UNIVERSITI PUTRA MALAYSIA

REMOVAL OF HYDROGEN SULFIDE BY PHYSICO-BIOLOGICAL FILTRATION USING DRIED ACTIVATED SLUDGE AND RICE HUSK SILICA

SEYED MAHMOUD MEHDINIA CHOUBI

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BY

SEYED MAHMOUD MEHDINIA CHOUBI

Thesis Submitted to the School of Graduate Studies, Unversiti Putra Malaysia, In Fulfilment of the Requirements for the Degree of Doctor of Philosophy

April 2011

DEDICATION

This work is dedicated to my wife, son, daughter, father and mother, brother and sisters who are to be patient for praying and waiting for me to complete my study

Abstract of thesis presented to the Senate of Universiti Putra Malaysia
In fulifilment of the requirement for the degree of Doctor of Philosophy

REMOVAL OF HYDROGEN SULFIDE BY PHYSICO-BIOLOGICAL FILTRATION USING BIOFILM AND RICE HUSK SILICA.

By

SEYED MAHMOUD MEHDINIA CHOUBI

April 2011

Chairman: Assoc. Prof. Puziah binti Abdul Latif, Ph.D

Faculty: Environmental Studies

The main goal of this study was to determine the effectiveness of mixed rice husk silica with dried activated sludge as a packing material for physico-biological filter for removal of hydrogen sulphide (H_2S). Removal efficiency (RE), elimination capacity (EC), and pressure drop were used to show the performance of the filters. Three separate filters (physical, biological, and physico-biological filters) were built using PVC cylinder (packed to one litter). Rice husk silica, dried activated sludge and mixture of rice husk silica with dried activated sludge were used in these physical, biological and physico-biological filters, respectively.

In this study, the system was operated under different conditions of two parameters, namely different inlet gas concentration and different inlet gas flow rate. The inlet and outlet concentrations of H_2S were measured using H_2S detector model ppb RAE 3000, USA. In order to determine the characteristics of rice husk silica, the Brunauer-Emmett Teller (BET) specific surface area was performed using a ThermoFinnigan Sorptomatic apparatus and nitrogen adsorption at -196°C. Both the shape and pores of rice husk silica were studied using scanning electron microscope (SEM).

The BET method showed that rice husk silica has a very high surface area (226.3 m^2/g) with a median pore radius of 2.4 nm and a mesoporous structure. Meanwhile, the chemical composition analysis showed that rice husk silica consisted up to 97.35 % of SiO_2. The physico-biological filter showed more than 99.96 % RE with empty bed residence time (EBRT) of 45 to 90 sec and 300 ppm inlet concentration of H_2S. However, the RE decreased to 96.87 % with the EBRT of 30 s. In the same condition, the biological filter showed 99.37% RE. Nonetheless, the RE was shown to have dropped to 82.09 % with the EBRT of 30 s. The physical filter showed an average RE of 45.83 % with EBRT of 75 to 90 s, and it was saturated after 13 days of operating time with 300 ppm inlet concentration of H_2S. The maximum EC was obtained in the physico-biological filter up to 52.32 $gm^{-3}h^{-1}$, with the RE of 96.87% and H_2S mass loading rate of 54 $gm^{-3}h^{-1}$. The maximum EC in the biological filter was obtained up to 44.33 $gm^{-3}h^{-1}$ with the RE of 82.09% and the H_2S mass loading rate of 54 $gm^{-3}h^{-1}$. In the physical filter, on the contrary, the maximum EC was obtained only up to 11.47 $gm^{-3}h^{-1}$ with the RE of 62.41% and the H_2S mass loading rate of 18.36 $gm^{-3}h^{-1}$. After 53 days of operating time and 54 $gm^{-3}h^{-1}$ of mass loading rates, the maximum pressure drop reached to 3.0 and 8.0 (mm H_2O) for the physico-biological and biological filters, respectively. Nevertheless, the pressure drop did not increase in the physical filter in the same condition. In biological and physico-biological filters, there is a direct and very high relationship between the increase of the H_2S mass loading rate and the amount of pressure drop ($r= 0.98, p< 0.01$) and ($r= 0.96, p< 0.01$), respectively. Based on the findings of this study, mixed rice husk silica and dried activated sludge could be considered as suitable packing material for the physico-biological filter to remove H_2S.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENYINGKIRAN HIDROGEN SULFIDA OLEH PENURASAN FIZIKOBIOLOGI DENGAN MENGGUNAKAN BIOFILM DAN SILIKA SEKAM PADI

