Międzynarodowa Środowiskowa Szkoła Doktorska
przy Centrum Studiów Polarnych
w Uniwersytecie Śląskim w Katowicach

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Title of PhD project: Sedimentation of solid particles in aqueous systems with rheological properties modified by dispersed biopolymers

Providing institute: Institute of Geophysics of the Polish Academy of Sciences

Requirements:

1. Master's degree in chemical and process engineering or physics.
2. Experience in working in a laboratory.
3. Very good knowledge of fluid mechanics.
4. Programming skills to analyse and visualise data (e.g., R, Matlab). Moreover, programming in Java or Python will be an asset.
5. An additional asset will be BSc and MSc theses confirming the abovementioned skills,
1. scientific publications, conference presentations, and participation in research projects.
6. Very good knowledge of English, and effective communication in speech and writing.

Description of the tasks:

1. Participation in the preparation and execution of hydrodynamic experiments using highresolution visualisation and image analysis methods and Particle Image Velocimetry.
2. The analysis of image data to assess the sinking dynamics of solid particles and the flow field of fluid around particles.
3. Measurements and analysis of rheological properties of biopolymer aqueous solutions.
4. Preparation of scientific papers and conference presentations.
5. Regular reporting on work progress.

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6. Taking part in scientific and didactic tasks of IG PAS, specifically the Laboratory of Hydrodynamic Micromodels where PhD thesis will be conducted.

Summary of the doctoral project:

Sedimentation is a relevant element of biogeochemical cycles in water bodies. Particles such as plankton, mineral grains, organic matter and their aggregates take part in CO2 transport, and the cycling of nutrients and pollutants, e.g., nano- and microplastics. However, sedimentation remains understudied in the conditions of intense algal blooms in seas and lakes, known as mucilage events when microorganisms release excessive amounts of biopolymers (e.g., polysaccharides and proteins). These polymers form hydrogel networks of varying degrees of aggregation, which can result in water changing its properties from Newtonian to non-Newtonian, thereby modifying the hydrodynamics of environmental processes. Understanding how modification of the rheological properties of natural waters affects sedimentation is crucial for comprehending current environmental problems since the intensity and extent of algal blooms are likely to increase with ongoing climate change.

To understand these processes we must gain knowledge of interactions between a solid particle and fluid which change with an increasing concentration of biopolymers. Previous research conducted at the Laboratory of Hydrodynamic Micromodels of the IG PAS, where the PhD thesis will be carried out, has shown that rheological properties of the fluid such as shear-thinning and viscoelasticity induce fluctuations in the particle's falling velocity, chaotic motion trajectory, instability of spatial orientation and changes in the velocity field in the particle's wake. These effects influence the drag on sinking particles and thus the sedimentation rate. However, the details of these processes in an environmental context need further extensive investigations. **The main goal of the proposed PhD thesis will be to determine the impact of the modified rheology of aqueous solutions on the dynamics of falling solid particles.** The

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research aims to compare non-Newtonian effects in freshwater and saltwater environments, taking into account the influence of pH and ionic strength on the formation of the gel structure of solutions. In the study, particles with specific physical properties and model polysaccharides, a dominant type of biopolymer during algal blooms, will be used. Experiments will be conducted in sinking columns using visualization techniques, high-resolution cameras and the Particle Image Velocimetry (PIV). Additionally, rheological measurements will be performed for the tested systems.

In addition to a significant contribution to the development of Earth and Environmental Sciences, the results will constitute a platform for exchanging knowledge in the field of two-phase flows and rheology of aqueous solutions of biopolymers with basic research fields (e.g. fluid mechanics, physical chemistry) and applied sciences (e.g. mining, pharmacology, food technology) that use related systems in technological processes.

Other information:

The work will be carried out under the supervision of:

dr hab. inż. Magdalena Mrokowska, prof. IG PAS, e-mail: m.mrokowska@igf.edu.pl, Institute of Geophysics PAS.

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Information on the IEDS admissions: https://www.mssd.us.edu.pl/en/admission-2024-2025/