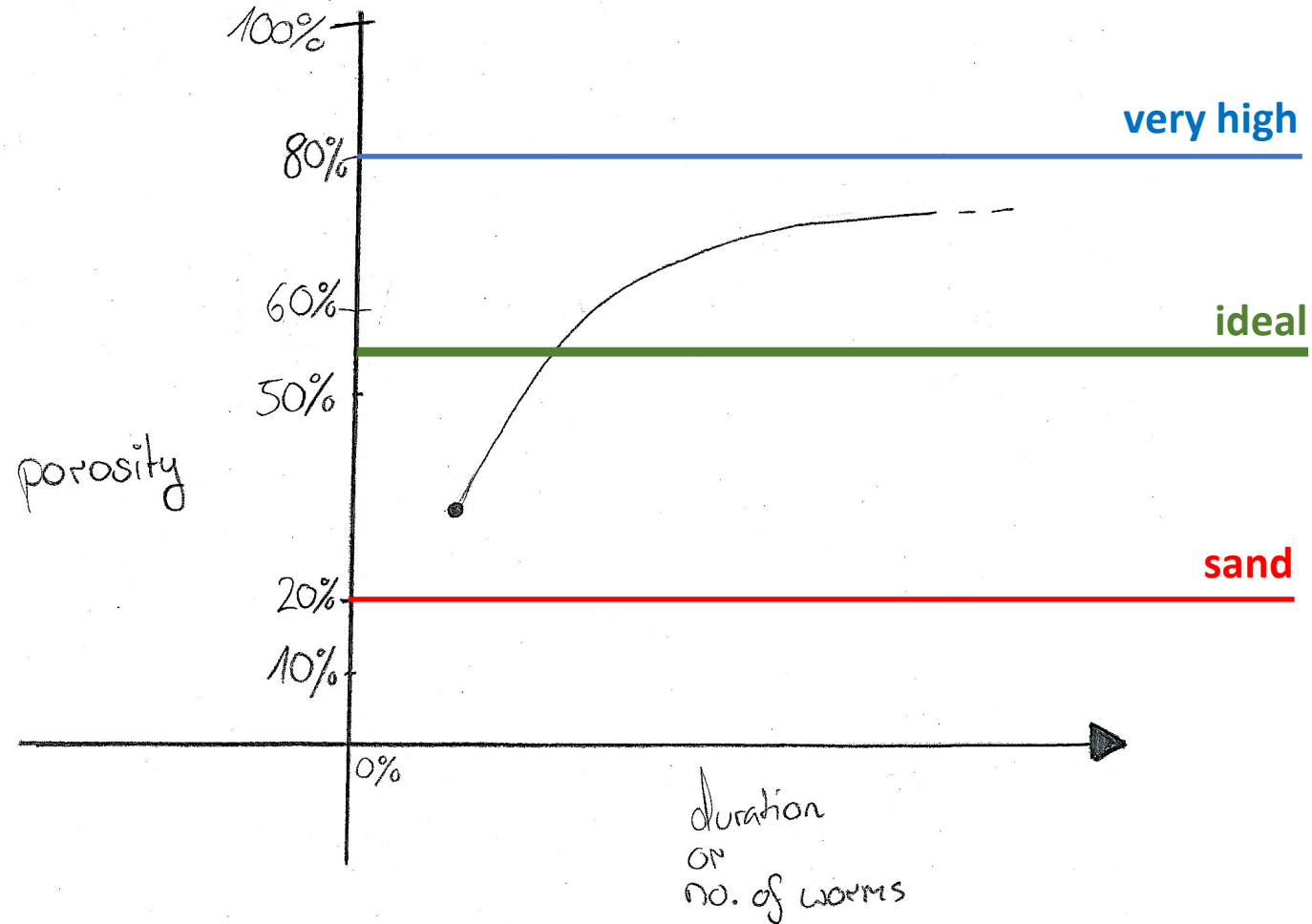
Pushing  
needle  
into soil



my machine to measure **force**



# Hypothesis: Impact of worms on soil properties



# Experiments

## Parameters

- **number** of worms in soil
- **duration** of observation in days

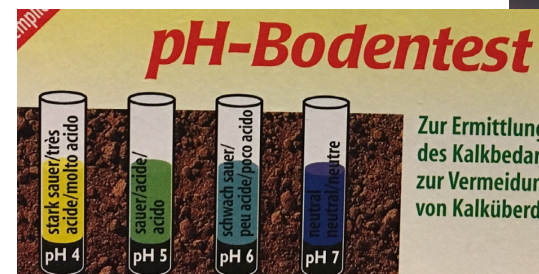
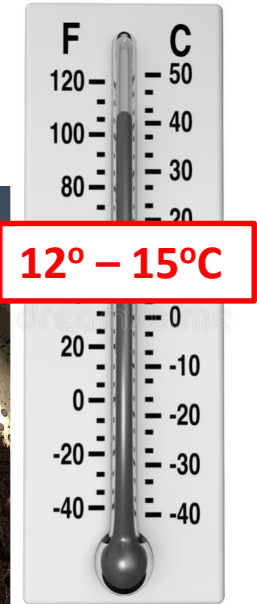
## Measured variables

