## Improvement of Sulfate and Metal Removal from Industrial Wastewater Using Marine Waste Extract as an Economic Source of Nitrogen Supplement

Sulfate and metal rich wastewater is generated from the industries such as mining, electroplating, metal processing and chemical. Different chemical and biological methods are available to treat such wastewater. Among the methods, sulfate reducing bacteria (SRB) mediated passive treatment was found promising in terms of its cost effectiveness and environment friendly nature. The efficiency of the SRB mediated treatment system is dependent on the resilience of the microbial community inside the bioreactor. The resilience of the SRB community is dependent on the availability and assimilation of the nitrogen from its source in the growth substrates. Further, developing area of research in this field is to transfer the knowledge of conventional treatment methods to a plant based system that can be used for various applications. The underlying objective of the current work is to develop suitable substrate rich with organic nitrogen in a reactor and measure it in terms of cost, and ability to support sulfate, and metal removal. The first two chapters include the introduction and literature review on the subject. The rest of the work of the thesis is divided in remaining three chapters that would explain the work carried out.

The protein rich extracts,prepared from marine organic wastes, were used to develop an alternative nitrogen source for SRB. Two different methods were followed to prepare the extract, such as alkaline hydrolysis and *Lactobacillus* mediated fermentation. The resulting extracts were termed as marine waste extract (MWE) and *Lactobacillus* fermented marine waste extract (MWEL), respectively.Nutritional characterization study indicated that both the extracts were rich in nitrogen. A detailed cost analysis indicated the MWE is a cost effective nitrogen source. The above is given in detail in chapter 3.

In the batch study explained in chapter 4, the comparison between MWE, MWEL and the commercial nitrogen sources (tryptone, $NH_4Cl$, yeast extract, corn steep liquor and $NH_4HCO_3$) indicated that MWE was best able to support growth of SRB and sulfate reduction. MWE supplemented SRB growth medium (MSRB) was able to support higher growth of SRB than the standard growth media such as, Postgate B, modified Postgate B, and Widdel and Pfennig. In the batch study, the optimization of multiple parameters such as pH, sulfate and MWE using response surface methodology (RSM) indicated that the positive interaction of the optimized parameters could improve both the SRB growth and sulfate reduction.

Similarly, the continuous study, as reported in chapter 5, was performed using a laboratory scale packed bed reactor (PBR). The kinetics study revealed that the growth rate of SRB was kinetically favorable at the optimized dosing of sulfate and MWE, and it followed the uncompetitive inhibition model.The Denaturing Gradient Gel Electrophoresis (DGGE) and Fluorescent *in-situ* Hybridization (FISH) showed that the microbial population developed inside the PBR was dominated by the SRB population (87-89%) and contained diverse microorganisms such as *Desulfotomaculum*, *Desulfovulgaris*, *Desulfobacter*, *Clostridium*, *Bacteroides*, *Aminobacterium* and *Aminomonas*. The optimization of pH, HRT, sulfate, TOC, and MWE concentration using Taguchi approach exhibited the influence of the parameters in the following order, pH> MWE> sulfate> HRT> TOC. When operated at the optimized conditions, the total treatment process could successfully remove nearly complete sulfate (96-99%) at the rate of 60-62 mg/L. h. from the wastewaters collected from the coal and metal mines. The metals such as Fe, Cu, Zn, Ni and Mg were also removed significantly (98-99%).

In conclusion, as provided in the chapter 6, the process developed and the results obtained showed the prospect of promising commercial development of a sustainable technology to treat the wastewater in a large scale.


***Keywords:***Nitrogen source; sulfate reducing bacteria; sulfate and metal rich wastewater; marine waste extract; single and multiple parameter optimizations; Box-behknen design; Taguchi approach; SRB growth kinetics; packed bed bioreactor.