Micro- and mesocosms for assessing ecosystem effects of radiation

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Background

A number of organisations have recognised the need for protection of the environment from radiation [1] and advocated an **ecosystem-based approach** [2]. Ecosystem response to radiation exposure depends on the different species sensitivities and the multitude of direct and indirect pathways by which individual organisms can be affected. Despite this, many radiation protection frameworks rely heavily upon reference organism approaches like the ICRP RAPs, or are based on data from single species experiments, which may overlook multiple interactions that exist in ecosystems [3]. Radioecological research is therefore attempting to shift focus towards studying impacts on the structure and functions at population, community and ecosystem levels.

The Project

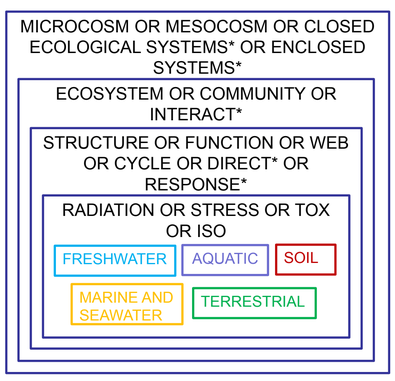
We set out to review the available literature on designing and running multi-species studies when planning test systems for use in radioecology.

Microcosm and mesocosms are ecological test systems that can be used to study ecosystem responses to anthropogenic stressors, ranging from small scale laboratory test tubes to large artificially created habitats (see images). Cosms allow control of spatial and temporal variability of applied stressors, either abiotic or biotic, making them ideal for chemical risk assessment, whilst their simplistic notion allows for experimental studies and replicability [4]. Although large-scale mesocosms are more realistic in terms of natural conditions, small microcosms can accurately represent natural habitats and/or parts of ecosystems [5]. *Furthermore, larger cosms may be more stable over time, while smaller cosms are more replicable* [4].

Review process

We employed a tiered approach to search the **ISI Web of Science** database to screen the available literature in five steps. The searches were performed on all words in the articles with no restrictions in research domain, areas, document type or year of publication. In the last step, search words were singularly for the different habitats.

The relevant articles that were not caught in our first search were evaluated for keywords that we could include in the search tiers. We performed a second search in the Web of Science database with updated keywords (*).



Evaluation

We designed a spreadsheet with **four categories and 60 columns** addressing the following;

1. **Cosm description**: mimicked environment, size/volume, materials, location
2. **Organisms in cosm**: numbers, species, natural/lab, trophic level
3. **Study design**: duration, units, treatment levels, type of stressor, controls
4. **Endpoints/assessments**: structural and functional, abiotic and biotic, indirect and direct, significant effects, Stats
5. **General conclusion**: easy to keep, extra instillations, notes

For every article, each reviewer provided a 1/0 answer or chose one of the predefined options in the columns. The resulting spreadsheet will be used to rigorously investigate trends over time, patterns across literature, difference in terms used, endpoints favoured, statistics applied and importantly, areas lacking information/analyses.

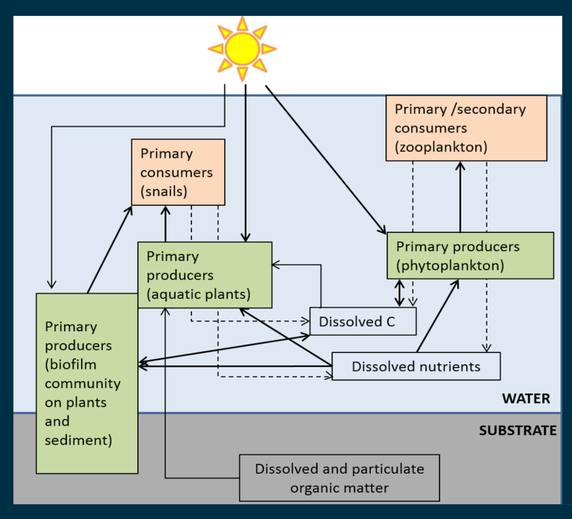
Inclusion Criteria

The resulting list of literature were further limited based on three criteria;

- **Trophic level** – 2 or more
- **Size**- 100 L of fluids or a surface area of one m^2 was applied due to safety issues like accumulated waste from an experiment including radionuclides or the size of a gamma irradiation beam.
- **Complexity** – 3 species or more for ecological relevance

**Studies exclusively studying bacterial communities were excluded.*

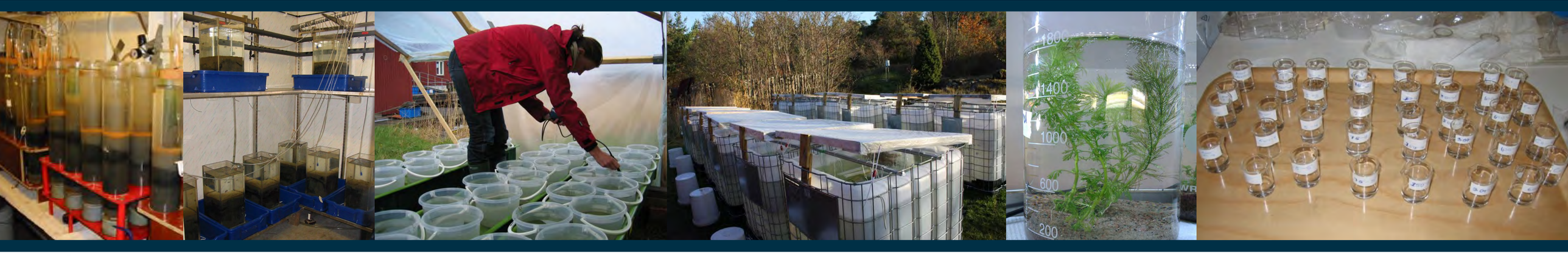
Only abstracts were read in the first exclusion round, and evaluated based on inclusion criteria. We performed overlap reading of 10% of all articles to ascertain potential reader bias.



Results so far…

Our initial search, under tier one, resulted in **21,000 articles**. In radiation research however, micro- and mesocosms are rare, most examples are of aquatic systems and very few terrestrial ecosystems. Our review thus far has resulted in approximately **3,000** studies of potential interest, of which less than **20** studies include the term ionizing radiation.

- Of **3,000** abstracts, **700** were selected as meeting all of our inclusion criteria.
- These **700** articles will be included in the spreadsheet (unless they do not meet our inclusion criteria after entire article is read).
- Thus far, **315** papers have been evaluated, of which **196** are included in our spreadsheet.



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4. Beyers. R and Odum. H (1994) Ecological Microcoms. Springer-Verlag New York Inc. New York, NY, United States
5. Spivak. AC et al., (2010) Moving on up: can results from simple aquatic mesocosm experiments be applied across broad spatial scales? Freshwater Biology 56:279–291