Oleh

SEYED MAHMOUD MEHDINIA CHOUBI

April 2011

Pengerusi: Profesor Madya Puziah binti Abdul Latif, Ph.D

Fakulti : Penganjian Alam Sikitar

Tujuan utama kajian ini adalah untuk menentukan keberkesanan silika sekam padi campur dengan enap cair kering diaktifkan sebagai bahan bungkusan untuk penuras fizikobiologi untuk penyingkiran hidrogen sulfida (H_2S). Kecekapan pembuangan (RE), keupayaan penyingkiran (EC), dan penurunan tekanan digunakan untuk menunjukkan prestasi penuras. Tiga penuras yang berasingan (penuras fizikal, biologi, dan fizikobiologi) yang dibangunkan menggunakan silinder PVC (dipek untuk satu liter). Silika sekam padi, enap cair kering diaktifkan dan campuran silika sekam padi dengan enap cair kering diaktifkan telah digunakan dalam penuras masing-masing; fizikal, biologi dan fizikobiologi.

Dalam kajian ini, sistem ini dikendalikan di bawah keadaan yang berbeza daripada dua parameter, iaitu kepekatan salur masuk gas dan kadar aliran salur masuk gas yang berbeza. Kepekatan salur masuk dan keluar gas H_2S diukur menggunakan pengesan H_2S ppb model RAE 3000, USA. Untuk menentukan ciri-ciri silika sekam padi, Brunauer-Emmett-Teller (BET) luas permukaan khusus dilakukan dengan

menggunakan alat ThermoFinnigan Sorptomatic dan jerapan nitrogen pada -196 ° C. Kedua-dua bentuk dan leliang silika sekam padi dikaji dengan menggunakan mikroskop elektron imbasan (SEM).

Kaedah BET menunjukkan bahawa silika sekam padi mempunyai luas permukaan yang sangat tinggi (226.3 m^2 /g) dengan radius leliang median 2.4 nm dan satu struktur mesoporus. Sementara itu, analisis komposisi kimia menunjukkan silika sekam padi itu mengandungi sehingga 97.35 % SiO_2. Penuras fizikobiologi menunjukkan lebih daripada 99.96% RE dengan masa mastautin katil kosong (EBRT) dari 45 ke 90 saat dan 300 ppm kepekatan salur masuk gas H_2S. Namun, RE jatuh kepada 96.87 % dengan EBRT 30 saat. Dalam keadaan yang sama, penapis biologi menunjukkan 99.37% RE. Walau bagaimanapun , RE ditunjukkan telah menurun ke 82.09 % dengan EBRT 30 saat. Penuras fizikal menunjukkan purata RE 45.83 % dengan EBRT 75 ke 90 saat , dan ia dipenuhi selepas 13 hari masa operasi dengan 300 ppm kepekatan salur masuk gas H_2S. EC maksimum yang diperolehi pada penuras fizikobiologi mencecah 52.32 $gm^{-3}h^{-1}$, dengan RE sebanyak 96.87% dan H_2S kadar pemuatan jisim 54 $gm^{-3}h^{-1}$. EC maksimum yang diperolehi pada penuras biologi mencecah 44.33 $gm^{-3}h^{-1}$, dengan RE sebanyak 82.09% dan H_2S kadar pemuatan jisim 54 $gm^{-3}h^{-1}$. Sebaliknya dalam penuras fizikal, EC maksimum diperolehi hanya sampai 11.47 $gm^{-3}h^{-1}$ dengan RE dari 62.41% dan kadar pemuatan jisim H_2S adalah 18.36 $gm^{-3}h^{-1}$. Selepas 53 hari masa operasi dan 54 $gm^{-3}h^{-1}$ kadar pemuatan jisim, maksimum penurunan tekanan mencecah 3.0 dan 8.0 (mm H_2O) untuk penuras masing-masing; fizikobiologi dan biologi. Namun demikian, penurunan tekanan tidak meningkat dalam penurass fizikal pada keadaan yang sama. Dalam penuras biologi dan fizikobiologi, ada hubungan langsung dan sangat tinggi di

antara peningkatan kadar pemuatan jisim H_2S dan jumlah penurunan tekanan; masing-masing *($r = 0.99$, $p < 0.01$)* dan ($r = 0.95$, $p < 0.01$). Berdasarkan penemuan kajian ini, silika sekam padi campur dan enap cair kering diaktifkan boleh dianggap sebagai bahan bungkusan sesuai untuk penuras fizikobiologi untuk menyingkirkan H_2S.

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I certify that an Examination Committee met on 19 April 2011 to conduct the final examination of **Seyed Mahmoud Mehdinia Choubi** on his **Doctor of Philosophy** thesis entitled **"REMOVAL OF HYDROGEN SULFIDE BY PHYSICO-BIOLOGICAL FILTRATION USING DRIED ACTIVATED SLUDGE AND RICE HUSK SILICA"** in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the supervisory committee were as follows:

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Date:

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 institutions.

SEYED MAHMOUD MEHDINIA CHOUBI

Date: 16/May/2011

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