- **water** added
- **force** applied

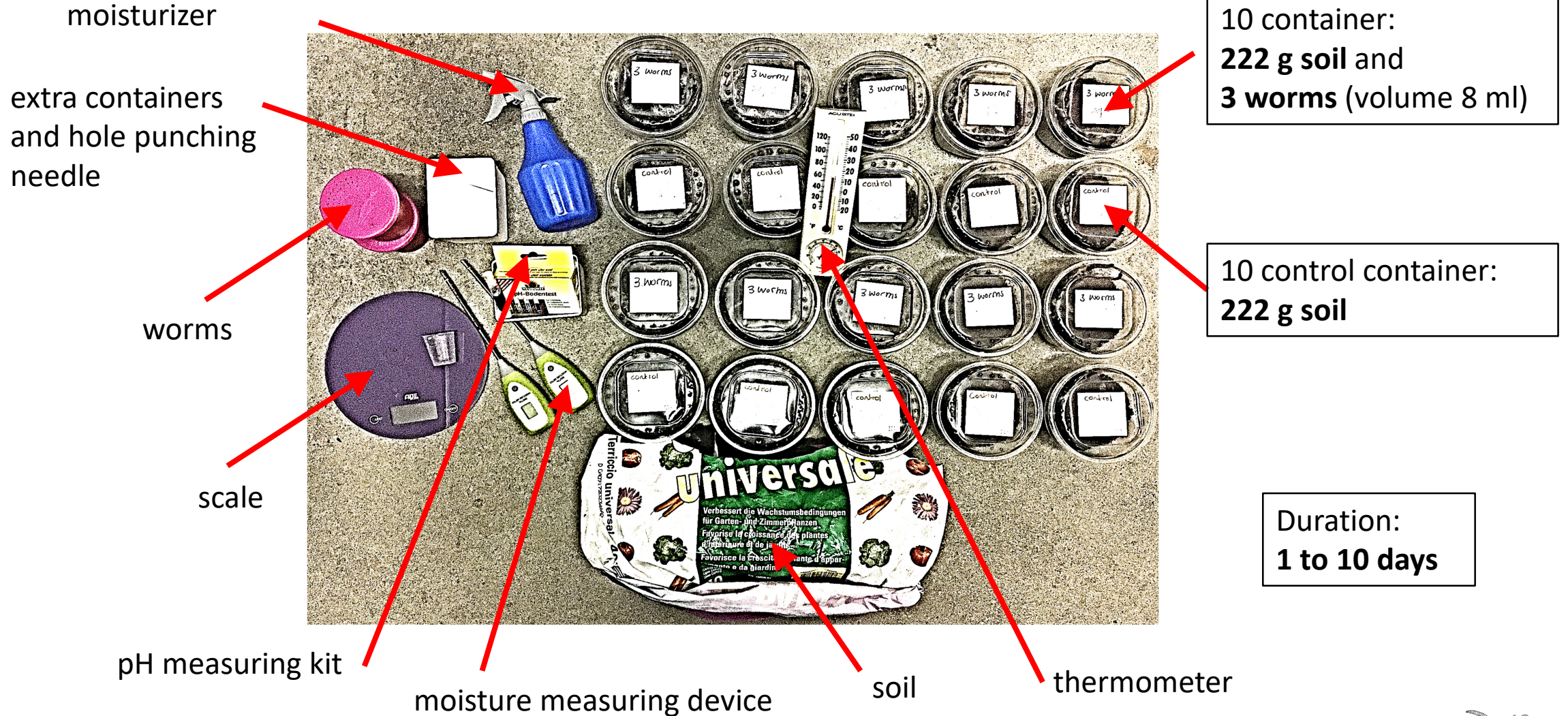
## Calculated

- **porosity** of soil

## Control variables



# Experiment 1: Set-up



# Experiment 1: Procedure

1. Fill with water up to solid surface
2. Measure

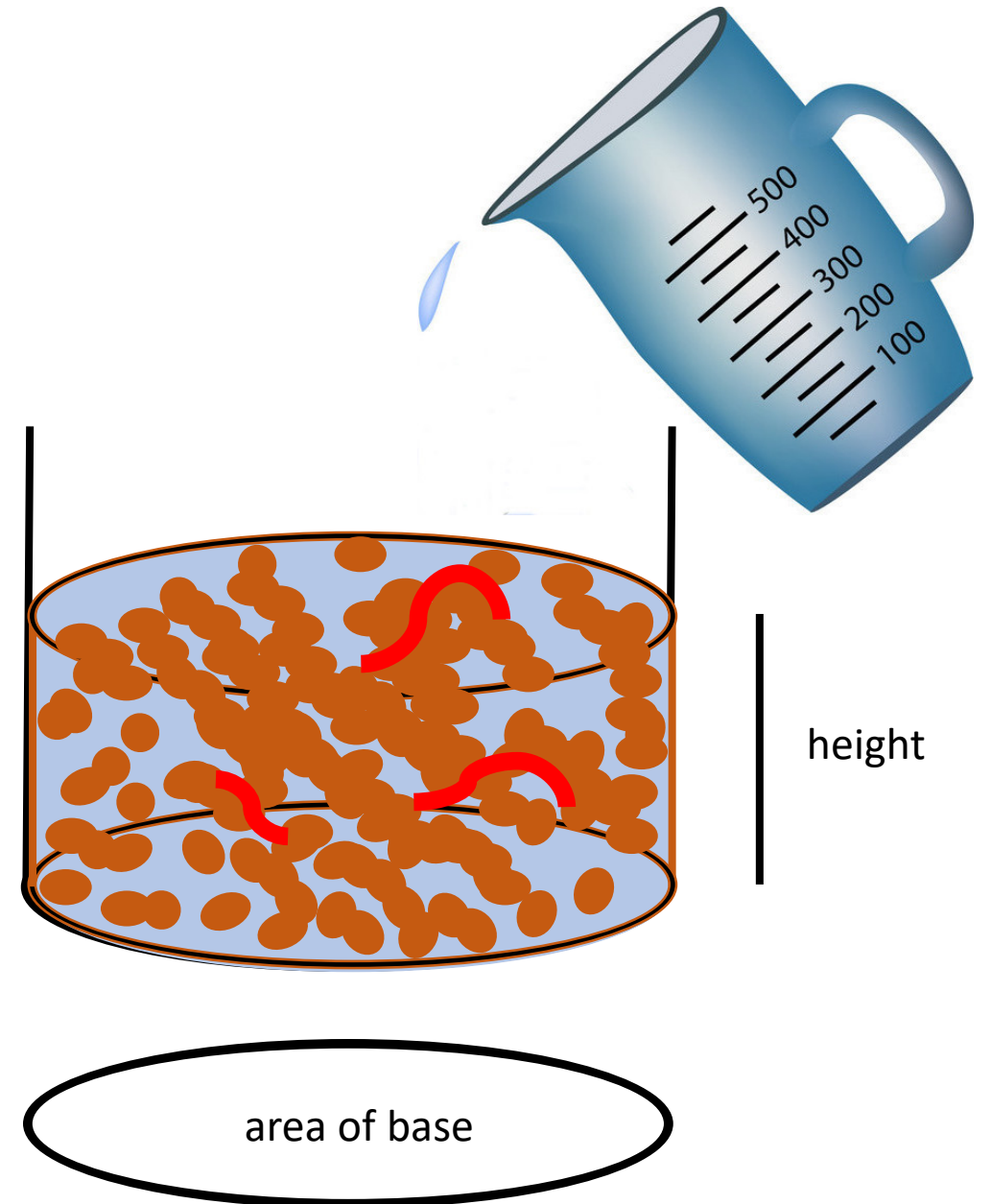
$$V_T = \text{area of base} \cdot \text{height}$$

