Assessing the Potential Impact of Land-Applied Municipal Biosolids to a Suite of Environmentally-Relevant Indicator Organisms: Part 1: Methodology using Terrestrial Biota

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Why study land-applied biosolids?

- Realization: huge pieces of puzzle missing
- Biosolids land-applied despite limited knowledge of environmental impact
- Need to ensure that land-application is a sound and sustainable disposal practice

Recent research

- Focus on *identification*, *fate*, *transport* of contaminants, pathogens
- Any *impact* studies focus on single-species assessments
- Application rates often unrealistic
- Biosolids often used in “spiked” bioassays

Additionally

- 2004 MOE/OMAF “Draft: Guide for the Beneficial Use of Non-Agricultural Source Materials on Agricultural Land”
- Storage requirements, buffers, set back distances, incorporation requirements, protection for municipal wells, winter spreading restrictions, agronomic application rate restrictions, quality of pathogen standards
- “confirmation that application rates must not cause short or long term harmful effects”
- Nowhere is it suggested how this is to be carried out

Objectives

- **Assess potential *impact* from municipal biosolids under controlled laboratory conditions**

- **Conduct long-term bioassays on:**
  - **i) terrestrial**
  - **ii) receiving water biomes**

- **Use suite of environmentally-relevant organisms**

- **Use range of environmentally-relevant application rates**

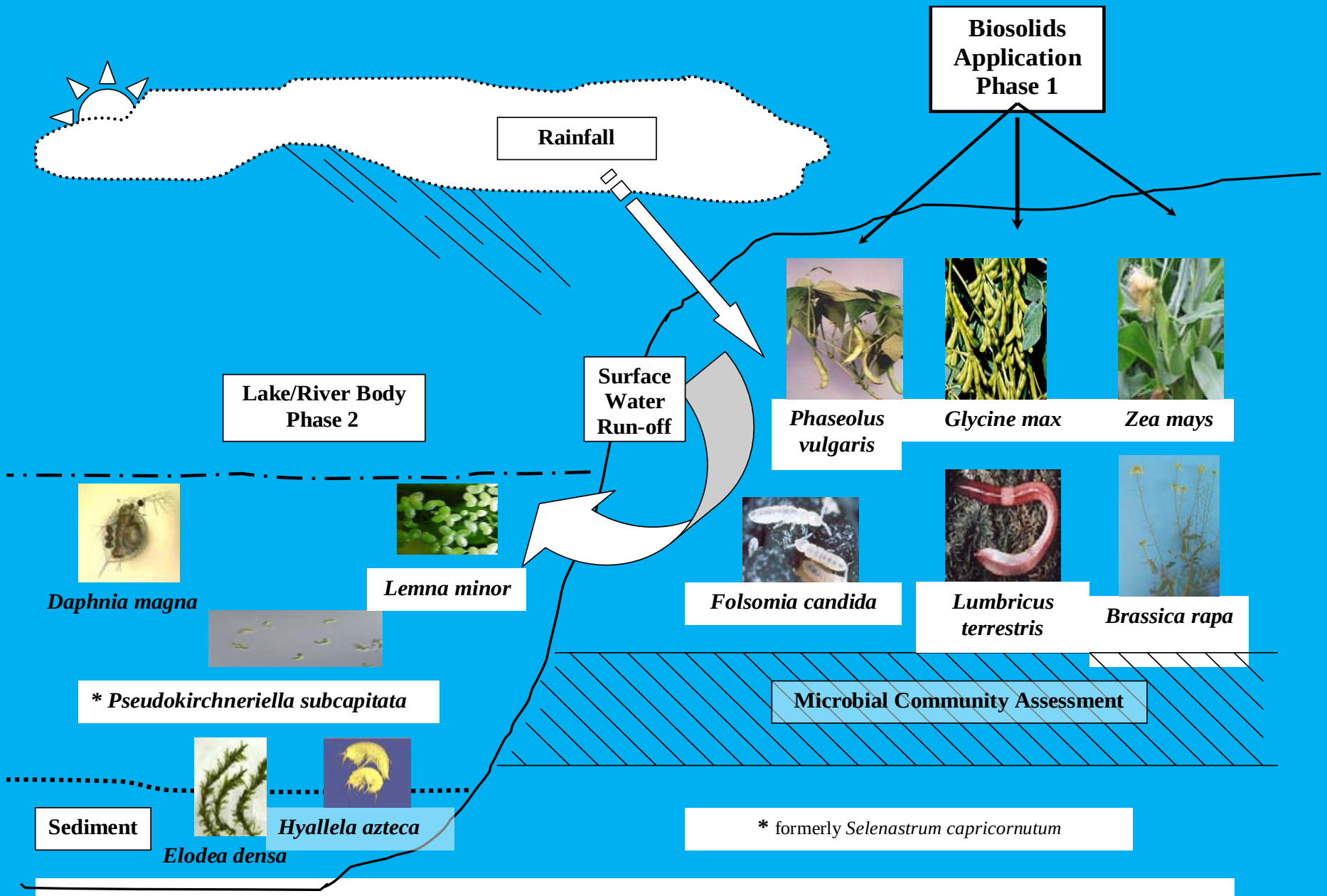

Figure 1. Possible contamination pathways and specific bioassays for the assessment of biosolids application impact.

Lumbricus terrestris - *earthworm*

- Detritivorous; leaf litter taken below along with soil
- Meadows, grasslands

- Bioassays *adapted* from EC protocols

- Increase soil fertility
  - One acre, ½ million worms
  - Move 5 tons soil/year
  - Food for birds, reptiles


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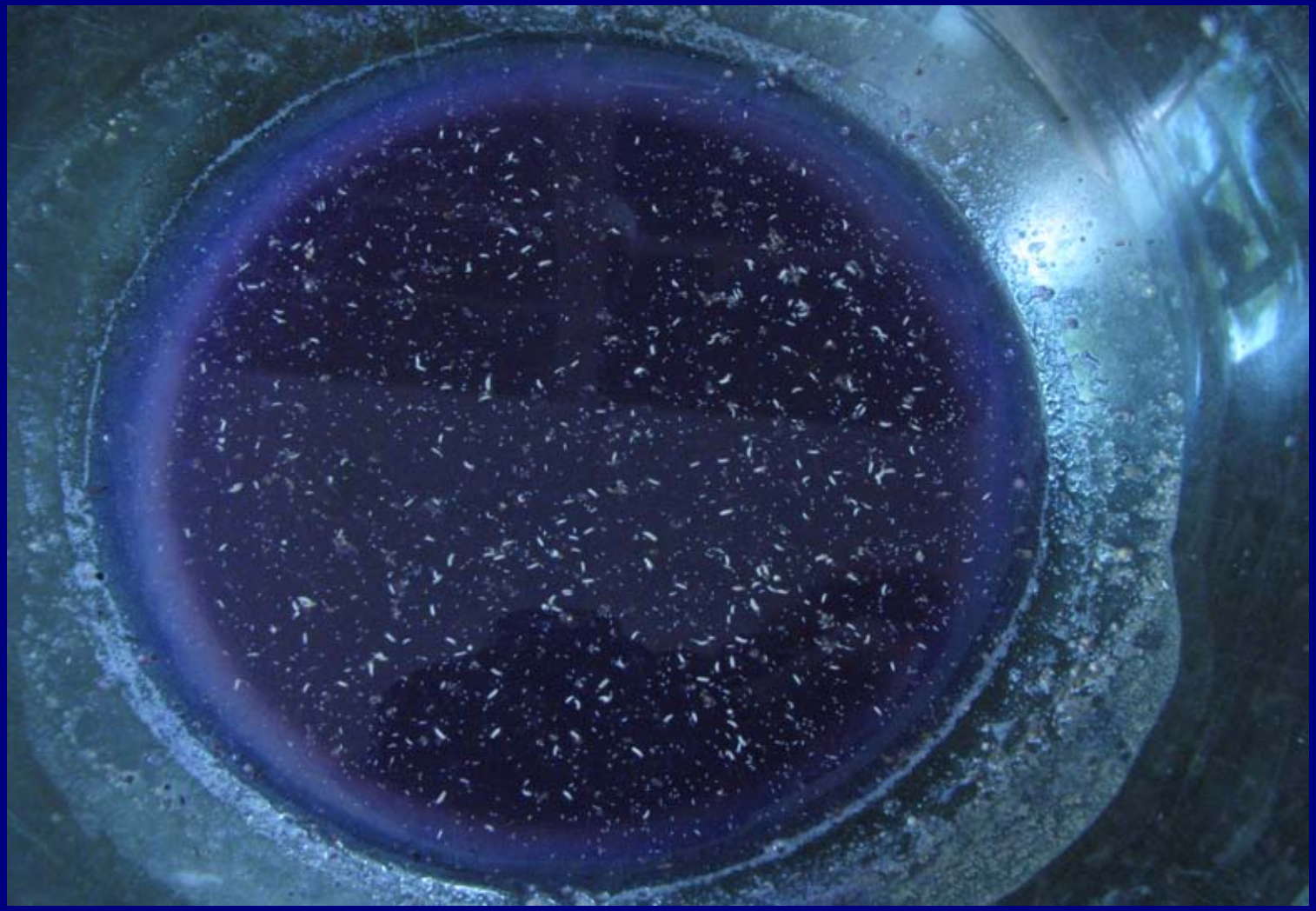
Folsomia candida - springtails

