CHAPTER
4
PHYSICO-CHEMICAL TREATMENT FOR PALM OIL MILL EFFLUENT

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4.1 INTRODUCTION

In palm oil processing, waste materials such as empty fruit bunches (EFB), oil palm trunks (OPT), palm kernel shells (PKS) and palm oil mill effluent (POME) have been produced in large quantities (Nabila et al., 2023). Among these waste products, POME, a product of the clarification process is considered to be highly polluting. Approximately 60% of the POME production is released as wastewater from the clarifying process, between 35 to 45% is released as sterilizer condensate or effluent from the sterilizing of the fresh fruit bunch and about 4% is discharged as residual oil lodged in the press machine (Tan et al., 2021). POME is a significant environmental issue in South East Asian nations whose economies mostly depend on the oil palm sector. The destruction of habitat, particularly aquatic ecosystem degradation, has caused the oil palm sector to face criticism from all over the world (Sakai et al., 2022). To address this, a number of cutting-edge processes have been created to guarantee that POME can be treated on a large enough scale to meet regulatory requirements for disposal into water bodies. Key treatment processes include anaerobic digestion, which involves the breakdown of organic matter by microorganisms in the absence of oxygen, leading to the production of biogas; aerobic treatment, which uses oxygen to further degrade organic pollutants and reduce biochemical oxygen demand (BOD); membrane filtration technologies, such as ultrafiltration and reverse osmosis, that effectively remove suspended solids and contaminants; and coagulation-flocculation, a chemical process that helps aggregate and remove fine particles from the effluent. These methods, when integrated and optimized, enable the treatment of POME to levels that comply with environmental regulations, thus mitigating its impact on ecosystems.

The treatment of POME is, however, not limited to biological processes. Since physicochemical treatments have been employed in the past with differing degrees of efficacy, they have also drawn considerable attention (Khan et al., 2023). Applications that seek to recover POME solids while also combining an effluent treatment would greatly benefit from physicochemical treatment processes as the recovered solids might then be utilized as animal feed and fertilizer. The suggested physicochemical treatment processes for POME include sedimentation, centrifugation, flotation, coagulation and flocculation.

4.2 SEDIMENTATION AND CENTRIFUGATION

Historically, the poor settling of POME has posed a significant challenge in its treatment. Karim and Hie (1987) were among the first to observe that raw POME exhibited poor settling properties, which resulted in only a slight reduction in total suspended solids (TSS) without the need of coagulants. The settleability of raw POME, defined as the ratio of the initial height of the POME suspension and the depth of the supernatant layer in a measuring cylinder, was found to be only 20% after 20 hours (h) (Priatna et al., 2023). This indicated that relying solely on gravitational settling was insufficient for effective treatment. In a more recent study, Khadaroo et al. (2022) confirmed these findings, emphasizing the limited decrease in TSS when POME is left to settle naturally. Ahmed et al. (2015) also highlighted the impracticality of clearing POME without the aid of coagulants, given its poor natural settleability. To overcome these challenges, recent advancements have focused on enhancing the settling process through mechanical means. One such advancement is the use of centrifugation, which allows for the forceful separation of POME components in a short period. Omoregie et al. (2023) demonstrated that centrifuging raw POME at 15,000 rpm for 30 minutes (min) at room temperature resulted in a clear, brownish supernatant, a compact residue, and a thin coating of oil. The process effectively separates the oil droplets through creaming while sedimenting the suspended and colloidal particles at high speeds (10,000 rpm) and low temperatures (5 °C), as shown by Wu et al. (2010). This method was found to reduce chemical oxygen demand (COD) and TSS by 40% and 100%, respectively, in the oil-free supernatant, while Wah et al. (2002) reported corresponding reductions of 30% and 86%. These technological advancements, particularly the use of centrifugation, have demonstrated significant improvements in the treatment of POME. While centrifugation effectively enhances the settleability and separation of POME components, the overall effectiveness of these methods in meeting environmental regulations still depends on the integration of additional treatment processes. Thus, while centrifugation represents a major step forward, it is most effective when combined with other methods, such as coagulation-flocculation and membrane filtration, to ensure comprehensive treatment.

4.3 FLOTATION

Dewi and Sari (2017) reported on the electroflotation of lead dioxide-titanium anode and stainless-steel cathode of POME at pH 4 and 10. Almost half of the original COD was removed after 3 hours of electrolysis at pH 10; the removal was only slightly improved by extending the electrolysis period to 20 hours. The main reason for the improved total COD removal for the electrolyzed dispersion at pH 10 was actually the enhanced electroflotation of the suspended particles, specifically plant cell debris and entangled oil droplets at higher pH.