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I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Engineering (Civil Engineering)

_____

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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TREATMENT OF PALM OIL MILL EFFLUENT USING STRUVITE PRECIPITATION METHOD

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ABSTRAK

Sisa kilang minyak sawit (POME), sisa cecair yang diperolehi selepas pengekstrakan minyak sawit dianggap sebagai salah satu sumber utama pencemaran air di Malaysia. POME mengandungi sejumlah besar nutrien, bahan organik dan pepejal terampai. Pengolahan nutrien daripada POME akan memberi manfaat untuk tujuan pertanian. Penggunaan kaedah pemendakan 'Magnesium Ammonium Phosphate'(MAP) telah menunjukkan pendekatan yang berkesan dalam merawat air sisa yang mengandungi sejumlah besar nutrien, pada masa yang sama menghasilkan baja yang berkualiti tinggi. Oleh kerana POME mengandungi ammonium dan fosphat yang bernilai ia dijangkakan struvite dapat diekstrak dari POME dengan menggunakan kaedah MAP. Dalam kajian ini, satu penyelidikan makmal telah dijalankan untuk menilai keberkesanan pengekstrakan struvite dari POME dengan menggunakan tiga kombinasi kimia yang berbeza iaitu $MgCl_2$ + Na_2HPO_4, $MgCl_2$ + KH_2PO_4 dan MgO + H_3PO_4 di bawah keadaan pH berubah-ubah (iaitu pH 7.5, 8, 9 dan 10). NaOH telah dipilih sebagai agen kawalan pH. Selain itu, teknik kawalan pH alternatif juga dipertimbangkan, iaitu penggunaan kapur ($CaCO_3$), karbon teraktif (AC) dan kalsium hidroksida ($Ca(OH)_2$). Kualiti struvite yang diperolehi dinilai dari segi ciri-ciri dan kualiti kesuburan baja untuk pertumbuhan pokok. Ciri-ciri kesuburan struvite yang diperoleh diuji menggunakan Fluorescents X-ray (XRF) dengan mengenalpasti unsur nutrien dan kepekatannya manakala kualiti pembajaan diuji pada sirih gading atau *Scindapsus Aureus.* Pertumbuhan pokok dipantau dengan perubahan masa. Beberapa pot kawalan juga dipertimbangkan iaitu dengan tidak menambah baja, baja komersil, dan baja struvite. Semua ujikaji dijalankan mematuhi kaedah APHA. Hasil ujikaji menunjukkan bahawa dua kondisi optimum yang berbeza telah dikenal pasti bergantung kepada keperluan rawatan, (i) untuk hasil struvite maksima. (ii) untuk penambahbaikan maksimum kualiti air POME selepas rawatan. Hasil struvite tertinggi telah dihasilkan adalah sebanyak 26.88% dengan menggunakan gabungan $MgCl_2$ + Na_2HPO_4 + NaOH pada pH 8 selepas 1 jam diikuti oleh 20.34% dengan menggunakan MgO + H_3PO_4 dan 18.86% menggunakan $MgCl_2$ + KH_2PO_4 pada pH 10 dan 9. Selain itu, penambaikan kualiti water selepas dirawat dengan menggunakan MgO + H_3PO_4 + NaOH pada pH 7.5 iaitu sebanyak 97% kepekatan COD dan hamper 100% daripada ammonium telah disinggirkan. sebanyak 46.80% struvite telah dihasilkan apabila campuran $MgCl_2$ dan Na_2HPO_4 digunakan bersama karbon teraktif sebgai agen kawalan pH. Walau bagaimanapun, jika dibandingkan dengan menggunakan NaOH sebagai teknik agen kawalan pH, ($Ca(OH)_2$) menunjukkan peningkatan yang lebih rendah dalam kualiti air dengan penyingkiran sebanyak 70%, 21% dan 92.8% untuk COD, kalium, dan ammonium.XRF mendedahkan bahawa beberapa logam berat telah dikenal pasti dalam semua mendakkan yang diperoleh menggunakan teknik yang berbeza dan kaedah penyucian diperlukan. Selepas kaedah penyucian, ciri-ciri mendakkan struvite didapati mematuhi piawaian yang relevan dan sesuai digunakan sebagai baja untuk tujuan pertanian. Berdasarkan ujian kesuburan, didapati bahawa pertumbuhan *Scindapsus Aureus* menggunakan struvite yang diperoleh dalam kajian ini lebih tinggi berbanding dengan pertumbuhan menggunakan baja yang tersedia secara komersil menunjukkan bahawa struvite yang diperolehi dari POME mempunyai ciri kesuburan yang lebih baik. Walaupun kualiti air bertambah baik, kebanyakan parameter yang diuji melebihi piawaian yang ditetapkan maka kaedah mendakkan struvite hanya boleh digunakan sebagai pra rawatan dalam POME mentah. Rawatan sekunder lain diperlukan untuk memastikan penambahbaikan kualiti efluen dan mematuhi piawaian yang telah ditetapkan.

