UNIVERSITI TEKNOLOGI MARA

PHYTO-ADSORPTION INTEGRATION FOR REMOVAL OF FERRIC ION FROM ACID MINE DRAINAGE: AN EXPERIMENTAL AND MOLECULAR MODELLING APPROACH

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ABSTRACT

A significant environmental issue associated with mining and sulphide minerals is acid mine drainage (AMD). Soil, groundwater, and surface water are all negatively impacted by AMD's high acidity and harmful metal concentration. Oxidation of sulphide and indirect oxidation of ferric ion led to creation of AMD. The water quality is bad with pH level is acidic and not suitable for recreation. The quality of water needs to be restored by removal of ferric ion and suitable treatment methods need to be developed. Hence, for this study, Tasik Puteri is selected as a research base. Among the objectives to be achieved was to characterise water quality of Tasik Puteri based on heavy metals analysis using Inductively Coupled Plasma - Optical Emission Spectrometry (ICP-OES) and pH before ferric ion removal. Next, to prepare and characterise CAMC using Fourier Transform Infrared Spectroscopy (FTIR) and Thermogravimetry Analysis (TGA) as an adsorbent in phyto-adsorption integration. Then, the effectiveness of phyto-adsorption integration for the removal of ferric ion experimentally based on pH and ferric ion content in water, plant and sand before and after treatment. The interaction of ferric ion and CAMC through molecular modelling by BIOVIA Material Studios were also being analysed in this study. A novelty approach is done through an integrated phyto-adsorption for the removal of ferric ion from acid mine drainage. The advantages of integrated phytoremediation and adsorption using modified cellulose are cost effective and environmental friendly. The study was initiated with an analysis of Tasik Puteri water followed by CAMC synthesis and characterisation. Next, pilot plant study of integrated phyto-adsorption was conducted along with an investigation of the molecular interaction of CAMC and ferric ion. The study confirmed that the water is higher of iron content of 1.652 ± 0.159 ppm to 2.213 ± 0.052 ppm. The results is higher than permissible limit by Interim National Water Quality Standards for Malaysia (INWQS) with pH value around 3-4 and fall under Class V that is suitable for irrigation confirmed the occurrence of AMD. Synthesis and characterisation of CAMC as a new potential adsorbent for ferric ion showed that the carbonyl group is successfully embedded in CAMC through FTIR and TGA. Finally, phyto-adsorption integration successfully reduce the ferric ion in water by 98.71% simultaneously increase pH in water by 83.33% and decrease of Fe in sand by 17%. Other than that, based on radial distribution function (RDF) analysis in molecular modelling, it can be concluded that ferric ion were adsorbed on CAMC solvent molecules surface via the formation of Fe-O_2 bond, Coulomb interaction as well as Van der Waals forces. In conclusion, phyto-adsorption integration successfully remove ferric ion and proved by molecular modelling. Furthermore, phyto-adsorption integration can also be a model for an industrial field that relates to iron.

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INTRODUCTION

1.1 Research Background

The physical and chemical deterioration of surface and ground waters are possible effects of mining. These effects include acidic or salty water discharges, which frequently contain dissolved metals and other components associated to mines, as well as sediment deposition and discharge in rivers and lakes (Singh et al., 2022). Acid mine drainage (AMD), often known as acid mine drainage, is a significant issue for water quality that is associated with mining. Sulfide-containing materials undergo direct oxidation, which is followed by the indirect oxidation of ferric ions, resulting in AMD (Luís et al., 2022). It results in acidic fluids that mobilize sulfate, other dissolved solids, and hazardous metals. These waters can contaminate drinking water and reduce the viability of the habitat for aquatic life when they are released into nearby aquifers, lakes, and streams (Akhtar et al., 2021). As a result of iron ore mining, Tasik Puteri, a known recreation lake which was once used in the iron ore washing process for Bukit Besi mining. It is a man-made lake which is a built dam from Sungai Dalam stream (Zulkefli & Awang Besar, 2021). Unfortunately, the lake is suspected to be linked with AMD which is one of the main water pollutant in the field of mining and a global problem that contributes to ecological destruction in water (Jouini et al., 2020). In order to restore the quality of water, a suitable method need to be developed.

Today, world development has turned to green technology as an alternative technology to treat polluted water areas. One of the green technology is phytoremediation, an emerging and innovative clean-up technology of the plant - based for the environmental (Atia et al., 2019). Phytoremediation can be applied to large areas and it is useful for treating a wide variety of contaminants such as toxic elements, radionuclides and organic substances and growth media such as soils, sludges, sediments and water since it is environmentally friendly method and an economical energy-efficient (Karn et al., 2021).

Other than that, adsorption, chemical precipitation, ion exchange and solvent extraction are among the methods used for the removal of trace metals from water (Qasem et al., 2021). However, adsorption is one of the most interesting methods since