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ME 420 Mechanical Engineering Individual Research Project

Design of a Turbulence Generator for Limnological Studies

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Background & Problem Domain

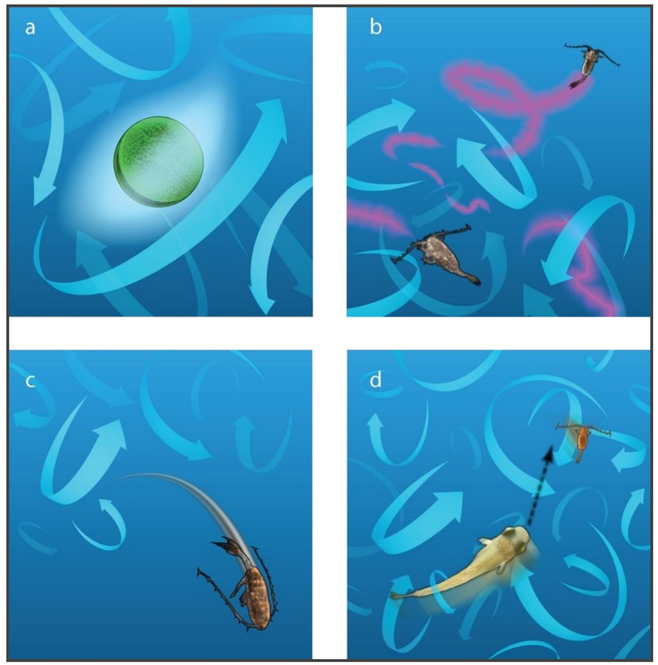

Figure 1: *Interaction between small-scale turbulence and aquatic organisms (adapted from literature)*

- Limnology refers to the study of physical, chemical, and biological processes in inland water bodies such as lakes and rivers
- Small-scale turbulence plays a key role in limnological processes and organism behavior.
- Limitations exist in current laboratory-scale turbulence generation methods.
- **Engineering challenge: generating controlled, repeatable turbulence suitable for flume-based limnological experiments.**

Knowledge Gaps and Significance

- Laboratory turbulence generators are widely used in experiments.
- Existing studies employ diverse and application-specific turbulence generation mechanisms.
- Design details and engineering validation are often limited or not systematically reported.
- Lack of standardized, well-documented turbulence generator designs for flume-based limnological studies
- Need for a systematically designed and experimentally validated turbulence generator from an engineering perspective.
- Limnological turbulence is commonly quantified using the turbulent kinetic energy dissipation rate (ε), which spans several orders of magnitude depending on the environment. (Typical reported values are on the order of 10^{-9} to 10^{-5} m^2/s^2.)

Objectives

01. Review state of the art small scale turbulence generators that can be used in a flume.

02. Design a suitable turbulence generator.

03. Fabricate a prototype.

04. Validate the prototype by deploying it in a flume.

Proposed Methodology and Timeline

Table 1 : Proposed project methodology and timeline

Phase	Activity	Timeline (Weeks)	Semester
1	Literature review and identification of limnological turbulence scales	1–7	7
2	Conceptual design and selection of turbulence generator configurations	5–8	7
3	CAD-based detailed design of the selected configuration	8-11	7
4	Simulations of the selected configuration	11-13	7
5	Final design refinement based on simulation results	1-4	8
6	Prototype fabrication	4-8	8
7	Experimental testing in a laboratory flume	8–10	8
8	Data analysis and final reporting	10-14	8

Expected Outcomes

01 A detailed and validated design of a turbulence generator for limnological studies.

02 Defined turbulence performance targets based on limnological requirements.

03 Fabrication of a prototype and experimental validation.

References

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Thank You