ABSTRACT

Palm oil mill effluent (POME), a residual liquid waste obtained after extraction of oil is considered one of the main sources of contamination of watercourse in Malaysia. POME contain significant amount of nutrients, organic matter and total suspended solids. Recovery of nutrients from POME would be beneficial for agricultural purposes. The use of Magnesium Ammonium Phosphate (MAP) precipitation method has been shown to provide effective treatment of wastewater containing substantial amount of ammonium and phosphate at the same time producing high quality fertilizer. As POME contained appreciable amount of both ammonium and phosphate, it is expected that struvite can be extracted from POME using MAP precipitation method. In this study, a laboratory investigation was conducted to evaluate the effectiveness of struvite extraction from POME by using three different chemical combinations, namely $MgCl_2$ + Na_2HPO_4, $MgCl_2$ + KH_2PO_4 and MgO + H_3PO_4 under variable pH condition (i.e pH 7.5, 8, 9 and 10). NaOH was selected as the pH control agent. In addition, alternative pH control techniques were also considered, namely the use of chalk ($CaCO_3$), aeration, activated carbon (AC) and high calcium hydrated lime ($Ca(OH)_2$). The quality of the struvite obtained was evaluated in terms of the characteristics and fertilizing quality for plant growth. The fertility characteristic of the struvite obtained was tested using X-ray Fluorescents (XRF) by identifying nutrient element and concentrations whereas the fertilizing quality was tested on sirih gading or *Scindapsus Aureus* plant. The growths of the plants were monitored with elapsed time. Several control pots were also considered namely by no addition of fertilizer, commercial fertilizer, and struvite fertilizer. All tests were conducted following APHA standard procedure. Test results revealed that two different optimum conditions were identified depending on the treatment requirement, (i) for maximum struvite recovery (ii) for maximum improvement of POME water quality after treatment. These optimum conditions were influenced by pH, contact times, and chemical combinations. The maximum struvite recovery obtained was about 26.88% by using $MgCl_2$+Na_2HPO_4+NaOH combination at pH 8 after 1 hour of mixing time followed by 20.34% using MgO + H_3PO_4 and 18.86% using $MgCl_2$ + KH_2PO_4 at pH 10 and 9, respectively. On the other hand, the improvements in POME water quality after treatment was obtained using MgO+H_3PO_4+NaOH at pH 7.5 in which about 97% of COD concentration and almost 100% of ammonium concentration was removed. About 46.80% of pure struvite was recovered when $MgCl_2$ and Na_2HPO_4 were mixed and activated carbon was used as the alternative pH control agent. However, when compared to using NaOH as the pH control technique, $Ca(OH)_2$ showed lower improvement in the water quality with removal efficiency of 70%, 21% and 92.8% for COD, potassium, and ammonium, respectively. XRF revealed that some traces of heavy metals existed in all precipitates obtained using different techniques prior to purification. After purification, the characteristics of struvite precipitates were found to comply with relevant standards and suitable to be used as fertilizer for agricultural purposes. Based on the fertility tests, it was found out that the growth of *Scindapsus Aureus* using struvite precipitates obtained in this study was superior as compared to the growth using commercially available fertilizer indicating that struvite obtained from POME has greater fertility characteristic. Although improvements in the water quality parameters were achieved, most of the parameters considered were found to be greater than the allowable regulatory discharge limits. Hence, struvite precipitation method can only be considered as a pre-treatment in treating raw POME. Other secondary treatment is required to further improve the quality of effluent and comply with effluent discharge limits.

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