- Standard soil test organism
  - 1mm
  - Easily-cultured
  - Avoidance tests
  - Reproductive tests
- Detritivores
- Abundant macroarthropod
  - 100.000/cu m top soil

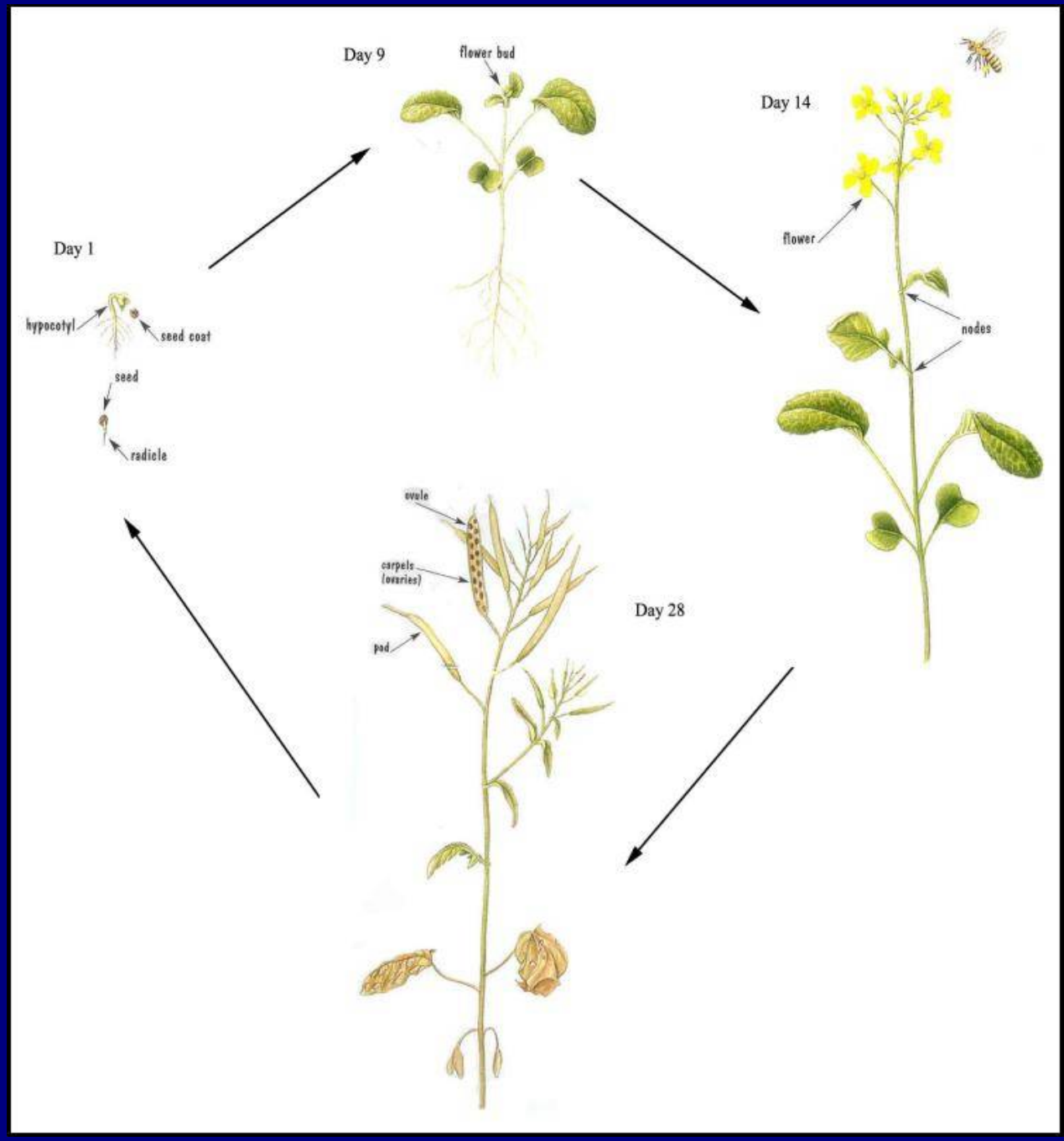
Springtail counting procedure



Brassica rapa

Brassica rapa

- Monocot
- 10-15 cm
- short lifecycle
- multi-generation testing
- acute / chronic / reproduction



