SEDIMENT: AN UNDERVALUED COMPARTMENT IN MESOCOSM STUDIES

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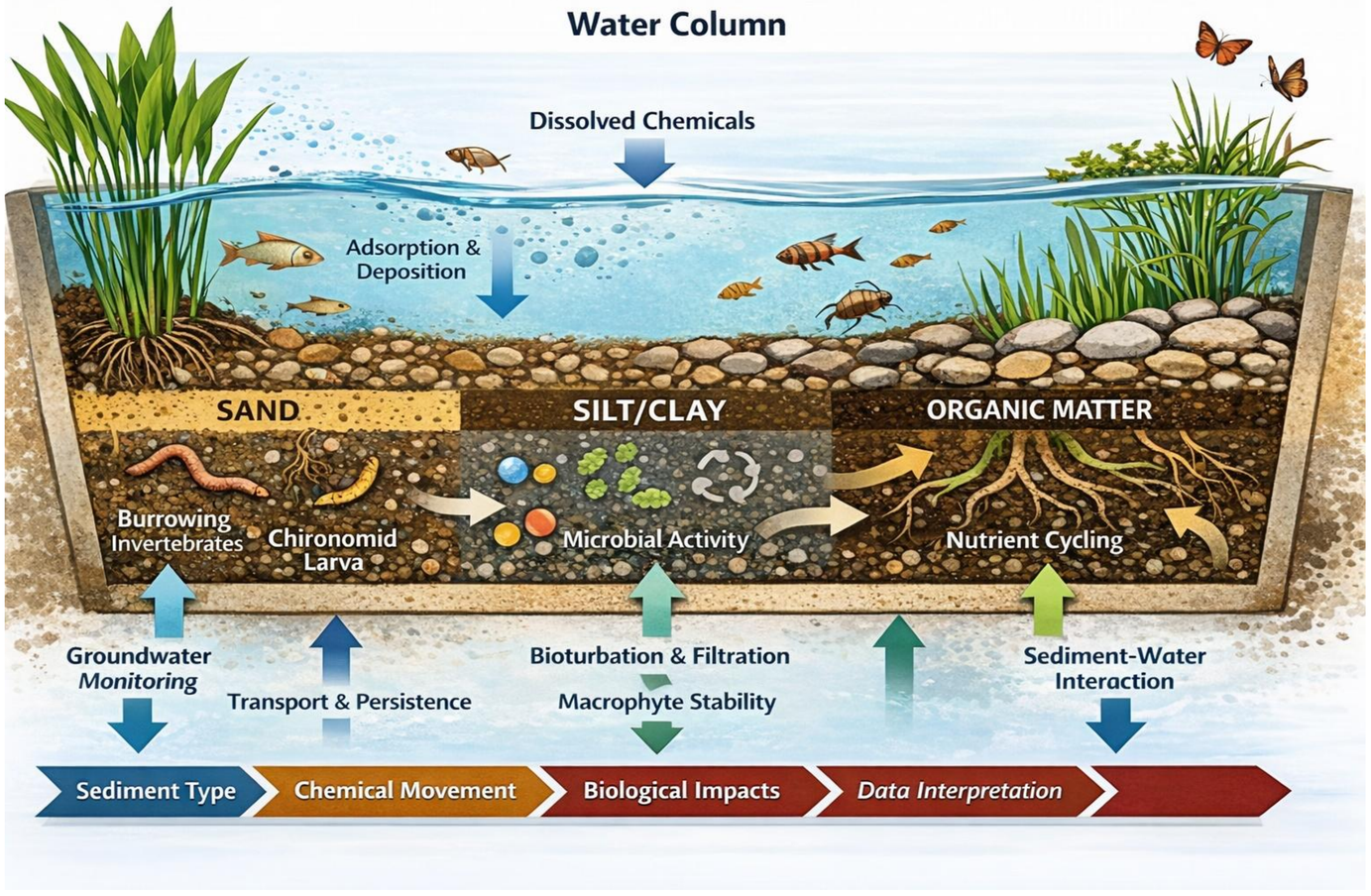
CAMBRIDGE ENVIRONMENTAL ASSESSMENTS

INTRODUCTION:

The sediment layer is a key part of any mesocosm test system, however, it's influence on the test design is largely undervalued. Generally, the sediment compartment is primarily only of interest if the test substance is known to have physio-chemical properties of concern, e.g. they would bind to the sediment, or degrade slowly, and is often only investigated for analytical residues. Variations in sediment type, from sandy and silty/clay substrates, to the amount of organic matter (OM) present, can alter chemical movement, nutrient cycling, biological interactions, and function of benthic habitats within test systems.

