IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Chemical and Biological Remediation Methods for Coal Acidic Mine Drainages (CAMDs)	
Project Number	**IMURA0386**	
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Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?
(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

1. Advanced computational engineering, simulation and manufacture
2. Infrastructure Engineering

3. Clean Energy
4. Water √ **(Mining, Water Reclamation)**
5. Nanotechnology
6. Biotechnology and Stem Cell Research

The research problem

Define the problem

Coal mining processes and abandoned coal mines (as in the case of Singrauli area, Madhya Pradesh (MP), India) cause several types of environmental problems. Some of the major problems are: a) generation of coal acidic mine drainage (CAMD); b) presence of dissolved heavy metals in the acidic discharge and c) the presence of the sulphur in the oxidized or reduced form in the mine water. The priority environmental problem to be addressed is the acidic discharge that typically permeates to the ground water table and causes acidification of water body and the surrounding environment. Acidic conditions are lethal to most of the plants, animals and microorganisms. CAMD is typically caused due to oxidation of organic sulphur and/or pyritic sulphur (FeS_2) due to its exposure to oxygen and water during mining of coal according to the reaction represented below:

$$FeS_2 + 3.75O_2 + 3.5H_2O \leftrightarrow Fe(OH)_3 + 2H_2SO_4$$

The pyritic sulphur can be varying and as high as 5%. The generation of sulphuric acid causes reduction in the pH of coal mine drainage to values as low as 3-4. Further oxidation of Fe^{+2} (ferrous) to Fe^{+3} (ferric) by iron oxidizing bacteria can enhance the rate of oxidation of pyritic sulphur and aggravate the acidification problem. Thus there is a need to select and implement appropriate combination(s) of chemical and biological treatment methods that are sustainable in the long run for: a) neutralization of CAMD and b) removal of toxic heavy metals and c) removal sulphur through reduction and precipitation as metal sulfides or as elemental sulphur (S^0).

Project aims

Define the aims of the project

The goal of the proposed project is to select appropriate chemical and biological treatment options for CAMD mitigation. The overall aim is to develop a treatment technology that is sustainable in terms of cost, energy requirement, with minimal environmental impacts.

Specific Objectives of the Project

1. Neutralization of acidic discharges using locally available Red Mud (Bauxite residue or waste product) generated by Hindalco Alumina refinery at Renukoot, MP, India which is

very basic in nature. In addition other organic matter to neutralize the pH and promote metal precipitation will be also tried.

2. Use of sulfate reducing bacteria (SRBs) in a bioreactor for treating coal generated acid mine drainage. SRBs are obligate anaerobic bacteria and use sulphate as the terminal electron acceptor in their respiration process and reduce it to sulphide (S^{2-}). This metabolic process generates alkalinity and also precipitates metals. A major drawback of SRBs is that mostly sulfate reduction is slow at acidic pH (at ~ 3.0 - 4.0). The process is known to be approximately 300 fold slower as compared to that of at pH 6.0. However some recent investigations have reported reduction of sulfate to sulfide at pH as low as 3.00. Thus there is need to isolate, characterize such SRBs which can be subsequently be commercialized for field scale applications to treat acidic mine drains. The reactions for sulphate reduction by SRBs and formation of metal sulfide are represented below:

$$2CH_2O(aq) + SO_4^{2-} \rightarrow H_2S + 2HCO^{3-}$$

$$H_2S + Fe^{2+} \rightarrow FeS$$

$$2H_2S + Fe^{3+} \rightarrow FeS_2$$

3. Development of a low cost batch/continuous flow anaerobic reactor containing acidophilic sulphate reducing bacteria immobilized on a suitable support matrix. The growth of SRBs will be supported using cheap locally available carbon souce such as compost, bagasse or other agricultural residues.

4. Lab scale and pilot scale trial studies on the proposed chemical-biological methods and cost-benefit analyses.

Expected outcomes

Highlight the expected outcomes of the project

1) Development of a method using locally available Red Mud for neutralizing CAMD and absorbing heavy metals from CAMD.

2) Isolation of acidophilic sulphate reducing bacteria (SRBs) that can reduce sulphate/sulphite to elemental sulphur or sulphide. Sulphide can be subsequently precipitated as metal sulphides.

3) Development of a low cost anaerobic reactor using isolated acidophilic SRBs immobilized on a cheap matrix and carbon sources such as compost, agricultural residues, food processing industrial waste materials etc.

4) Economic analyses of chemical and biological treatment methods and further improvement of the efficiency of these proposed methods.

5) Lab-scale and pilot scale studies for the possible field scale implementation of proposed chemical-biological technology.

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

The project addresses one of the themes, Water. The proposed research project aims at the treatment and reclamation of huge volume of wastewater generated by acidic coal mines in India and stored in huge open pits. These open pit water contaminatet he nearby water bodies, soil and vegetation. The aim is to treat acidic water using low cost locally available red mud and biological reactors to remove sulphur, toxic heavy metals thatmeets the prescribed discharge permit limits.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

M. Tech in Environmental Engineering and Science or M. Tech in Chemical Engineering or M. Tech in Biotechonology or M.Sc with specialization in Chemistry and valid GATE score. The students should have aptitude for research and have good knowledge in the area of organic and inorganic chemistry, biochemistry.

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.