Phaseolus vulgaris (common bean)

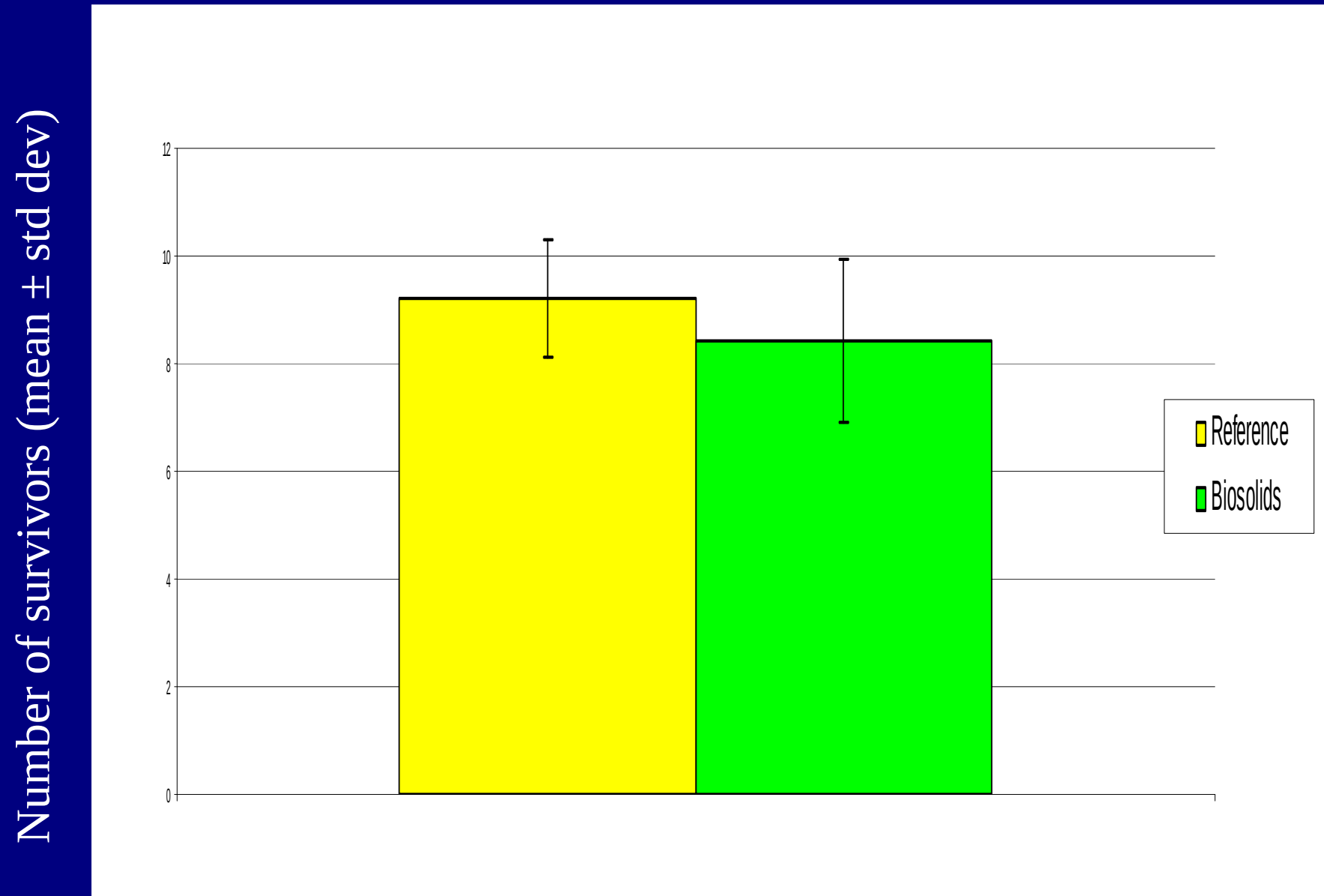
Phaseolus vulgaris

- **Common bean**
- **dicot, 20-60cm**
- **used in limited soil ecotox studies**
- **endpoints: germination, seedling growth**
- **short lifecycle, rapid growth**