$$V_L = \text{water added}$$

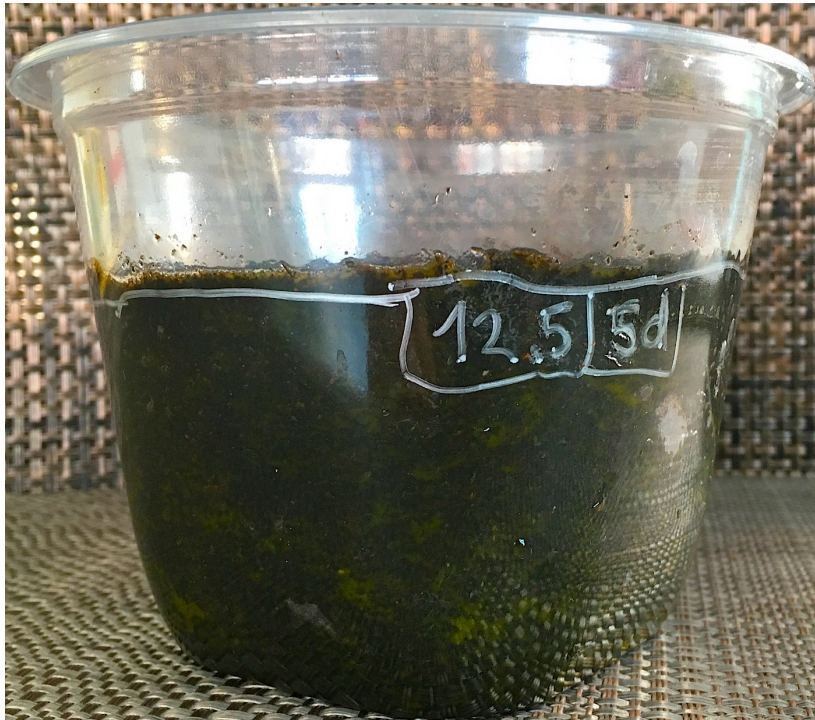
3. Calculate

$$P_{\text{Control}} = \frac{V_L}{V_T}$$

$$P_{\text{Worms}} = \frac{V_L + V_W}{V_T}$$



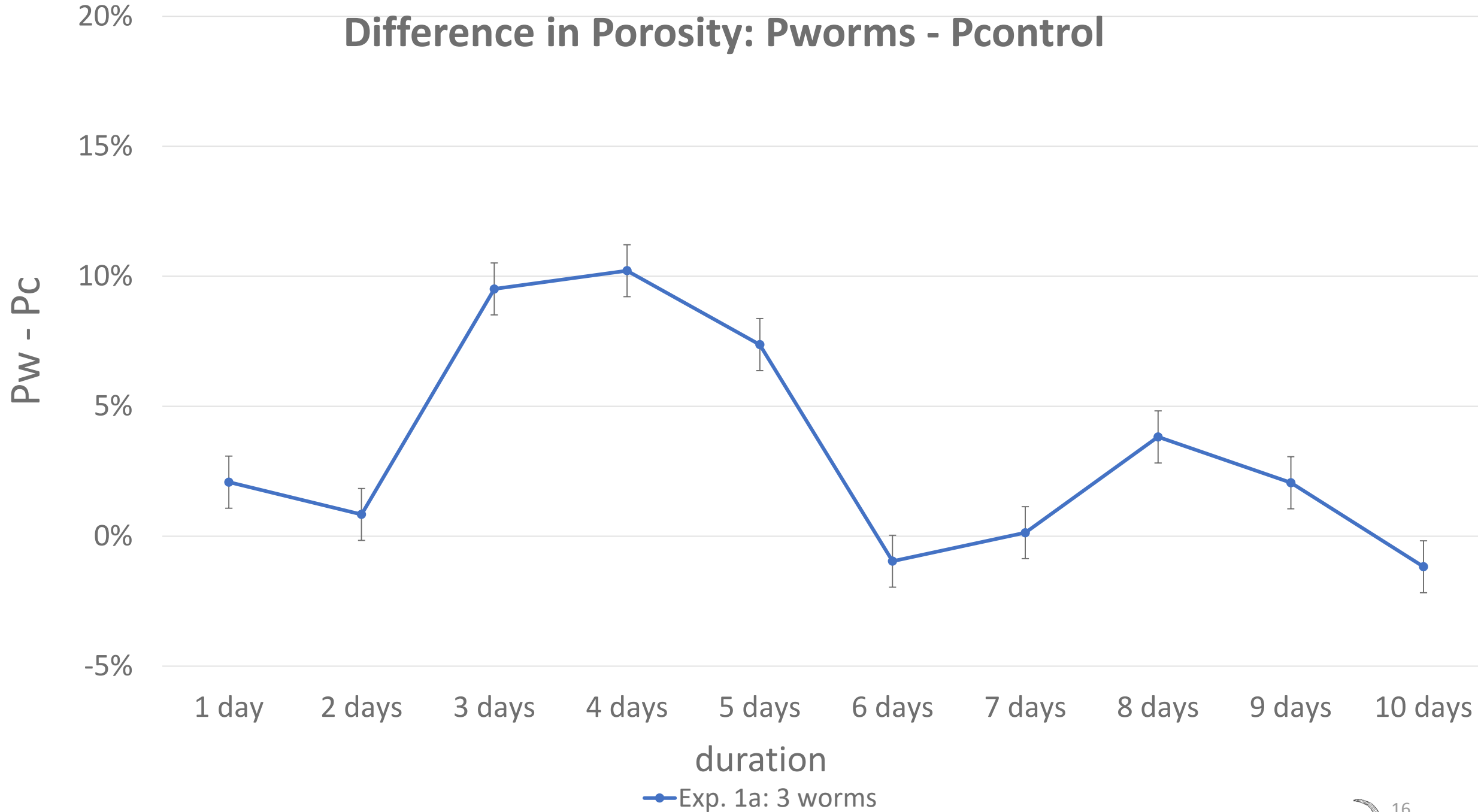
# Experiment 1: Example with yellow solution



$$P_{\text{Control}} = \frac{V_L}{V_T} = \frac{120\text{ml}}{340\text{ml}} \approx 35 \%$$

