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Palm oil mill effluent treatment using coconut shell – based activated carbon: Adsorption equilibrium and isotherm

Sherlynna Parveen Deshon Kaman[1], Ivy Ai Wei Tan[1,a] and Leonard Lik Pueh Lim[2]

[1]*Department of Chemical Engineering and Energy Sustainability, Faculty of Engineering, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.*
[2]*Department of Civil Engineering, Faculty of Engineering, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.*

Abstract. The current ponding system applied for palm oil mill effluent (POME) treatment often struggle to comply with the POME discharge limit, thus it has become a major environmental concern. Batch adsorption study was conducted for reducing the Chemical Oxygen Demand (COD), Total Suspended Solids (TSS) and Color of pre-treated POME using coconut shell-based activated carbon (CS-AC). The CS-AC showed BET surface area of 744.118 m²/g, with pore volume of 04359cm^3/g. The adsorption uptake was studied at various contact time and POME initial concentration. The CS-AC exhibited good ability with average percentage removal of 70% for COD, TSS and Color. The adsorption uptake increased over time and attained equilibrium in 30 hours. The equilibrium data were analyzed using the Langmuir, Freundlich, Temkin and Dubinin–Radushkevich isotherm models. Based on the coefficient regression and sum of squared errors, the Langmuir isotherm described the adsorption of COD satisfactorily, while best described the TSS and Color adsorption; giving the highest adsorption capacity of 10.215 mg/g, 1.435 mg/g, and 63.291 PtCo/g respectively. The CS-AC was shown to be a promising adsorbent for treating POME and was able to comply with the Environmental Quality Act (EQA) discharge limit. The outcome of treated effluent using CS-AC was shown to be cleaner than the industrial biologically treated effluent, achieved within shorter treatment time.

1 Introduction

The vast development of palm oil industry has led Malaysia to become the largest palm oil exporter to more than 100 countries [1]. Consequently, this increases the waste discharged, i.e. partly treated palm oil mill effluent (POME) into waterways. According to Malaysian Palm Oil Board (MPOB), as of December 2012, there were 429 palm oil mills nationwide; generating an average of 0.65 m^3 POME from every processed ton of oil palm fresh fruit bunches (FFB). Based on annual production of 9,288,000 tons of FFB in Sarawak; this results in an estimated annual effluent generation of 6,037,200 m^3.

Fresh POME is a hot (80-90^{o}C), acidic (pH 4-5) slury with unpleasant odor, and high colloidal suspension; which consists of mainly water, oil and total solids including suspended solids from debris of palm fruit residues [2]. POME is the result from processing of FFB mainly from physical processes such as sterilization, clarification and separation process of palm oil. Some researchers suggested that the dark, brownish color of POME could be attributed to the breakdown of lignocellulosic from the raw effluent into lignin and tannin [3, 4]. POME also contains various types of organic compounds which are mainly pigments extracted from sterilization of FFB, such as anthocyanin and carotene pigment [5].

The discharge of POME without appropriate treatment into waterways has been an environmental concern, as it affects the water quality. The high quantity of organic substance in POME has translated into high detection of Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) which has been a challenge for the treatment of this effluent. The degradation of POME in waterways can produce by-products which can be toxic to aquatic life and therefore, there is an urgency to treat POME properly before being discharged.

The typical characteristics of raw POME, biologically treated POME and the corresponding standard discharge limit of Environmental Quality Act (EQA) 1974, Department of Environment (DOE), Malaysia are shown in Table 1. The biologically treated POME characteristics showed non-compliance with the standard discharge limits. In this study, the collected POME was at pH 8, however the effluent was yet to comply with other parameters of EQA discharge limit.

In Malaysia, most of the operating palm oil mills are using the conventional ponding system for POME treatment in view of advantages such as low capital and operating cost. However, it requires large area due to the long hydraulic retention time (HRT), typically about 1–2 months. In addition, the current system has low efficiency in treating POME and sometimes could not meet the final

[a] Corresponding author: awitan@unimas.my