UNIVERSITI PUTRA MALAYSIA

EFFECT OF ULTRASONIC IRRADIATION ON LANDFILL LEACHATE

CHUA SZE YE

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By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master Science

EFFECT OF ULTRASONIC IRRADIATION ON LANDFILL LEACHATE

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Chair: Puziah Abdul Latif, PhD

Faculty: Environmental Studies

Landfilling method for the ultimate disposal of municipal solid waste material continues to be widely accepted and used due to its economic advantages of decomposition in a landfill. Landfill leachate is a type of wastewater which contains high concentration of organics which are difficult-to-treat with conventional treatment methods such as biological methods due to the presence of high fraction of molecular weight compounds and refractory organics. Ultrasonic irradiation was selected due to its several advantages which include elimination on the use of chemical oxidants for the treatment of complex organic compounds, shorter reaction time, etc. The 20 kHz ultrasonic-induced reduction of chemical oxygen demand (COD) and total suspended solids (TSS) were investigated. Several operating conditions, such as power density (24 – 188 W/L), pH (2 – 11), dilution factor (1:9, 1:1 and 9:1), addition of different types and

amount of catalyst ($FeSO_4$ and $CuSO_4$, 1.0 - 5.0 mmol/L and H_2O_2, 0.1 mmol/L) and powdered activated carbon (PAC, 1 - 6 g), were tested to study their effect on COD and TSS percentage reduction. Sample mineralization in term of COD and the particle rupture assessed by TSS were investigated. The optimum conditions from the operating systems were then selected together with by adding 2 g of powdered activated carbon which includes PAC/US, H_2O_2/PAC/US, $FeSO_4$/PAC/US and $CuSO_4$/PAC/US systems. Combination of ultrasonic and other treatment methods such as ultraviolet irradiation were also tested for its effectiveness in combination with ultrasonic irradiation. The treatment methods were also added with 2 g of powdered activated carbon. Overall, the best and optimum condition for the reduction of COD and TSS was PAC/US system with the reduction of 97.26 % and 65.00 %. The percentage reductions were enhanced at increased applied power densities (188 W/L), pH 7.4 (natural pH), initial leachate concentration and 2 g of PAC. The percentage reductions of the two parameters were as high as 97.26 % (PAC/US system) for COD and 87.64 % (H_2O_2/PAC/US) for TSS. Ultrasonic irradiation was shown to be an effective method for the reduction of COD and TSS. The total mineralization of organic pollutants by means of ultrasound irradiation alone and addition of catalysts still remains a difficult task especially for high strength wastewater such as leachate. Ultrasonic pre-treatment followed by other techniques, such as biological treatment or sonication coupled with other oxidation techniques seems to be a promising method to treat leachate in order to develop an economically more favorable integrated technique.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan ijazah Master Sains

KESAN SINARAN ULTRASONIK KE ATAS CECAIR LUPUSAN SAMPAH

Oleh

CHUA SZE YE

April 2010

Pengerusi: Puziah Abdul Latif, PhD

Fakulti: Pengajian Alam Sekitar

Kaedah pemendaman untuk pembuangan akhir bahan sisa pepejal terus diterima dan digunakan secara meluas disebabkan manfaat ekonomi. Cecair lupusan sampah adalah sejenis cecair yang mempunyai kepekatan organik yang tinggi dan sukar dirawati dengan kaedah konvensional seperti kaedah biologi kerana terdapat sebahagian daripada cecair ini yang mempunyai berat molekul pecahan tinggi dan sebatian organik refraktori. Kaedah rawatan secara sinaran ultrasonik telah dipilih disebabkan oleh beberapa keuntungan yang meliputi penghapusan penggunaan bahan oksidan kimia untuk rawatan sebatian organik kompleks, masa tindakbalas yang lebih singkat dan sebagainya. Penggunaan gelombang ultrasonik 20 kHz untuk mengalakkan pengurangan keperluan oksigen kimia (COD) dan jumlah pepejal terampai (TSS) telah dikaji. Beberapa keadaan operasi, seperti kepadatan kuasa (24 - 188 W/L), pH (2 - 11), kepekatan (1:9, 1:1 dan 9:1), penambahan pelbagai jenis dan jumlah mangkin ($FeSO_4$ dan $CuSO_4$, 1.0 - 5.0 mmol/L dan H_2O_2, 0.1 mmol/L) dan serbuk karbon teraktif (PAC, 1 - 6 g) telah

diuji mengenai keberkesanannya untuk peratusan penurunan nilai COD dan TSS. Pemineralan sampel dalam sebutan pengurangan COD dan pecahan zarah dalam sebutan TSS juga telah dikaji. Keadaan optima dari operasi tersebut kemudiannya telah dipilih dan ditambah dengan 2 g serbuk karbon teraktif yang meliputi PAC/US, H_2O_2/PAC/US, $FeSO_4$/PAC/US dan $CuSO_4$/PAC/US. Gabungan ultrasonik dan kaedah rawatan lain seperti sinaran ultra lembayung juga telah diuji untuk menilai keberkesanannya bagi kombinasi dengan ultrasonik. Kaedah rawatan juga ditambah dengan 2 g serbuk karbon teraktif. Secara keseluruhan, keadaan terbaik dan optima bagi pengurangan COD dan TSS adalah sistem PAC/US dengan penurunan 97.26 % dan 65.00 %. Peratusan penurunan kedua-dua parameter COD dan TSS meningkat pada peningkatan kepadatan kuasa (188 W/L), pH 7.4 (pH semulajadi), kepekatan dan 2 g PAC. Pengurangan peratusan dari dua parameter tersebut adalah setinggi 97.26 (sistem PAC/US) % bagi COD dan 87.64 % (H_2O_2/PAC/US) bagi TSS. Hasil kajian menunjukkan sinaran ultrasonik adalah kaedah yang berkesan untuk pengurangan COD dan TSS. Pemineralan jumlah pencemar organik dengan cara sinaran ultrasonik sendirian dan penambahan pemangkin masih merupakan satu masalah yang sukar untuk diatasi terutama untuk air kumbahan kekuatan tinggi seperti cecair sampah. Pra-rawatan ultrasonik diikuti dengan teknik-teknik lain, seperti rawatan biologi atau gabungan sonikasi dengan kaedah pengoksidaan yang lain mungkin berupaya bagi menghasilkan satu teknik integrasi yang lebih menjimatkan.

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I certify that a Thesis Examination Committee has met on 21st April 2010 to conduct the final examination of Chua Sze Ye on her thesis entitled “Effects of Ultrasonic Irradiation on Landfill Leachate” in accordance with the Universities and University Colleges Act 1971 and the

Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the degree of Master of Science.

Members of the Thesis Examination Committee were as follows:

AHMAD MAKMOM ABDULLAH, PhD
Associate Professor,
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

ABDUL HALIM ABDULLAH, PhD
Associate Professor,
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

MOHAMAD PAUZI ZAKARIA, PhD
Associate Professor,
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

MAKETAB MOHAMED, PhD
Associate Professor,
Faculty of Chemical and Natural Resources Engineering
Universiti Teknologi Malaysia
(External Examiner)

_____

BUJANG BIN KIM HUAT, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 23 July 2010

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

PUZIAH ABDUL LATIF, PhD
Lecturer
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

SHAHARIN IBRAHIM, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Member)

_____

HASANAH MOHD GHAZALI, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 12 August 2010

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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CHUA SZE YE

Date: 11 June 2010

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