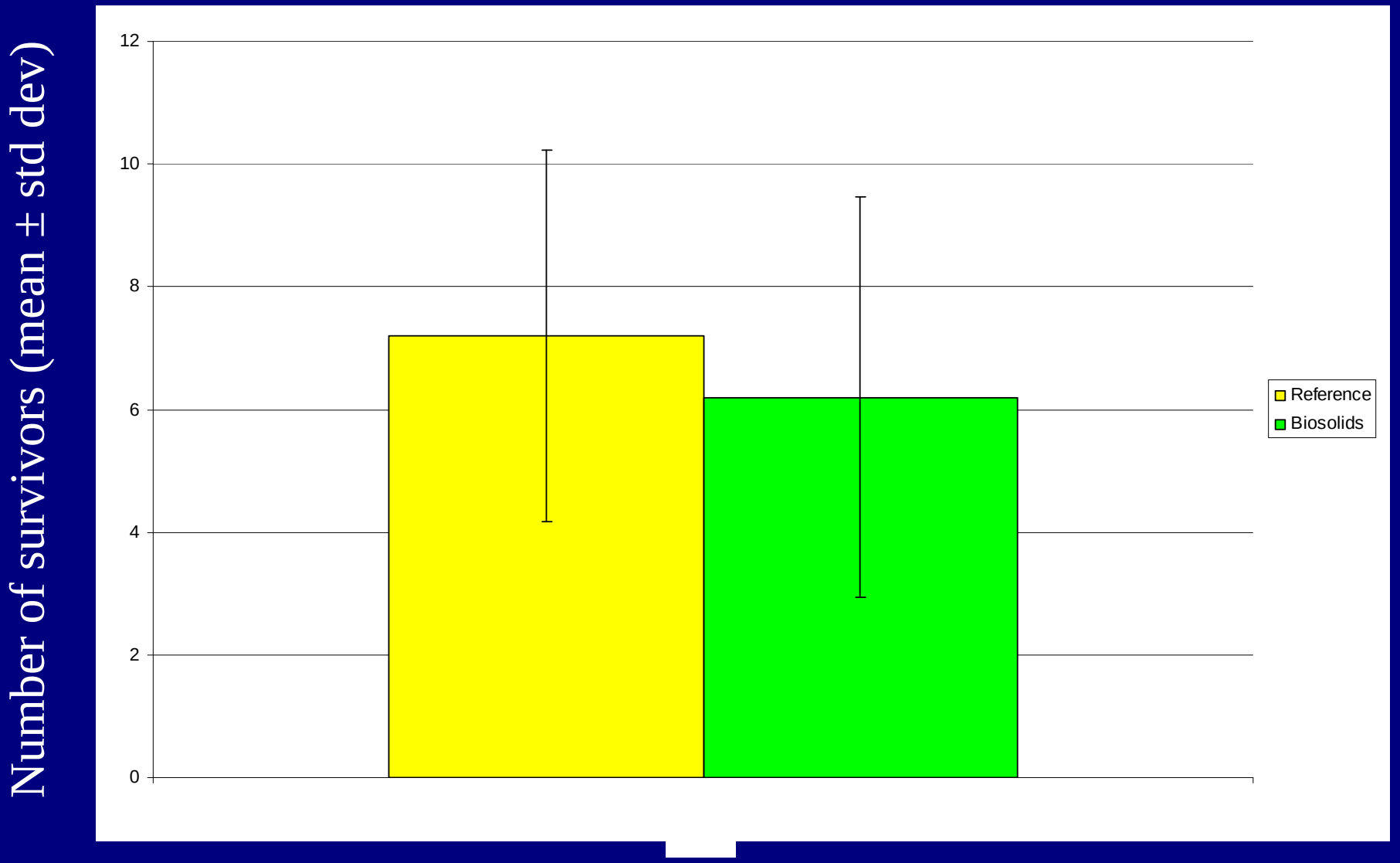
Glycine max (soya bean)

Various stages of *Zea mays* (corn)