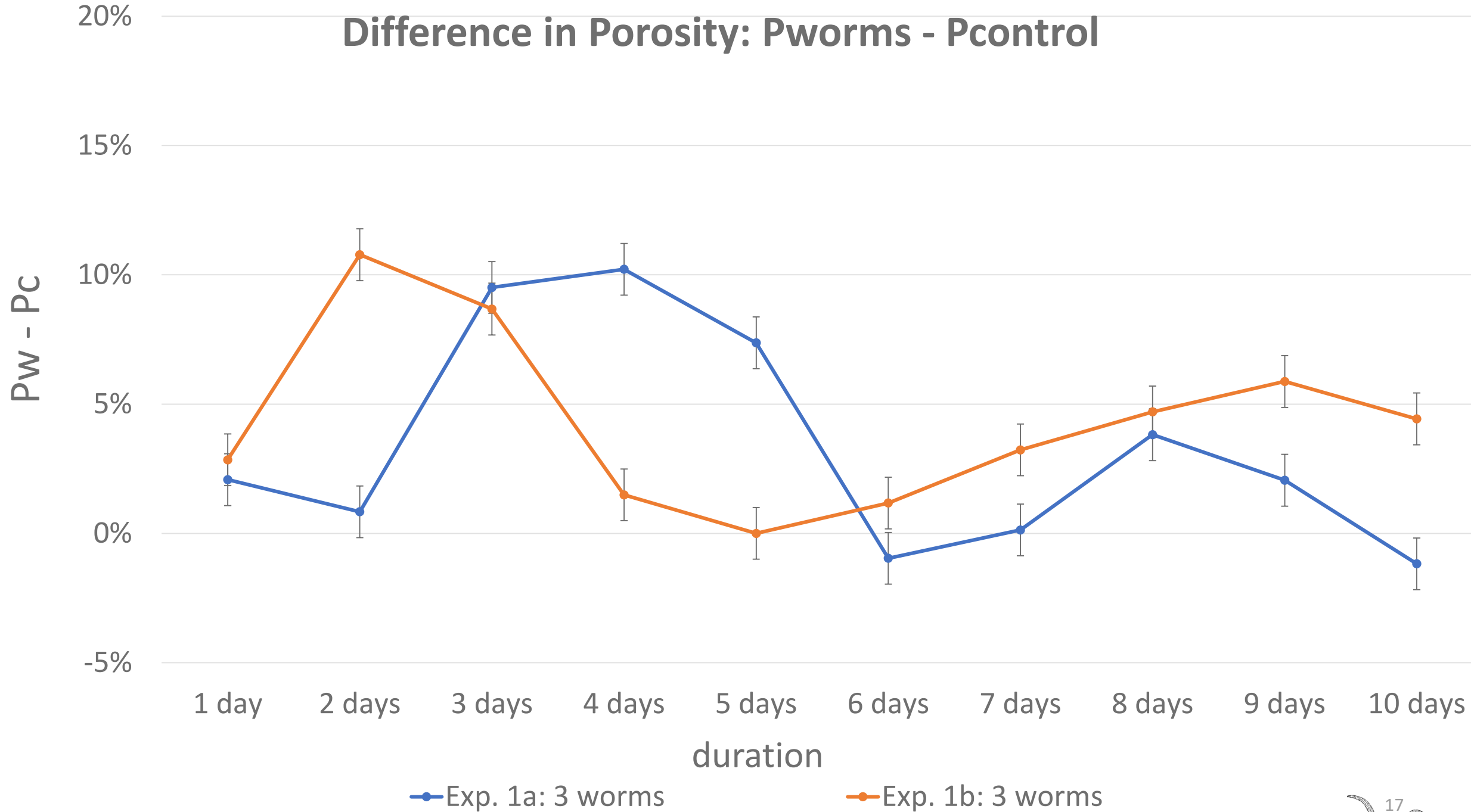
$$P_{\text{Worms}} = \frac{200\text{ml} + 16\text{ml}}{380\text{ml}} \approx 56 \%$$

