

INTISARI

Air asam tambang merupakan permasalahan lingkungan yang sering terjadi pada penambangan batubara, limbah cair yang berupa air asam tambang mengandung kontaminan logam berat seperti besi dan mangan yang dapat menimbulkan ancaman serius bagi kesehatan manusia, hewan dan sistem ekologi. Berdasarkan hal tersebut, maka diperlukan adanya solusi sebagai upaya perbaikan kualitas air limbah air asam tambang. *Constructed wetland* merupakan salah satu sistem pengolahan limbah yang hemat biaya serta layak digunakan untuk mengolah air limbah dan lipasan (*run off*) yang meniru sistem rawa dengan teknologi yang digunakan berupa *Sub Surface Flow Constructed Wetland* (SSF-CW) dan *Free Water Surface Constructed Wetland* (FWS-CW). Penelitian ini bertujuan untuk mengidentifikasi pengaruh fitoremediasi oleh tanaman akar wangi (*Vetiveria Zizanioides L.*) dan adsorpsi oleh media zeolite alam, serta kombinasi keduanya terhadap penurunan besi dan mangan dalam air asam tambang. Desain *Constructed Wetland* terbuat dari plastic dengan model *Sub Surface Flow Constructed Wetland* (SSF-CW) mempunyai 3 zona, zona 1 yang berupa inlet dan zona 3 berupa outlet mempunyai dimensi 37 X 54,5 X 60 cm sedangkan zona 2 yang berupa zona reaksi dengan dimensi 75 X 52,6 X 43,5 cm untuk dimensi model *Free Water Surface Constructed Wetland* (FWS-CW) adalah 75 X 52,6 X 43,5 cm. Air limbah dialirkan dengan sirkulasi secara terus-menerus menggunakan pompa. Penelitian dilakukan sebanyak 2 kali tahapan. Untuk tahap I, operasi dijalankan selama 15 hari dan tahap II dijalankan selama 24 jam. Studi kesetimbangan adsorpsi dilakukan untuk mempelajari mekanisme adsorpsi zeolite alam dengan metode batch. Uji adsorpsi batch dilakukan dengan mencampurkan zeolite alam dalam jumlah yang berbeda (2,4,6,8 dan 10 gram) dengan 100 ml larutan sintetik, larutan tersebut diaduk menggunakan water bath shaker selama 24 jam pada suhu 32°C, dengan hasil isotherm adsorpsi Freundlich untuk besi dan mangan mempunyai pendekatan R^2 mendekati 1. Pada *Constructed Wetland* tahap I besi dan mangan hampir habis terjerap 100% pada reaktor RI dan RII sehingga dilakukan tahap ke II dengan penambahan RIII, yaitu menghasilkan keseluruhan penyisihan besi dan mangan yang sangat tinggi pada setiap reaktor, secara berurutan adalah 99,95%, 99,93% dan 97,70% untuk besi, dan mangan adalah 99,97%, 99,35%, dan 94,23%. Kombinasi adsorpsi oleh zeolite alam dan fitoremediasi dengan akar wangi pada RI paling efektif dalam penyisihan besi dan mangan. Model kinetika laju penurunan besi dan mangan dalam limbah air asam tambang pada sistem SSF-CW untuk besi dan mangan mengikuti model pseudo orde 2, sedangkan reaktor III dengan sistem FWS-CW model mengikuti pseudo orde 1 untuk besi dan mangan mengikuti model pseudo orde 2.

Kata kunci: Air Asam Tambang, Adsorpsi, Fitoremediasi, Isotherm Freundlich, *Constructed Wetland*, Penyisihan Besi, Penyisihan Mangan

ABSTRACT

*Acid mine drainage is an environmental problem that often occurs in coal mining, liquid waste in the form of acid mine drainage contains heavy metal contaminants such as iron and manganese which can pose serious threats to human health, animals and ecological systems. Based on this, it is necessary to have a solution as an effort to improve the quality of acid mine drainage. Constructed wetland is a waste treatment system that is cost-effective and feasible to use to treat wastewater and runoff that imitates a swamp system with the technology used in the form of Sub Surface Flow Constructed Wetland (SSF-CW) and Free Water Surface Constructed Wetland (FWS-CW). This study aims to identify the effect of phytoremediation by vetiver (*Vetiveria Zizanioides L.*) and adsorption by natural zeolite media, as well as the combination of both on the removal of iron and manganese in acid mine drainage. The Constructed Wetland design is made of plastic with the Sub Surface Flow Constructed Wetland (SSF-CW) model having 3 zones, zone 1 which is an inlet and zone 3 is an outlet having dimensions of 37 X 54.5 X 60 cm while zone 2 is a reaction zone with dimensions of 75 X 52.6 X 43.5 cm for the dimensions of the Free Water Surface Constructed Wetland (FWS-CW) model is 75 X 52.6 X 43.5 cm. Waste water is circulated continuously using a pump. The research was conducted in 2 stages. For phase I, the operation is carried out for 15 days and phase II is carried out for 24 hours. The adsorption equilibrium study was carried out to study the adsorption mechanism of natural zeolite by batch method. Batch adsorption test was carried out by mixing different amounts of natural zeolite (2,4,6,8 and 10 grams) with 100 ml of synthetic solution, the solution was stirred using a water bath shaker for 24 hours at 32°C, with the results of the Freundlich adsorption isotherm to iron and manganese have an R^2 approach close to 1. In the Constructed Wetland phase I iron and manganese are almost completely absorbed 100% in the RI and RII reactors so that the second phase is carried out with the addition of RIII, which results in a very high overall removal of iron and manganese in each reactor, respectively were 99.95%, 99.93% and 97.70% for iron, and manganese was 99.97%, 99.35%, and 94.23%. The combination of adsorption by natural zeolite and phytoremediation with vetiver in RI was most effective in removing iron and manganese. The kinetics model of the rate of reduction of iron and manganese in acid mine drainage in the SSF-CW system for iron and manganese follows a pseudo-order 2 model, reactor III with a FWS-CW system follows a pseudo-order 1 model for iron and manganese following a pseudo-order 2 model.*

Keywords: *Acid Mine Drainage, Adsorption, Constructed Wetland, Phytoremediation, Freundlich Isotherm, Iron Removal, Manganese Removal.*