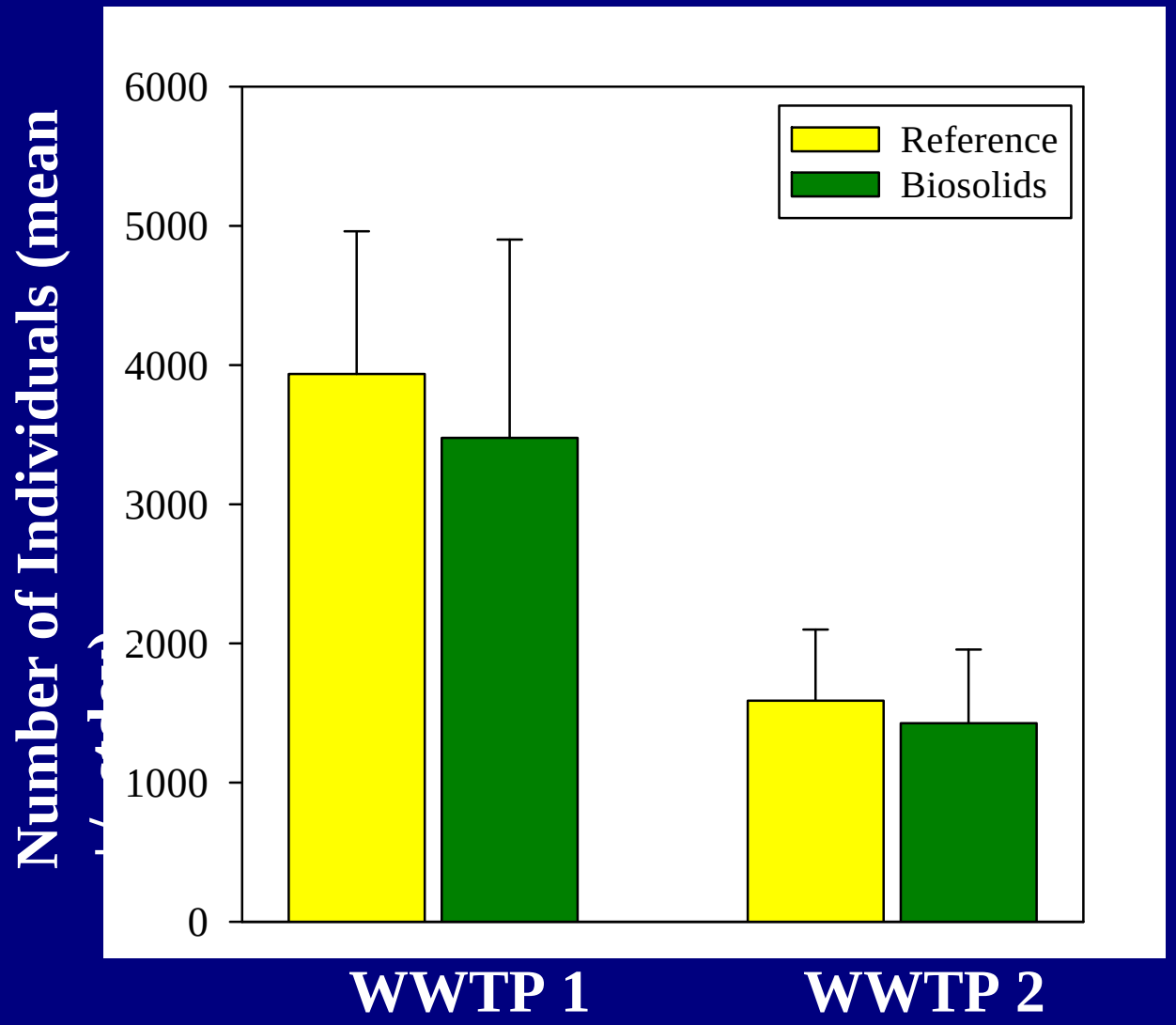
Lumbricus terrestris Survivorship after 7-day Acute Exposure