# Difference in Porosity: Pworms - Pcontrol

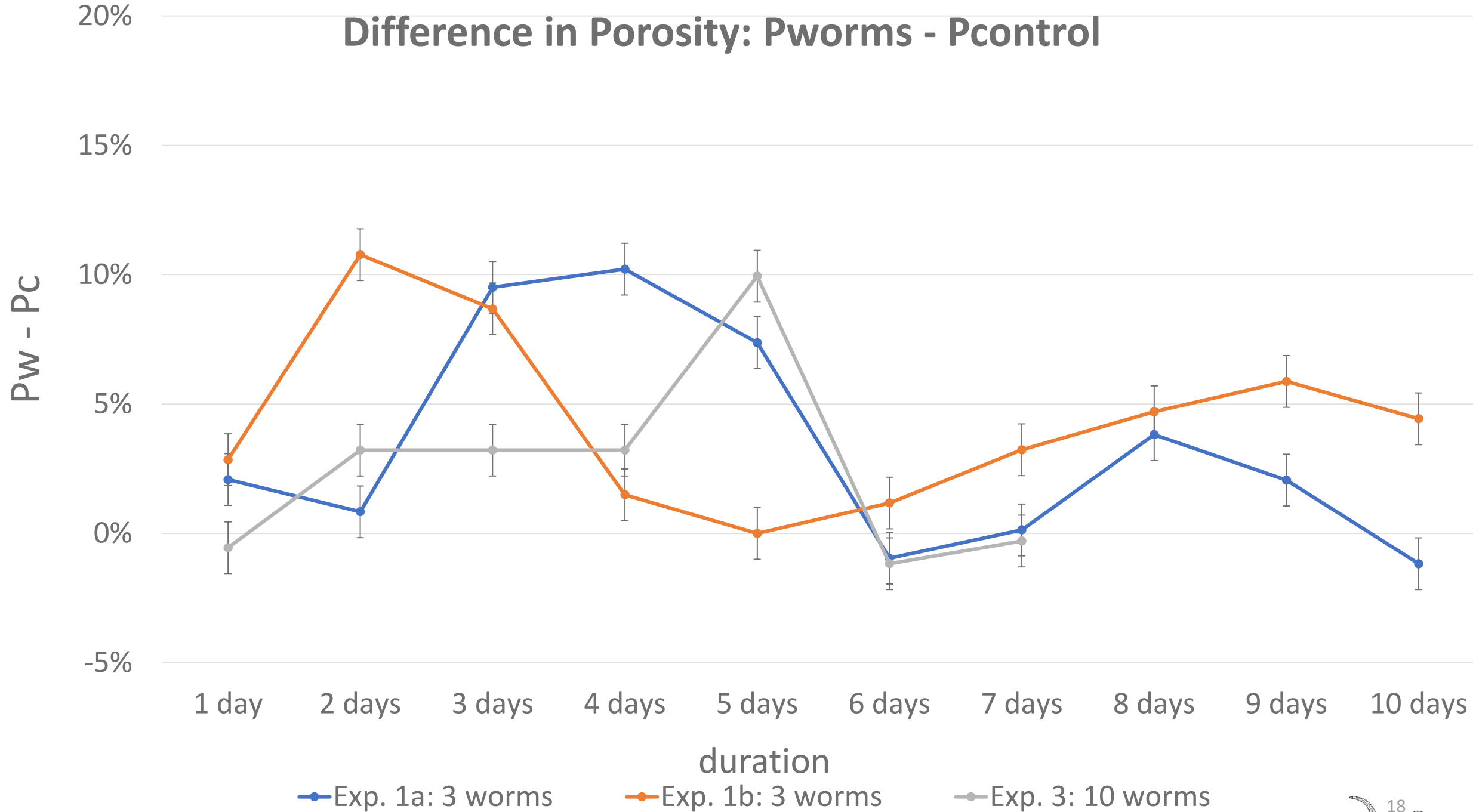




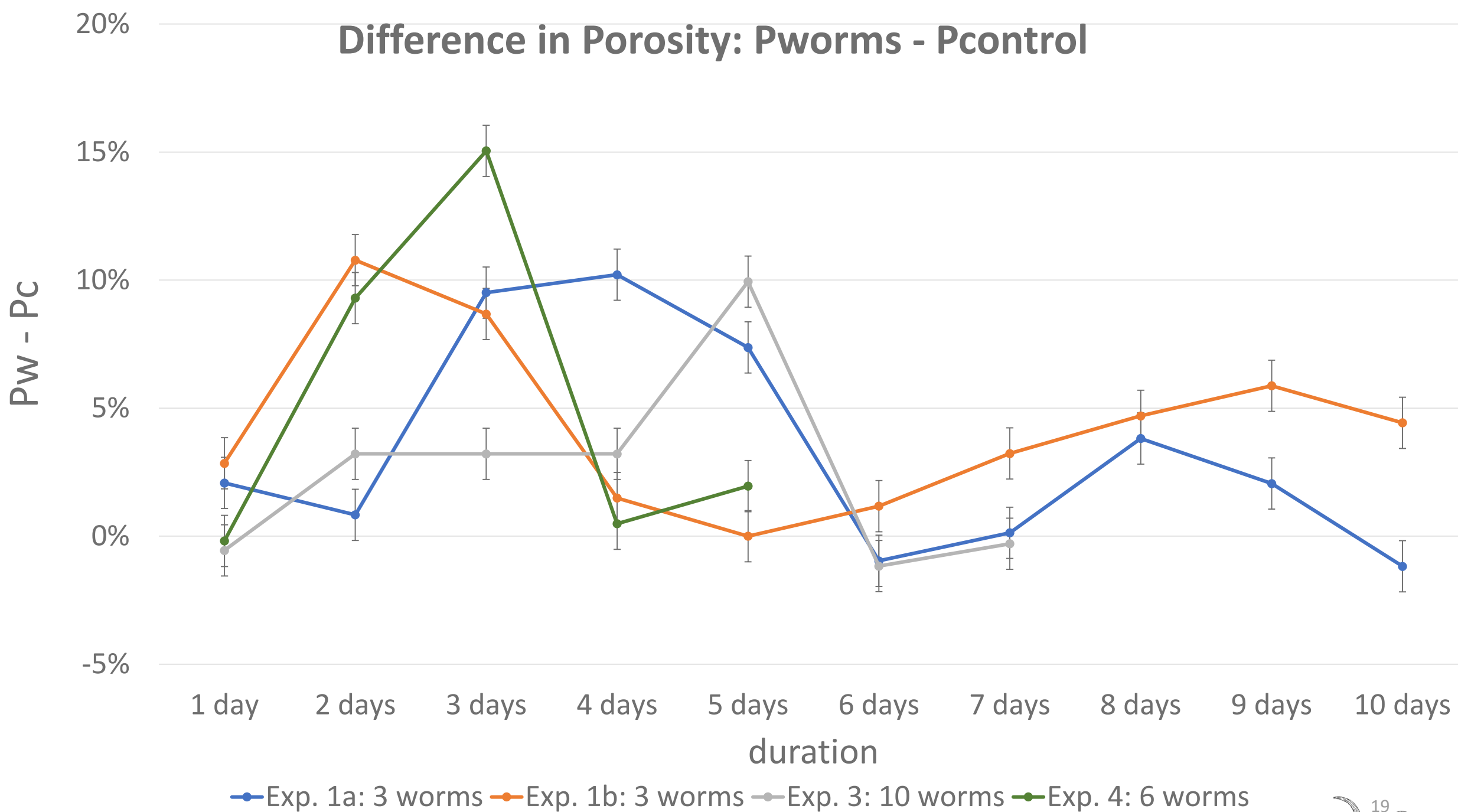
# Difference in Porosity: Pworms - Pcontrol