Variability in the coarseness of the sediment affects, macrophyte health, filtration, and groundwater exchange. Dipwell monitoring of groundwater simulations could be valuable data to interpret contaminant dynamics for transport and exposure persistence, thereby influencing test system stability and recovery. This could be carried out with a stone or mesh base with an overlaying membrane and a siphon tube.



Physical Properties

- % of stones > 10 mm ~ sediment structure.
- Worst-Case Scenario = fine/sandy, ↓OM, leeching, ↓ light availability, ↑ uprooting
- High nutrient sediment encourages fast growing, unstable macrophytes[5].
- High depositions of fine sediment led to a reduced periphyton stock and growth[5].
- Clay = remediation strategy for metal-based contaminants in sediment, reducing metal uptake by benthic organisms[11].

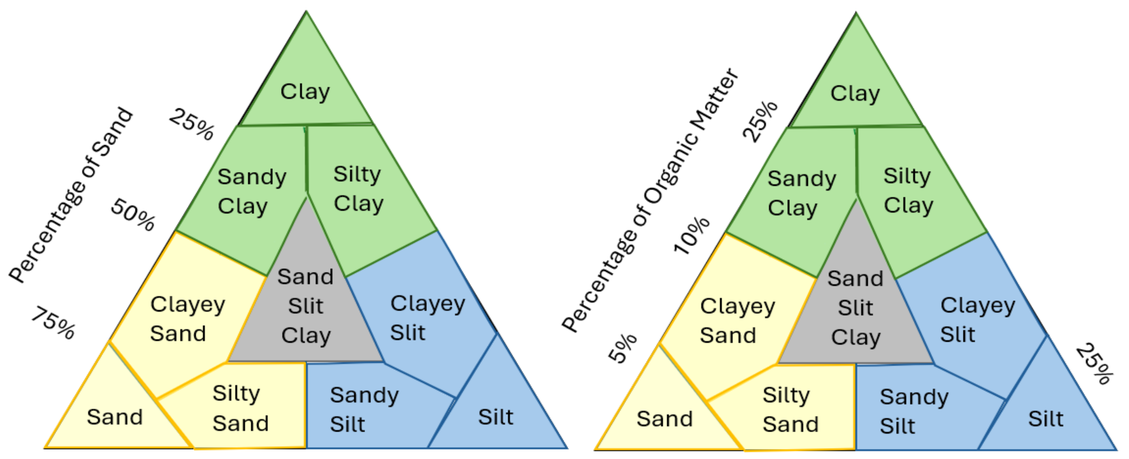
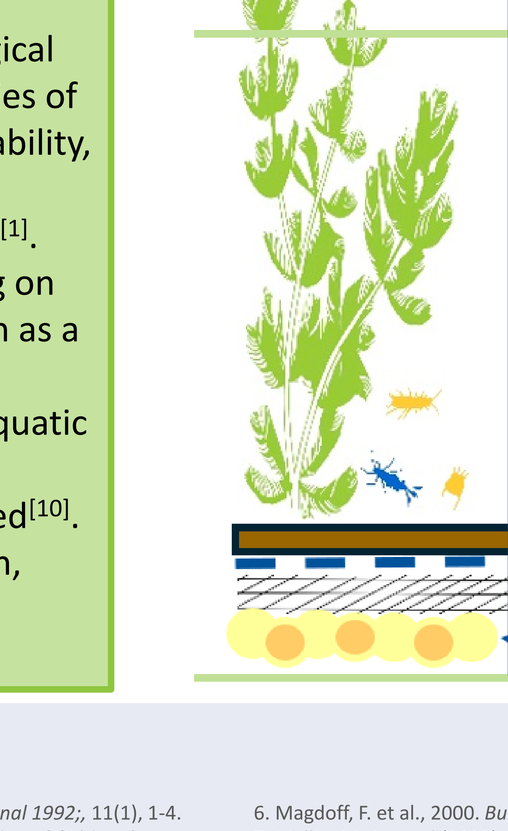


Figure 1: Depicts the physical and organic matter percentage for each type of sediment. The amount of organic matter and organic carbon held in each sediment type effects their chemistry, impacting the nutrient cycle of that pond[1].