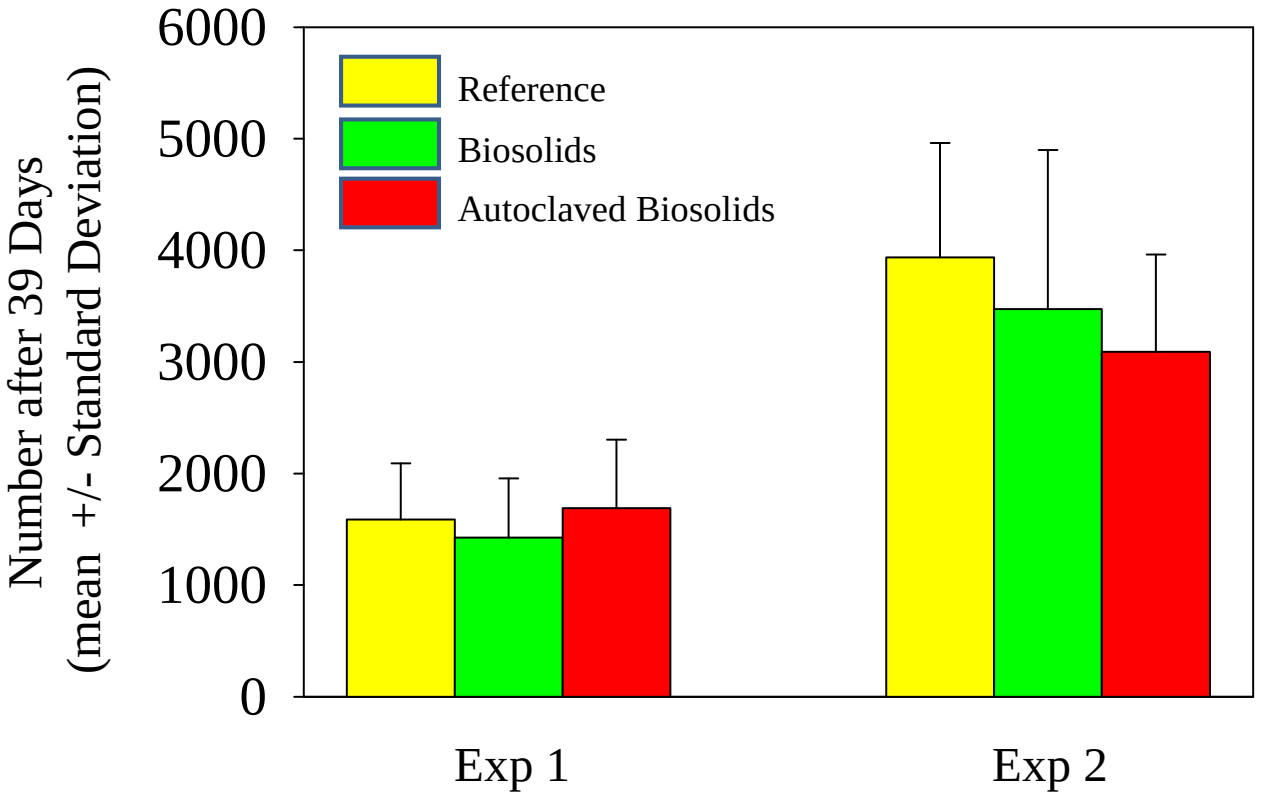
Lumbricus terrestris Survivorship after 28-day Exposure



Springtail Avoidance Test (14-Day)



Springtail Reproduction Test



Phaseolus vulgaris

- Germination ~ 10 Days
- Flowering Stage ~ 30 Days
- Bean Pod Production:
  Self Fertile ~ 37- 40 Days
- Mature Plants ~ 60 Days
- Ideal Growth Conditions:
  - Seed : 2.5 cm deep, 7.6 cm apart
  - 21° C
  - pH: 5.5 to 6.5
  - moist soil
    (40-60% available moisture)

Endpoints measured: Germination

Day 9: Germination of seeds planted in biosolids-amended soil

Endpoints Measured:
Plant Height and Total Leaf Length

Day 35: Reference soil and biosolids-amended soil (right)

Endpoints Measured:
Days-to-Flowering and Number of Bean Pods

Day 41

Day 66

Endpoints Measured:
Total Number of Seeds and Total Seed Weight

Day 84: Desiccated bean pods from reference

Endpoints Measured:
Root Length, Stem Width, and Shoot Length

Day 85: root length (left) and stem width (right)

Endpoints Measured: Plant Biomass

Endpoints Measured: Germination of F1 generation

Planting of F_1 generation in reference soil

Results: Non-Impacted Endpoints

Endpoint	Reference Mean (sd)	Biosolids Mean (sd)	ANOVA
(%) Germination	100	87	No sign difference(NSD)
Germination Rate (day)	6.2	7.4	NSD
Day-to-Flowering	30.2	32.3	NSD
Number of Bean Pods	2.4	2.4	NSD
Total Number of Seeds	7.7	6.1	NSD
Total Seed Weight (g)	2.58	2.58	NSD
Root Length (cm)	8.5	10.4	NSD
Shoot Length (cm)	15.5	12.9	NSD
Stem Width (mm)	3.42	3.20	NSD
Plant Biomass (g)	5.44	5.45	NSD
F_1 % Germination	80	100	NSD
F_1 Germination Rate (day)	7.1	6.7	NSD