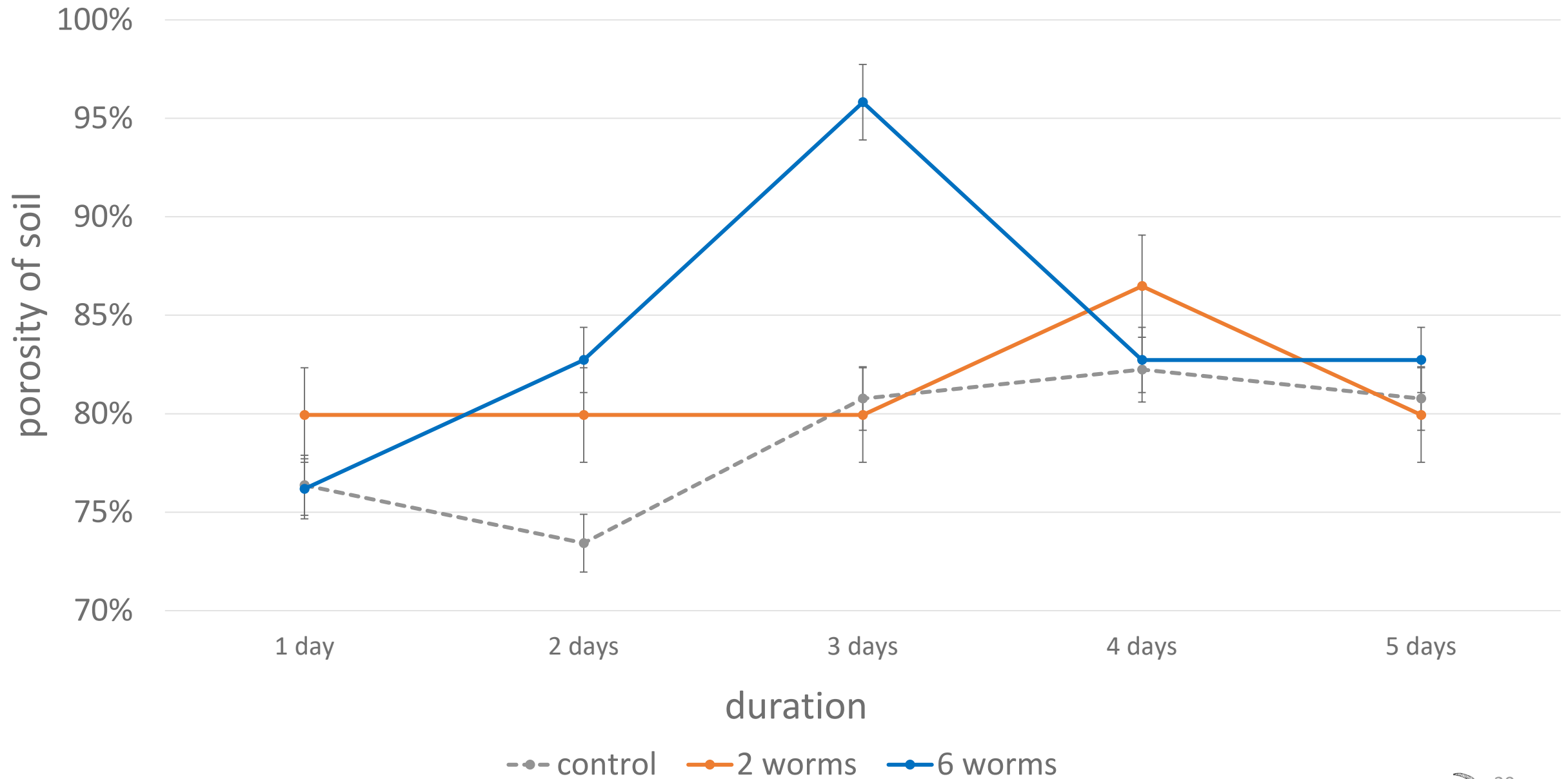
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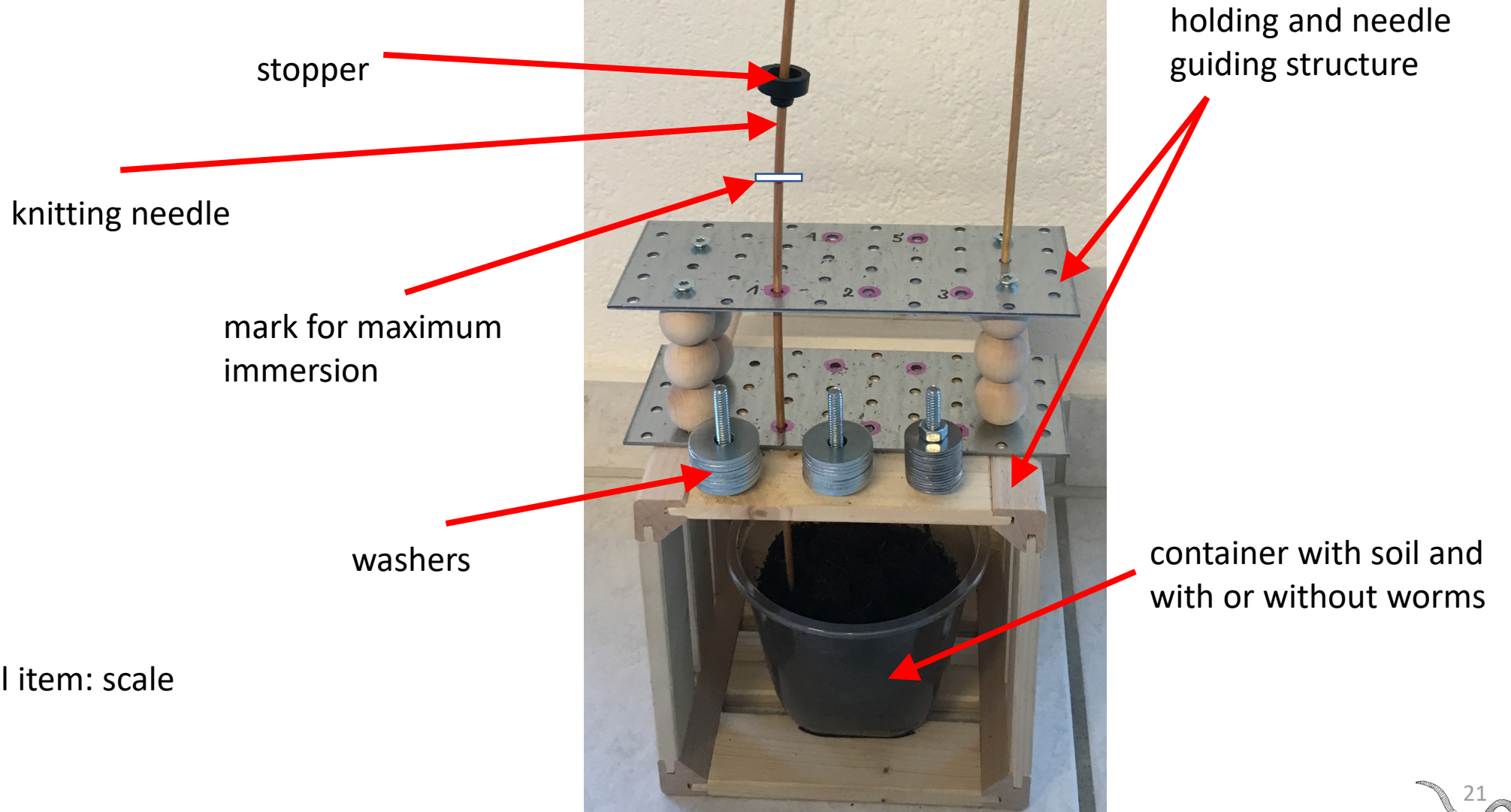
# Difference in Porosity: Pworms - Pcontrol