Biological interactions

- Rooted macrophytes depend on sediment structure to enhance habitat complexity and supports organism assemblages[6].
- Testing mostly carried out on Chironomids and *Hyalella Azteca*[8].
- ↑ fine sediment/silt produced a stress effect on macroinvertebrate traits through decreased photosynthesis[9].
- Benthic organisms are integral to ecological functioning and sediment-bound exposure is a major driver of risk for many pesticides. They include sediment spiked toxicity testing on *Oligochaeta* and *Myriophyllum*[3].
- Benthic invertebrates regulate nutrient turnover, burrowing and feeding activities alter chemical exchange.



Chemical Properties

- Worst-case = ↑ organic and microbial content, ↓ oxygen, ↑ Nitrogen and phosphorus, ↑ algal blooms.
- ↑ sediment thickness = ↑ regulation of the concentration of contaminants, including dissolved inorganic nitrogen and sulfates[4].
- OM affects the binding of fine sediment and pollutants, therefore holding any pollutants within the pond sediment[7].
- Macroinvertebrates are dependent on the biochemical nutritional quality of OM. Even if physical sediment characteristics are ideal, community growth is impacted by poor nutrition[8].

Design implication

- Varying sediment types would influence the biological impacts within the mesocosm, e.g. through activities of burrowing macroinvertebrates and macrophyte stability, highlighting how biological disturbance can alter sediment-water interactions and exposure profiles[1].
- An ideal sediment could be sand or clay depending on what is most appropriate, using macrophyte health as a proxy for sediment structure and function.
- Mesocosm turbidity should be equivalent to the aquatic environment that it hopes to mimic to support the biological productivity and nutrient cycling expected[10].
- Size/shape of pond and amount of sediment within, affects light levels and nutrient concentrations, especially of phosphorus.

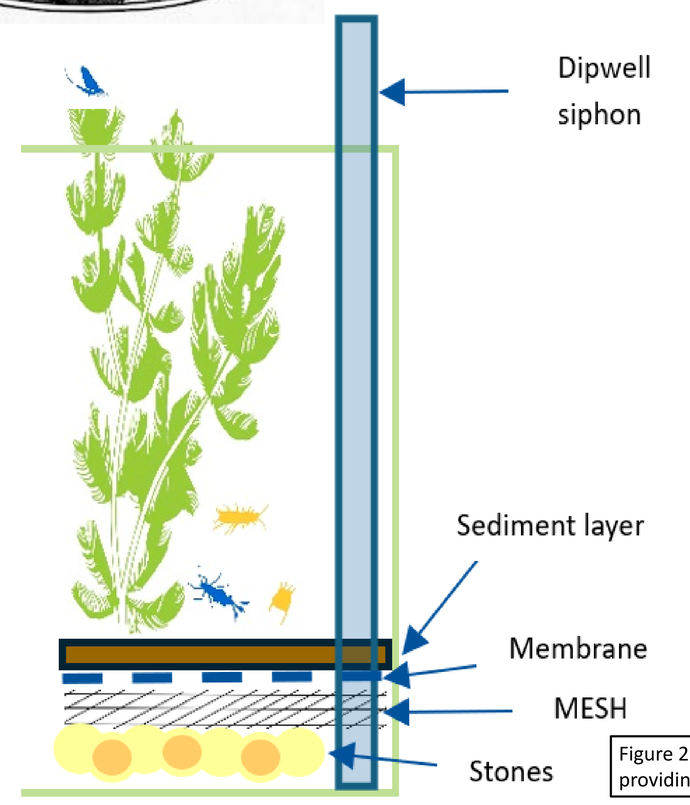


Figure 2: Demonstrates the process of dipwell monitoring of groundwater, providing data to interpret contaminant transport and exposure persistence.

Endpoint derivation [3]

FOCUS methodology for surface water does not consider multi-year applications or the potential accumulation in sediment. An accumulation factor could be incorporated into mesocosm design. This would represent a conservative approach, as it does not account for transport processes that could reduce accumulation. A tiered effect assessment for sediment organisms and consideration of how to link regulatory acceptable concentrations (RACs) to predicted environmental concentrations (PECs) would benefit interpretation of endpoints.

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