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Removal of Mercury, Lead and Copper from Aqueous Solution by Activated Carbon of Palm Oil Empty Fruit Bunch

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Abstract: The ability of activated carbon prepared from palm oil empty fruit bunches (EFB) to remove mercury (Hg(II)), lead (Pb(II)) and copper (Cu(II)) from aqueous solutions was investigated. The EFB activated carbon was produced by using chemical and physical activation processes. The adsorption capacity was determined as a function of adsorbate initial concentration and adsorbent dosages. Adsorption isotherms of the studied metals on adsorbent were determined and compared with the Langmuir and Fruendlich isotherm models. The EFB activated carbon showed excellent efficiency in removing Pb(II) and Hg(II) with percentage of removal up to 100% even at low adsorbent dosage. In contrast, only 25% removal of Cu(II) by the EFB activated carbon was observed. The study also showed that the adsorption of Hg(II), Pb(II) and Cu(II) by EFB activated carbon is dependent on the dosage of adsorbent and the initial metals concentration. The use of EFB as activated carbon is not only effective for Hg(II) and Pb(II) removal from wastewater but also helps in solving the problem of over-abundance of EFB as agricultural waste product.

Key words: Empty fruit bunch · Activated carbon · Adsorption · Heavy metals · Langmuir isotherm · Fruendlich isotherm

INTRODUCTION

The increase in industrial activities has caused many water bodies receiving loads of heavy metals that exceed the maximum permissible limit for wastewater discharge designed to protect the environment, human and animals [1]. Pollution by heavy metal ions, including mercury (Hg(II)), lead (Pb(II)) and Copper (Cu(II)), has become a major issue throughout many countries due to their possible toxic effects [2]. The risks of Hg(II) exposure, for instance, may contribute to adverse effects on central nervous system, pulmonary kidney functions and the chromosomes [3], while Pb(II) can bioaccumulate through the food chain [4]. Prolonged inhalation of Cu(II) spray is claimed to cause an increase in the risk of lung cancer [2]. Based on Malaysian Environmental Quality Act 1974, maximum permissible limits for Hg(II), Pb(II) and Cu(II) in drinking water are 0.005 mg/L, 0.10 mg/L and 0.20 mg/L, respectively.

Hg(II), Pb(II) and Cu(II) are released into the aqueous environment through variety of sources such as metal smelters, effluents from plastics, textiles, microelectronics and wood preservatives producing industries and usage of fertilizer and pesticides [5]. These metals cannot be degraded or destroyed, but can be removed from water bodies. Conventional methods for the removing of heavy metals include filtration, chemical precipitation and ion exchange, electrochemical deposition and membrane process. However, these methods are either inefficient or expensive especially when the concentration of the heavy metal ion is low, in the range of 1-100 mg/L [5].

Activated carbon is an efficient and versatile adsorbent for purification of water, air and many chemical and natural products [6]. However, the usage of activated carbon is limited by its high preparation cost [3]. Previous studies on the use of various agricultural wastes such as hulls of rice and wheat [3, 4], groundnut shells [6], palm oil shells [7] and physic nut wastes [8] as raw material for activated carbon shows that the preparation cost of activated carbon can be reduced if these waste is used.

Oil palm production is a major agricultural industry in Malaysia. Empty fruit bunches (EFB) are the solid residue left after the fruit bunches are pressed at oil mills and the oil extracted. Due to its high cellulosic fiber content and

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