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Treatment of effluents from palm oil mill process to achieve river water quality for reuse as recycled water in a zero emission system

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ABSTRACT

A major problem facing the palm oil industry is the need to use fresh river water for processing which leads to the discharge of treated palm oil mill effluent (POME) to the river daily. In this paper, we propose a practical solution using activated carbon and selected coagulants for the zero emission of POME final discharge, using river water quality as the benchmark. The target was on the reduction of chemical oxygen demand (COD) and suspended solids (SS) to meet river water quality for recycling and reuse of the POME final discharge as boiler feed water to fulfil the zero emission concept. Our results showed that a new two-step process, based on adsorption of organic pollutants on activated carbon (AC), with a ratio of 10 g AC per 1 L of wastewater (POME), followed by coagulation using a ratio of 0.6 g of polyaluminium chloride per 1 L of treated POME, was the best treatment. By using this new proposed treatment the final COD and SS of resulted residual water from palm oil mill process were 10 mg L^{-1} and 2 mg L^{-1}, respectively, which is better than river water quality. Therefore the objective of zero emission of POME final discharge can be achieved.

1. Introduction

In Malaysia, the palm oil mill business contributes substantially to the national economy. Malaysia is the second largest producer of palm oil in the world (Sumathi et al., 2008). In reality, producing palm oil also results in abundant wastes generation. In 2010 alone, the 421 palm oil mills in Malaysia (MPOB, 2012) generated about 60 million tonnes of palm oil mill effluent (POME) which would have been a major source of pollution if it was discharged directly into water sources (Agensi Inovasi Malaysia, 2011). In solving this problem, the palm oil industry uses the ponding system or direct disposal on land method. The majority of palm oil mills use a ponding system that include cooling, anaerobic, aerobic, facultative and algae ponds to treat their POME before discharge into the river. The current final discharge standards are given in Table 1.

In the concept of zero emission, no more waste goes out from the mill. Currently, the mill uses fresh upstream river water for its production and general usage. Each mill has its own treatment plant to treat river water. In general, one tonne of water is used to process one tonne of fresh fruit bunch (FFB) for the production of crude palm oil, which results in POME. POME is a colloidal suspension containing about 4000 mg L^{-1} of oil and grease, 50,000 mg L^{-1} of COD, 18,000 mg L^{-1} of SS (Ahmad et al., 2003), 750 mg L^{-1} of nitrogen and 180 mg L^{-1} of phosphorus (DOE, 1999). Despite treatment using open ponding systems, the final discharge still contains high levels of COD and SS, which are higher than river water. The COD and SS in fresh river water are 25–50 mg L^{-1} and 50–150 mg L^{-1}, respectively (Zainudin, 2010). Therefore in order to use this final discharge as recycled water to the mill, an additional treatment is necessary to achieve a zero emission concept.

To date, there is limited literature reporting the concept of zero emission solution for the palm oil industry. The concept of zero emission solution is shown in Fig. 1. Solid line arrows show water circuit in the existing palm oil mill process including the current

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Table 1
Characteristics of raw POME, POME final discharge and river water.

Parameters	Raw POME[a,b,c] (mg L^{-1})	POME final discharge (mg L^{-1})	River water (mg L^{-1})	Regulatory standard discharge limit[d] (mg L^{-1})
pH	3.4–4.7	8.50	7.05	5–9
BOD	10,250–25,020	65	8	100
COD	15,000–59,700	520	30	No discharge standard after 1894
SS	5000–18,000	217	40	400

All values except for pH are expressed in mg L^{-1}. Raw POME is POME directly discharged from the mill without any treatment.
[a] Ahmad et al., 2003.
[b] Krishnan et al., 2006.
[c] Belo et al., 2013.
[d] DOE, Malaysia, 1982.

wastewater treatment operations. Water is taken from river upstream and stored in a collection pond before being treated using chemicals such as alum, soda ash and p-floc coagulant prior to supply to the mill. The wastewater from the mill or POME directly goes to the anaerobic treatment, facultative ponds and algae ponds before being discharged to river downstream. According to our proposal, in order to achieve the zero emission concept, POME will not be released to the river as final discharge wastewater but recycled back to the mill (dotted line arrow in Fig. 1) using appropriate treatment.