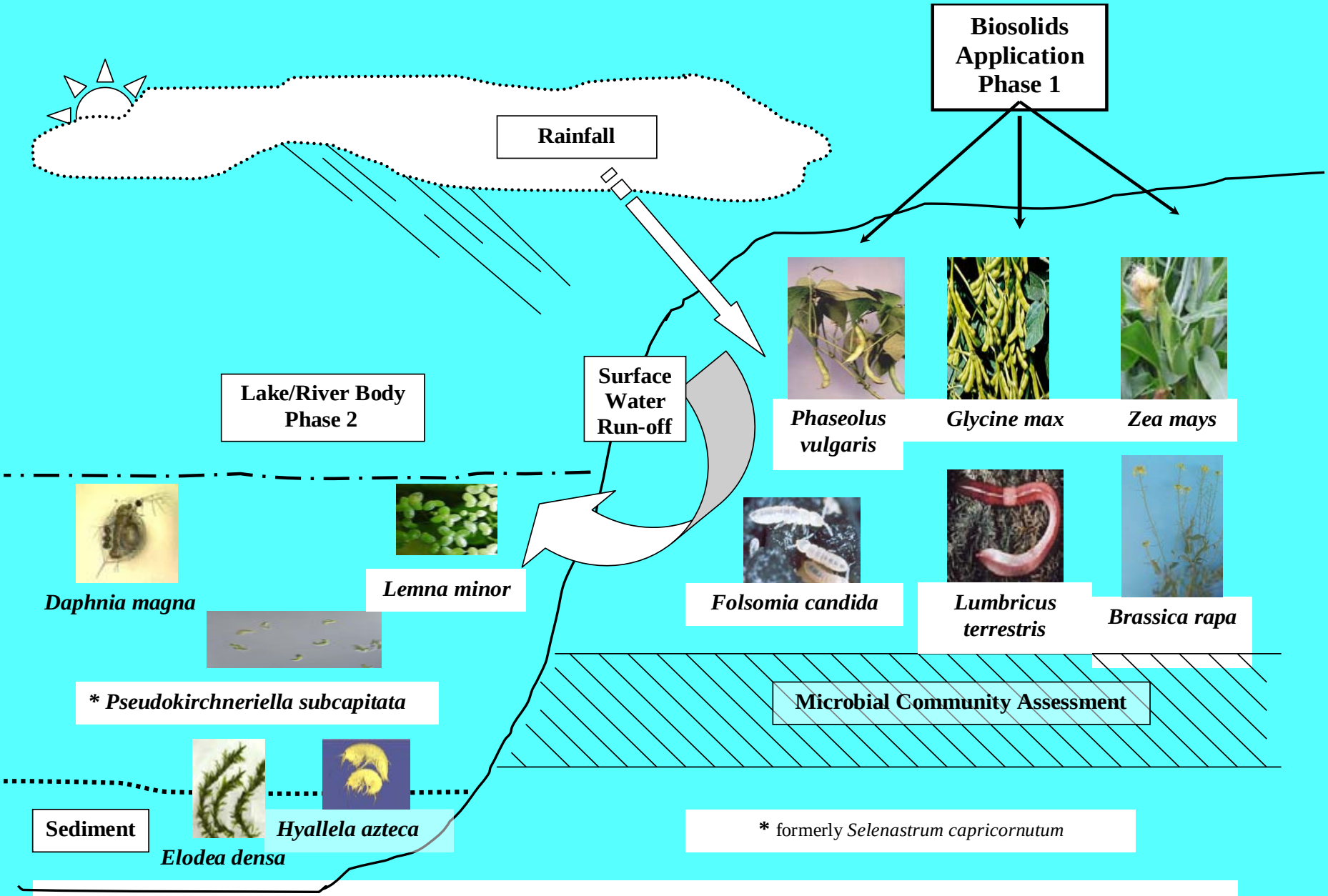


Figure 1. Possible contamination pathways and specific bioassays for the assessment of biosolids application impact.

Conclusions

- long-term bioassays indicated no deleterious impact of selected biosolids on terrestrial biota under controlled, laboratory conditions

- use of multi-organism, environmentally-relevant bioassays adds scientific veracity to assessing the sustainability of the land-application process

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