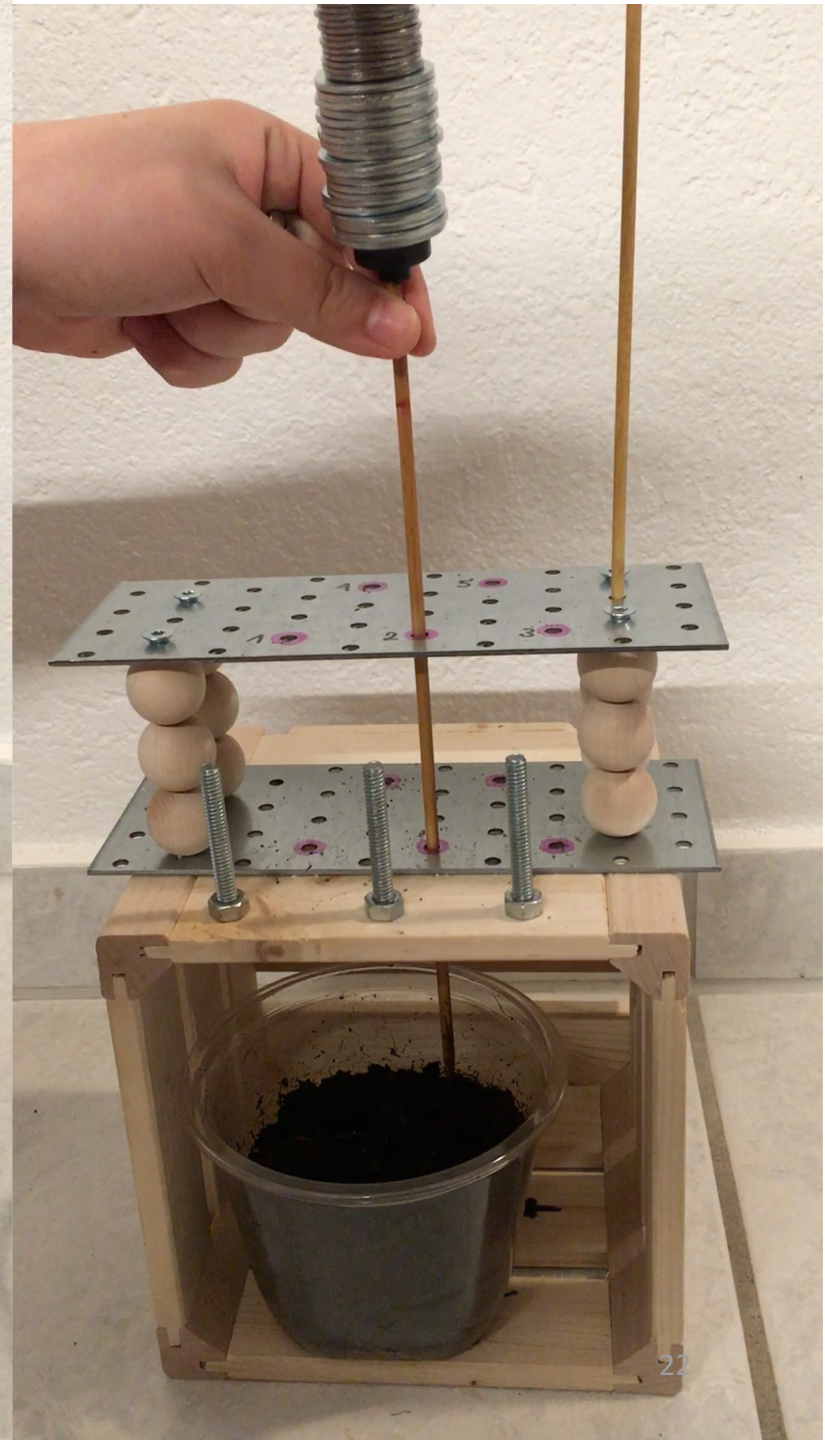
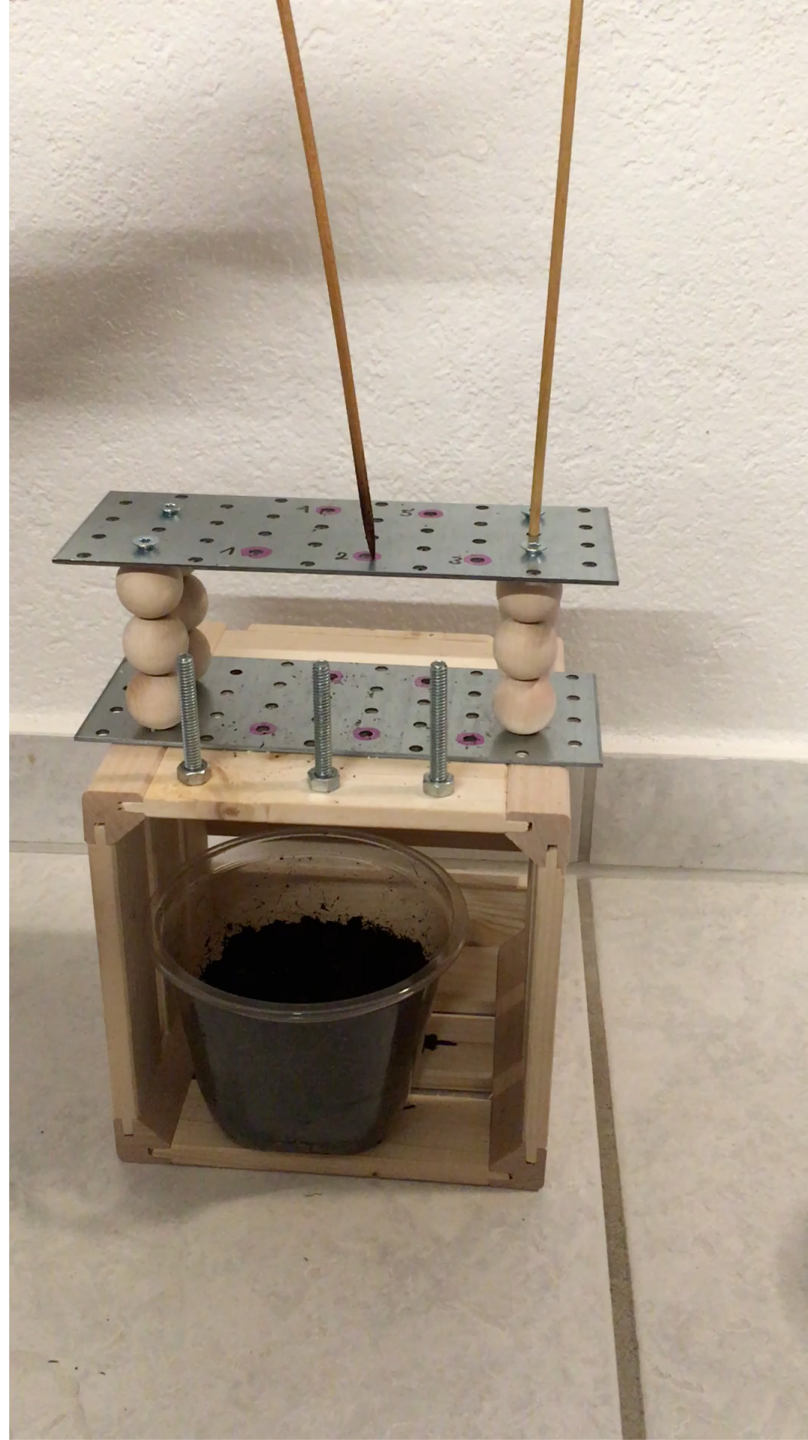
# Porosity depends on the number of worms