The objective of this research is to develop an appropriate adsorption-coagulation method for the treatment of POME final discharge for the removal of COD and SS to achieve river water quality so that the treated POME final discharge can be used as recycled water for the mill, thereby achieving the zero emission system.

2. Materials and methods

2.1. Sample preparation

Samples of POME final discharge were collected from FELDA Serting Hilir Palm Oil Mill in Negeri Sembilan, Malaysia. The effluent was collected from the final process line of POME treatment ponds within the plant. A sample of river water was collected from upstream intake point of nearby river of the palm oil mill. Both samples were preserved and stored at a temperature of less than 4 °C prior to use in order to prevent any biodegradation due to microbial activity which may affect the result of the experiment. The samples of POME final discharge and river water were characterized and analysed based on APHA Standard Methods for the Examination of Water and Wastewater (APHA, 2005) as shown in Table 1.

2.2. Materials

Industrial-grade alum, $FeCl_3$ and polyaluminium chloride (PAC) were obtained from My Synergy Factors (*M*) Sdn. Bhd. $FeCl_3$ and PAC were received in aqueous solution while alum was received in powder form. Activated carbon was supplied by MERCK, Germany with approximately 800 m^2 g^{-1} of surface area.

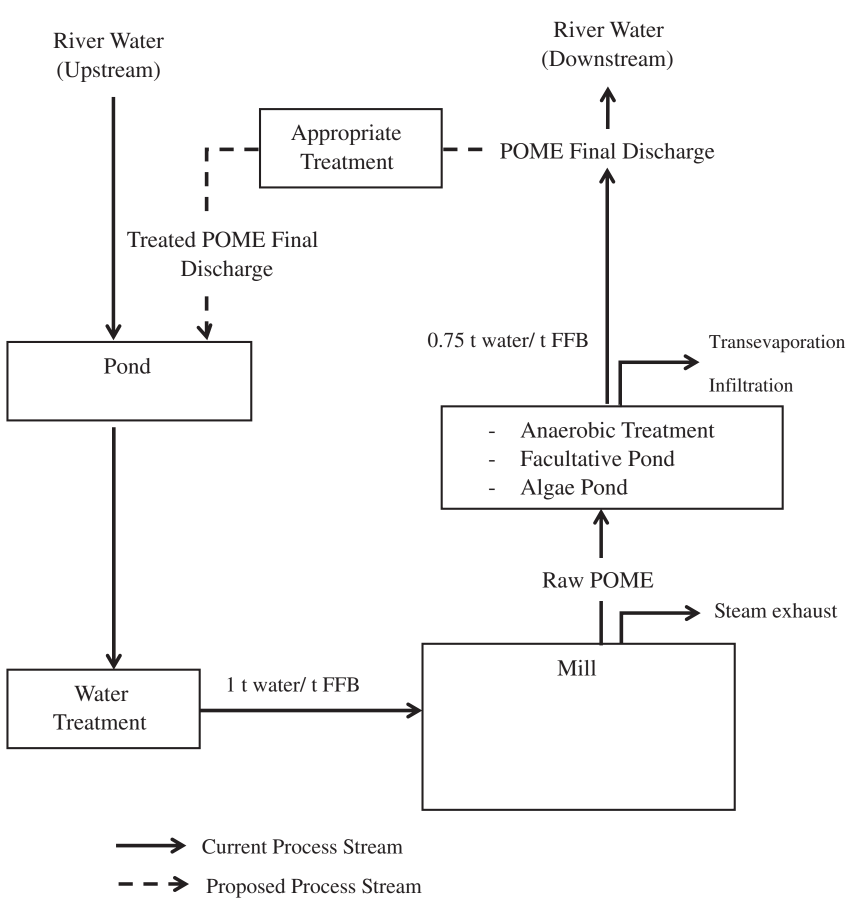

Fig. 1. Zero emission concept.