**Talking algae: an early warning system for water quality threats**

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**Full Project Description**

Algae are aquatic plants that can be extremely beneficial to ecosystems via oxygen production. Diatoms are a type of microalgae which are ubiquitous in most aquatic systems and perform a wide range of key ecosystem services, from primary productivity and carbon storage, to coastal erosion mitigation. Diatoms are an essential element of the food web of many aquatic ecosystems. However, seasonal algal blooms which occur as a result of anthropogenic nutrient loading can have severe impacts on human health, aquatic ecosystems, and the economy. Diatom blooms can be particularly harmful in water supply reservoirs, due to toxin production and filter blocking at water treatment works. Although their importance is commonly recognized, their behaviour is yet not fully understood. One open fundamental question is how these cells adapt to sudden changes in their physicochemical environment and evolve into harmful blooms.

Until now, there has been no consensus on whether diatoms communicate with each other and no accurate and self-sustained tool to monitor alterations in the aquatic ecosystem. Our group recently verified that the diatoms do in fact communicate via showing for the first time that electrical communication of cells can be recorded extracellularly by means of a unique measurement setup using low-impedance electrodes. This low impedance allows low frequency measurements of the whole population of cells, with improved signal-to-noise ratio. We have previously investigated Pseudo-nitzschia fraudulenta, given their ecological importance as a harmful algae bloom forming species. One key surprising finding of our work was that the electrical response of diatoms under light is completely different from that in dark: in light, the diatoms are electrically silent; however, in complete darkness a population of diatoms exhibit pronounced quasi-periodic oscillations or intercellular waves. These findings open a new page in the understanding of algal signaling and enable novel sensing technologies to predict the development of algae blooms and of an extensive range of stress-induced alterations in the aquatic ecosystem. To develop a technology able to sense and predict the development of algae blooms and translate an extensive range of stress-induced alterations in the aquatic ecosystem this project will address the following objectives:

• Devise sensors for microalgae monitoring

• Characterise the electrical signals from different types of microalgae and cyanobacteria, and their reaction to stress conditions (e.g. nutrient limitation and light stress)

• Relate cell signalling with cell health and productivity.

The PhD student will receive advanced training in electrical characterisation of organic sensors, electrophysiology and in biology-related subjects such as microalgae maintenance and growth. Additionally, the PhD student will gain valuable experience in leadership, organisation, and dissemination through courses at the University of Bath in research management, public engagement and scientific communication. As the project has a primary aim of developing an early warning system for algal bloom formation, liaison with the Water Industry (e.g. Welsh Water, Bristol Water and Wessex Water) will maximise project impact and student training opportunities.

**Real Life challenges this project will address**

Algae are aquatic plants that can be extremely beneficial to ecosystems via oxygen production. Diatoms are a type of microalgae which are ubiquitous in most aquatic systems and perform a wide range of key ecosystem services, from primary productivity and carbon storage, to coastal erosion mitigation. Diatoms are an essential element of the food web of many aquatic ecosystems. However, seasonal algal blooms which occur as a result of anthropogenic nutrient loading can have severe impacts on human health, aquatic ecosystems, and the economy. Diatom blooms can be particularly harmful in water supply reservoirs, due to toxin production and filter blocking at water treatment works. Although their importance is commonly recognized, their behaviour is yet not fully understood. One open fundamental question is how these cells adapt to sudden changes in their physicochemical environment and evolve into harmful blooms. Until now, there has been no consensus on whether diatoms communicate with each other and no accurate and self-sustained tool to monitor alterations in the aquatic ecosystem.

**What you should know about this project**

This multidisciplinary project will seek to develop an early warning system for algae blooms, a key topic and highly relevant for the water industry. The novel early warning system for algal blooms will be based on cell signalling that is stimulated by an increase in productivity due to changes in nutrient dynamics, reservoir mixing and other environmental variables. This interdisciplinary work has strong scientific and technological implications for probing ecological and physiological stress conditions in phytoplankton populations. The supervisory team comprises world-class expertise to develop this project from Biology to Electrical and Civil engineering. Additionally, they are the first ever academics to develop a remarkably easy sensing method to electrically detect micro-algae signalling. Furthermore, as the project has a primary aim of developing an early warning system for algal bloom formation, liaison with the Water Industry (e.g. Welsh Water, Bristol Water and Wessex Water) will maximise project impact and student training opportunities.

**What expertise you will develop**

The PhD student will receive advanced training in electrical characterisation of organic sensors, electrophysiology and in Biology related subjects such as micro-algae maintenance and growth. Specifically, the student will develop expertise in

(1) Material characterisation and fabrication, such as cleaning, spin-coating, metal evaporation, optical microscopy, atomic force microscopy scanning and electron microscopy and

(2) Electrical characterisation such as current-voltage characteristics, pulse measurements, Admittance Spectroscopy methods and Electrical Noise techniques,

(3) Analysis and modelling of cell-electrode interaction through software suites such as PSpice, Matlab and LabVIEW,

(4) Molecular biology tasks such as cell handling and maintenance

(5) Cell culturing and design and implementation of stress manipulation experiments, and

(6) Use of variable chlorophyll fluorescence methodology.

**Why this project is novel**

Until now there has been no consensus that microalgae communicate with each other. This project is novel because it will develop a system able to monitor real time microalgae communication. The project will build a reliable set of data to develop an understanding of algal signalling and enable novel sensing technologies to predict the development of algae blooms and of an extensive range of stress-induced alterations in the aquatic ecosystem. Specifically, this project will:

• Devise an electrochemically stable transducer for microalgae long term electrical monitoring

• Characterize the electrical signals from different types of microalgae and cyanobacteria, and their reaction to stress conditions (e.g. nutrient limitation and light stress)

• Relate cell signalling with cell health and productivity.

**Rest of Supervisory Team:**

**Stakeholder** Wessex Water

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