



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Shweta Singh
Roll Number : 166104009
Programme of Study : Ph.D.
Thesis Title: Biochemical Treatment of Acid Mine Drainage by Constructed Wetlands in Northeast India
Name of Thesis Supervisor(s) : Prof. Saswati Chakraborty
Thesis Submitted to the Department/ Center : Department of Civil Engineering
Date of completion of Thesis Viva-Voce Exam : 10/11/2022
Key words for description of Thesis Work : Acid mine drainage, Constructed wetlands, Heavy metals, Sulfate pollution, Phytoremediation, Metal recovery, Microbial metagenomics.

SHORT ABSTRACT

India is one of the largest producers of coal and coal mines are the major backbone of India's economy. Amongst various pollution concerns of coal mining, the incidence of acid mine drainage (AMD) is widespread and globally regarded as the most challenging wastewater. The management of AMD remains a great challenge as many remediation measures fail to attain a satisfactory economical and sustainable approach. AMD from the North Eastern Coalfield (NEC), Assam, India, is highly polluted and critical investigation of the AMD pollution for the potential remedial measures is scarce. The present study demonstrates a passive treatment strategy for AMD from the NEC using constructed wetlands (CWs). The influence of climatic variables on AMD characteristics and its deleterious impact on the surrounding soil was investigated. Elevated concentration (in mg L⁻¹) of Fe (0.12–302), Al (6.73–32), Mn (0.10–16), Co (< 1.47), Ni (< 5.24) and Cr (< 0.54) were found in the AMD. The release of pollutants increased in the monsoon season, followed by highly concentrated pollutants in the post-monsoon season. The change in the season had a predominant effect on the oxidative leaching of sulfide minerals. Horizontal subsurface flow CWs (HSSF-CWs) were designed to treat simulated AMD. The treatment performance of HSSF-CWs (A and C) utilizing various organic wastes as the wetland media were compared. Partial to complete removal of metals with negligible Mn removal and moderate sulfate removal (57–62%) was obtained. Media accounted major retention (58–95%) and plants (*Typha latifolia*) exhibited negligible metal uptake. Toxicity Characteristic Leaching Procedure suggested safe media disposal. The release of weakly bound Mn, Al, Co and Ni was indicated under an adverse environmental state. The role of plants and the impact of hydraulic loading rates (HLRs) in the remediation of AMD and metal attenuation were studied in planted (PCW) and unplanted (CCW) CWs. Significant impairment of sulfate reduction was observed in PCW (24–90%) than CCW (37–93%). Effluent water quality deteriorated and metal removal efficiency reduced drastically on increasing HLR. HLR has an important role in the passive treatment of AMD than the presence of plants in CWs. The application of a chelating agent and organic acids revealed high metal extraction from wetland media. Organic acids achieved comparable extraction efficiency with ethylenediaminetetraacetic acid (EDTA) and further good metal recovery values were obtained. The influence of seasonality on the efficacy of CW microcosms was studied. Rainfall has a stronger influence in the northeastern region of India. The effect of rainfall on sheltered (SCW) and unsheltered (UCW) CWs was investigated under natural conditions. Findings revealed a significant difference in the sulfate reduction of SCW (60%) and UCW (51%). Heavy rainfall imposed a highly sensitive and poor treatment response in UCW, resulting in a significantly lower treatment efficiency for all constituents due to possible shortening of hydraulic retention time in UCW with minimal or insignificant dilution effect. In addition, the long-term treatment appraisal of HSSF-CW (B) comprising gravel media was evaluated under varying COD/SO₄²⁻ ratios using lactate as a carbon source. The high average metal removal efficiency was attained for Fe (73%), Al (79%), Zn (98%), Co (95%), Ni (99%) and Cr (100%), but Mn (21%). As COD/SO₄²⁻ reduced from 0.67 to 0.33, sulfate reduction decreased from 74% to 44% and metal removal efficiency subsided. Dissimilatory sulfate reduction was identified as the major biological pathway. The formation of insoluble metal precipitates (oxides, hydroxides and sulfides) accounted for about 32–76% of metal removal. Major sulfate-reducing and iron-metabolizing microbial groups were identified to control the biochemical cycling of iron (oxidation or reduction) and its bioavailability.