**Project Title**

Environmental triggers for Geosmin production in freshwater ecosystems

**Lead Supervisor Name**

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**Full Project Description**

This project will determine the triggers initiating cyanobacterial production of taste and odour problem metabolite, 1,10-dimethyl-trans-9-decalol (geosmin). Geosmin is a metabolite produced in drinking water supply reservoirs primarily by cyanobacteria. It is a natural compound that results in an unpleasant earthy and/or musty taste to drinking water, resulting in customer product rejection and complaints. To prevent this, final treated water undergoes costly removal of these compounds using activated carbon filtration, at a cost of up to £1,500 per day per water treatment works. Taste and odour issues are estimated to cost the UK Water industry over £200 million per annum (Drinking Water Inspectorate, DWI). This project will deliver a mechanistic model of the triggers for geosmin production that will drive evidence based management of lakes and reservoirs. Geosmin is produced by cyanobacteria in the mevalonate (MV) and 2-methylerythritol-4-phosphate isoprenoid (MEP) metabolic pathways. It is a precursor for a range of important cellular compounds in cyanobacteria, including photosynthetic pigments. Recent work by the PI within Welsh Water has determined that geosmin production is the result of periods of rapid growth phase by cyanobacteria when exposed to reducing or low concentrations of nitrate and increasing or high concentrations of ammonium. This can be explained as ammonium is the most biologically available nitrogen (N) fraction, being the most reduced form in aquatic systems. This project will use three test sites to determine nutrient triggers for geosmin synthesis by cyanobacteria: Pentwyn and Pontsticill reservoirs and Llwyn-Onn reservoir have been studied by the PI and are known sites with geosmin production and cyanobacteria taxa recorded include Dolichospermum and Oscillatoria, both known geosmin producers. The water chemistry at each site has been studied as part of a taste and odour investigation by the PI and Welsh Water. The test sites therefore provide ideal sources for samples to test for a mechanistic pathway between nutrient supply and geosmin synthetase activity and hence geosmin production. The student will perform the following tasks to determine causal limakge between nutrient dynamics and geosmin production:- • Samples will be collected from each test site to determine molecular protocols for measurement of geosmin synthetase activity, expressing this as a function of the total geosmin synthetase pool present. This will enable a quantitative measurement of gesomin synthetase activity to be produced. • Taxa of cyanobacteria present will be determined by molecular techniques to determine the likely source taxa. • Manipulative nutrient experiments concentrating on relative supply rates of ammonium, nitrate and phosphate will be performed in ex situ flow through semi-continuous batch cultures. • Nutrient experiments will be repeated under a range of environmental simulations, e.g. manipulating temperature and light field. • Measurements will be made of productivity, health (e.g. nutrient limitation) and photophysiological down regulation (light acclimation state), using variable chlorophyll fluorescence. • Measurements will be made of intracellular and extracellular geosmin concentration. • Manipulations will then be tested in ex situ mesocosm studies facilitated by research collaboration of the CoI and the Centre for Ecology and Hydrology (CEH).

**Real Life challenges this project will address**

Taste and odour issues is a key priority within the UK Water Industry and abroad. In recent years there has been a UK-wide increase in customer complaints regarding drinking water supply due to earthy and musty taste and odour. The cause of this has been linked to volatile organic compounds (VOCs), in particular 2-Methylisoborneol (MIB) and 1,10-dimethyl-trans-9-decalol (geosmin). In water supply reservoirs, the main producers are the cyanobacteria, in particular the filamentous species such as Oscillatoria and Dolichospermum. The problem to the Water Industry is that, when the cyanobacteria are damaged or die, geosmin and MIB are released and hence get into the water supply system, either in the reservoir or during treatment. Their removal then requires treatment, including the use of activated granular or powdered carbon (GAC and PAC respectively) filtration. It is estimated that MIB and geosmin cost the UK Water Industry over £200M per year, e.g. including daily treatment costs of £1.5k per Water treatment Works over late summer periods of maximum cyanobacteria productivity. This project will determine the causes of geosmin production and hence provide the evidence to support catchment management intervention to mitigate the problem. This is an essential aspect regarding water supply resilience in the face of climate change which favours enhanced cyanobacterial abundance.

**What you should know about this project**

This interdisciplinary project addresses a critical issue (taste and dour in drinking water supply) for the Water Industry exploiting a blend of classical fresh water ecology and algal physiology combined with genomic approaches to determine the functional drivers underlying Geosmin production. The student should have a sound background in basic freshwater ecology and ideally an understanding of nutrient dynamics in relation to cyanobacteria harmful algal blooms (HABs). The PI, Dr Rupert Perkins, and CoI, Professor Peter Kille, are experts in their respective fields and have a track record of working with Welsh Water and the Environment Agency respectively. These interactions place the supervisory team in a unique position to apply there combined expertise to a real-world issue that impacts water industry and Environmental regulators equally. There will be a strong industry link throughout the project, with applied supervision from staff within the Catchment Management team at Welsh Water.

**What expertise you will develop**

The student will develop expertise on how nutrient dynamics impact on the physiology of prokaryote and eukaryote phototrophs in fresh water systems. This will be combined with genomic and bioinformatic training to characterise the regulation of geosmin biosynthesis pathways within benthic algal biofilm that impact fresh water systems. The project will work closely with Welsh Water exposing the student directly to the Water Industry. The student will be part of the Cardiff University postgraduate school and hence be able to utilise a wide range of training options, as well as having the opportunity to work within Welsh Water for short placements to maximise the usefulness of the project outputs.

**Why this project is novel**

Exploiting genomic tools to unravel the geosmin production within real-world algal communities represents an ambitious and highly unique opportunity. Currently the supervisory team, working with Welsh Water, have identified aspects of nutrient dynamics that trigger geosmin production by cyanobacteria within Welsh Water drinking water supply reservoirs. However there has been no linkage between nutrients, cyanobacteria productivity and geosmin synthetase activity and geosmin production. The work is therefore completely novel research as it aims to determine this casual pathway.

**Rest of Supervisory Team:**

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