PROJECT 1

Title: Degradation of Trace Organic Wastewater Contaminants in a Tropical Coastal Aquifer

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Introduction

The presence of trace levels of organic contaminants in wastewaters is an issue of concern where such waters are reclaimed for potable and non-potable uses. The potential impacts of some of these compounds include abnormal physiological processes and reproductive impairment (e.g. endocrine disrupting chemicals), increased incidences of cancer and development of antibiotic-resistant bacteria. Hence, there is a need to identify and quantify the organic contaminants present and to understand their fate in the environment. In the past, one of the problems has been in the analytical techniques for detecting these compounds at low concentrations. However, new and more sensitive methods are now emerging, enabling better detection and quantification of trace organics. In this study, LCMSM will be used to develop protocols to detect pharmaceutical residues, hormones and other organic wastewater contaminants that may be present in treated wastewaters and reclaimed waters.

One of the ways in which wastewaters can be reclaimed is through Soil Aquifer Treatment (SAT), where microbes, soil and groundwater act to further remediate and remove contaminants. Recent studies executed at Stanford and elsewhere have demonstrated that SAT is an effective method for removing some of the organic contaminants, such as alkylphenol ethoxylate residues and some chelating agents (EDTA, NTA). Preliminary data obtained at an Arizona site indicate that SAT may also be effective for the removal of some commonly found pharmaceuticals. Information to predict these removals is incomplete, however. More detailed studies are needed to specify the geochemical conditions and the residence time required for complete removal and, most importantly, to design SAT systems such that the water quality meets specified standards.

Objectives

This study will focus on the behaviour and transformations of selected trace organics (e.g. pharmaceutical residues) when exposed to soil, microbes and groundwater conditions typical of a tropical coastal aquifer. Specific objectives are to

1. Investigate the occurrence of pharmaceutical trace contaminants in biologically treated wastewater
2. Identify the biological transformations of pharmaceutical trace contaminants that occur during SAT
3. Correlate the occurrence of trace contaminants and the extent of treatment with bioassay

Research Approach and Research Tasks

The student will design and execute coordinated laboratory and field experiments to study sorption and biodegradation behaviour so that an understanding of the mechanisms of fate and transport during groundwater recharge can be established. The approach will be to characterize

contaminant attenuation in microcosms that simulate field conditions and to verify the applicability of these findings by comparing laboratory data with field data.

Specific Research Tasks

1. Optimisation of analytical protocols for selected pharmaceuticals including ibuprofen, ketoprofen, and carbamazepine using HPLC/MS/MS,
2. Screening biological effluent and the Changi experimental field sites for pharmaceutical residues,
3. Determine isotherms for the selected compounds with Changi sand using previously developed protocols to establish a concentration-time and concentration-distance relationship,
4. Development of soil microcosms with materials from the ongoing column studies for the study of biological contaminant transformation under recharge conditions,
5. Identification of metabolites and pathways using a combination of advanced analytical techniques.
6. Compare microcosm results with results from the field.

Organization and Training

This study will complement ongoing research efforts in the Water Quality Analytics of the Clean Water Programme (CWP), a collaborative study with Stanford University. For the CWP, the WQA team is tasked to develop protocols for the analysis of water quality to evaluate the SAT for the Changi aquifer site. Some of these protocols have been provided through the Stanford collaboration and some will be jointly developed as the research progresses. The SSP student will be able to participate in the method development for detecting target organic compounds of interest and hence, to use the developed technique to further explore the fate and transport behaviour. In particular, the student will be able to support the ASR field study by carrying out measurements of selected organic contaminants in the effluent plume when it is injected into the coastal aquifer. It is anticipated that the student will initially spend some time at Stanford University on method development for characterization of the selected trace organic contaminants, and subsequently carry out the bulk of the experimental work at NTU. Both universities have recently acquired an API3000 LCMSMS system so there is compatibility in data acquisition whether the student is working at Stanford or at NTU.