Removing organometallic compounds from wastewater

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Introduction:

Over the years, organometallic compounds such as organo tin and lead compounds, have been used in a wide number of commercial applications. As a result, the environment has received a large load of these highly toxic compounds, causing environmental and economic damage worldwide. Because of their toxicity and bioaccumulation potential most of these compounds have been registered as priority pollutants by the European Union in the Pollutant Emission Register and in the Water Framework Directive. This means that they have to be removed before (waste)water can be discharged. This represents a real challenge for the (waste)water industry as some organometallic compounds are persistent in water or cannot be removed by current technologies/treatment methods. Recently, Arvia technology Ltd (the case partner in this project) developed a novel water treatment technology that uses a low capacity, proprietary graphitic adsorbent material (Nyex TM) that can be electrochemically regenerated, to remove and completely oxidize organic contaminants from aqueous solutions. This technology has been successfully applied in the removal of acid violet and metaldehyde from water. In addition, in a recent lab scale pilot study it has been successfully applied in the removal of tributyltin from water showing the potential to remove a wide range of other organometallic contaminants. Although, this technology might provide a simple, flexible and reliable solution to organometallic waste problems with significantly lower operating costs than traditional alternatives it remains unclear whether this is possible. This is because the fundamental molecular scale adsorption processes associated with this technology and the effectiveness of removing target organometallic compounds in complex, natural, water samples, such as peat waters, are still poorly understood. In addition, it remains unclear what happens to the metal after the treatment, if it binds to the surface of the adsorbent material, 'poisoning' the Nyex and can have a negative impact on the treatment process.

Project Summary:

In this project the effectiveness of this process for the destruction of a variety of organometallic compounds (such as organo tin and lead compounds) in synthetic and complex (natural) water matrices will be assessed. This will be done using, small/lab scale set ups as well as larger, industry size treatment units. A variety of state of the art analytical and imaging technologies, including techniques that allow detailed information about the organometallic composition and structure at the single and sub-particle level to be collected, will be used to examine the fundamental relationships behind the attachment, detachment and possible fragmentation reactions that occur on the adsorbent surface during the process. These will include experiments to characterise the starting material, determine the breakdown products and to acquire snapshots of ex situ reacted surfaces. Modelling of adsorbate-organics interactions will be used to produce predictive models for different classes of contaminants. Critically, the synergy of the lab

scale and larger scale experiments, the use of state of the art analytical/imaging techniques and modelling will allow the effectiveness of the destruction process to be deduced, providing a step change in our understanding of this potentially important novel wastewater treatment method.

The student working on this cross-disciplinary project will gain a wide breadth of training in hydrology, organic (geo)chemistry, environmental mineralogy/surface chemistry and analytical (geo)chemistry and would suit a student with a background in any of these fields. They will have access to world-class facilities in the Williamson Research Centre for Molecular Environmental Science at the University of Manchester. The techniques will provide a basis for a future career in environmental science, in the industrial, government or academic sectors, in a rapidly expanding research area of international importance. The student will also work with the industrial partner in this project, Arvia Technology UK, bringing appropriate research budget enhancements and exposure to a thriving industrial environment.

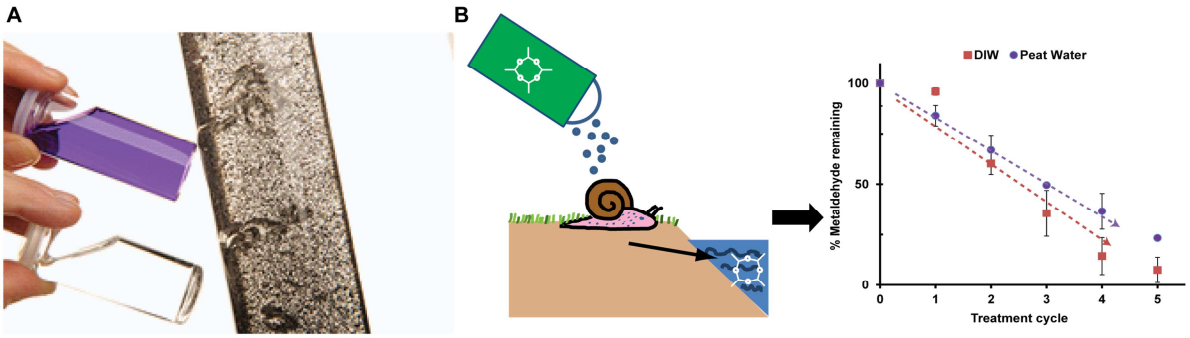

Image 1 Caption – Removal of (A) acid violet (dye) and (B) metaldehyde (pesticide to control snails and slugs) from water using NyexTM.

References

1) Mohammed et al. (2011) Continuous water treatment by adsorption and electrochemical regeneration. Water Research, 45 (10), 3065-3074; 2) Brown et al. (2004) electrochemical regeneration of a carbon-based adsorbent loaded with crystal violet dye. Electrochimica Acta, 49, 3269-3281; 3) Asgha et al. (2012) Waste water treatment by adsorption with electrochemical regeneration using graphite-based adsorbents, 42, 797 - 807; 4) Nabeerasool et al. (2015) Removal of metaldehyde from water using a novel coupled adsorption and electrochemical destruction technique. Water 7 (6), 3057-3701.