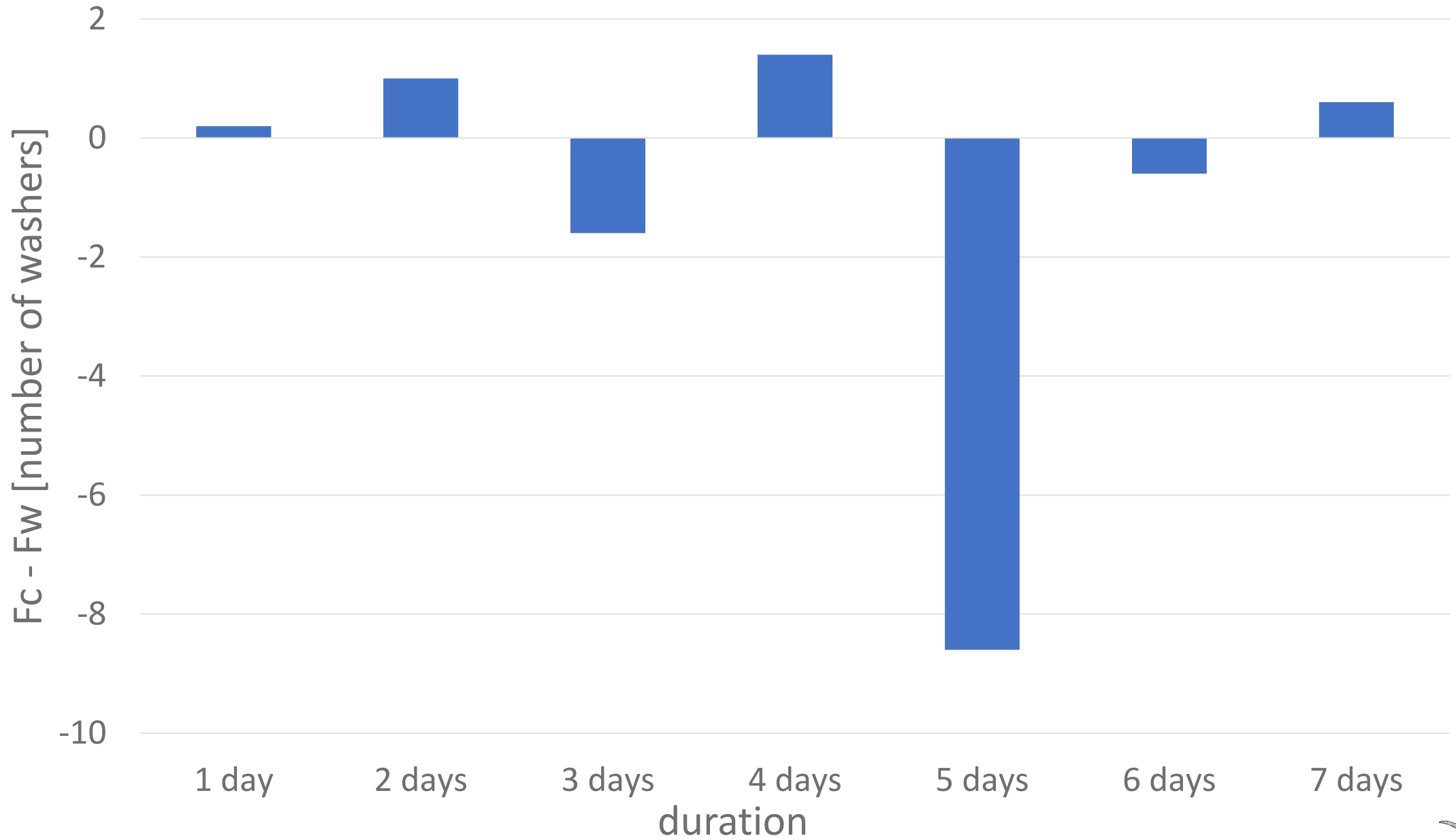
# Experiment 2: Set-up



# Experiment 2: Procedure

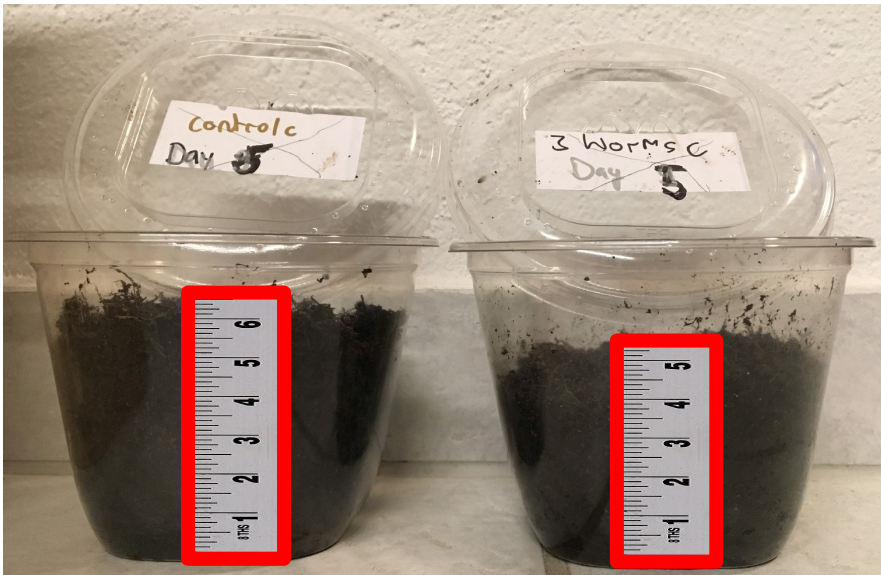


# Difference in Porosity: Fcontrol - Fworms



# Analysis of experiments

- More worms → higher maximum porosity
- Early in experiment: porosity increase
- Later in the experiment (5 to 7 days):  
→ soil more compact



→ **compacting worms**

→ wet, pasty and bulky castings





# Conclusion

## Large earthworms

- early: tunnels increase porosity
- later: cast compacts soil

## Small earthworms

- de-compact soil
- feed on some cast

→ mix is ideal for fertility of soil

## Hypothesis

- worms  $\uparrow$  maximum porosity  $\uparrow$
- early in my experiment: duration  $\uparrow$  porosity  $\uparrow$



Thank you for your attention

# Sources

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