ABSTRACT

Methane (CH_4) a potent greenhouse gas (GHG), has more than doubled in past decades and continues to rise. Historically, landfills have been the largest source of anthropogenic CH_4 emission from the waste sector with 6,875 million metric tonnes of CO_2–eq in year 2010. Therefore, it is important to quantify CH_4 emissions from landfills to evaluate measures for reduction of GHG emission which contributes to global warming and climate change. At present, CH_4 emission rates from landfills have been estimated using mathematical and empirical models and among them, the first-order-decay (FOD) models are often credited for its estimation. The objective of this study is to quantify the CH_4 emission from Jeram Sanitary Landfill (JSL) in Kuala Selangor using the IPCC Waste Model. The output was verified using error function analysis (EFA) and later was used to calculate CH_4 emission from a temporarily closed cell. Quantification of CH_4 surface emission was also estimated using the flux chamber technique. Next, the influence of meteorological parameters such as rainfall, temperature, humidity and atmospheric pressure on CH_4 surface emission from landfill was also studied. As a part of the climate change mitigation effort, two cover materials to enhance CH_4 oxidation were designed for JSL using organic waste; (1) from a mixture of brewery spent grain (BSG) and compost of grass and cow manure; (2) BSG which was made into compost. Batch experiments were conducted to determine the ratio of BSG to compost, amount of material and optimum parameters for pH, moisture content and temperature. Column experiment to determine the best height/thickness of the biocover material was conducted subsequently. From the model verification exercise, it was noted that the IPCC Waste Model overestimated CH_4 emission at JSL

by 7% to 60%. The model input values which showed the least deviation from EFA was used as the site specific value for JSL. In terms of the meteorological parameters, only rainfall had a strong positive linear correlation to the surface emission of CH_4 during the wet period. As for the biocover performance, BSG and compost mixture was better at oxidizing CH_4 than the composted BSG. The 7:3 ratio of BSG to compost mixture with pH 6, 65% moisture and temperature at 35°C had the highest CH_4 oxidation in the batch experiment. In terms of the column experiment with laboratory condition, complete CH_4 oxidation was the fastest at 50cm height (within 5 days). While in the landfill, complete CH_4 oxidation was the fastest at 60cm height and it took 6 days to achieve it. On the other hand, BSG compost did not show good CH_4 oxidation potential. In conclusion, the two methods used to quantify CH_4 emission at JSL was a complement of each other. The influence of rainfall on the CH_4 flux emission was significant. Besides that, the use of BSG and compost mix as a biocover material had enhanced CH_4 oxidation through microbial activity thus reducing the CH_4 emission to the atmosphere.

ABSTRAK

Gas metana (CH_4) iaitu gas rumah hijau (GHG) yang aktif, telah dan sedang meningkat lebih dua kali ganda sejak beberapa dekad yang lalu. Sektor sisa, terutama dari tapak pelupusan sisa menjadi sumber pembebasan gas CH_4 antropogenik terbesar dengan anggaran persamaan gas karbon dioksida (CO_2) 6,875 juta tan metrik dalam tahun 2010. Oleh itu, sebagai salah satu langkah mengurangkan pembebasan GHG yang menyumbang kepada pemanasan global dan perubahan iklim, adalah penting untuk menghitung kuantiti pembebasan CH_4 dari tapak pelupusan sisa. Dewasa ini, kadar pembebasan CH_4 dari tapak pelupusan sisa dianggar dengan menggunakan model-model matematik dan empirikal. Di antara model-model ini, model *First Order Decay* (FOD) memberikan anggaran CH_4 yang baik. Ekoran itu, objektif kajian ini adalah untuk menghitung kadar pembebasan CH_4 dari Tapak Pelupusan Sisa Sanitari Jeram (JSL) di Kuala Selangor menggunakan *IPCC Waste Model*. Dapatan model itu disahkan dengan menggunakan *Error Function Analysis* (EFA) dan kemudiannya digunakan untuk mengira pembebasan CH_4 dari sebuah sel yang ditutup sementara di JSL. Kuantifikasi CH_4 permukaan juga dianggarkan menggunakan teknik *flux chamber*. Seterusnya, kesan faktor meteorologi terhadap pembebasan CH_4 dari tapak pelupusan sisa seperti hujan, suhu, kelembapan udara dan tekanan atmosfera juga dikaji. Sebagai salah satu usaha mitigasi perubahan iklim, dua *biocover* untuk meningkatkan pengoksidaan CH_4 kepada CO_2 telah diformulasikan menggunakan sisa organik yang diperbuat daripada; (1) campuran hampas bijirin dari kilang alkohol (BSG) dan kompos rumput dan najis lembu; (2) BSG yang telah dikomposkan. Ujikaji berkala telah dijalankan untuk menentukan nisbah BSG kepada kompos, jumlah bahan dan parameter

optimum untuk pH, kandungan kelembapan dan suhu. Kemudian, eksperimen turus untuk menentukan ketebalan bahan *biocover* juga dijalankan. Daripada proses pengesahan model, dapat dinyatakan bahawa *IPCC Waste Model* telah terlebih menganggar (7% hingga 60%) pembebasan CH_4 di JSL. Nilai input model yang menunjukkan sisihan piawai terkecil di EFA telah digunakan sebagai nilai penentu untuk JSL. Dari segi faktor meteorologi, hanya jumlah hujan mempunyai korelasi linear positif yang kuat terhadap pembebasan CH_4 permukaan semasa tempoh hujan. Dari segi keberkesanan *biocover*, campuran BSG dan kompos menunjukkan pengoksidaan CH_4 yang lebih baik pada daripada BSG yang dikomposkan. Nisbah 7:3 campuran BSG kepada kompos dengan pH 6 , kandungan lembapan sebanyak 65% dan suhu 35 ° C mempunyai pengoksidaan CH_4 yang tertinggi. Eksperimen turus dalam keadaan makmal pula menunjukkan pengoksidaan CH_4 paling cepat pada ketinggian 50cm (dalam masa 5 hari) manakala pada ketinggian 60cm di tapak pelupusan sisa 6 hari diperlukan. BSG yang dikomposkan tidak menunjukkan potensi pengoksidaan CH_4 yang baik. Kesimpulannya, kedua-dua kaedah yang digunakan untuk mengkuantifikasi pembebasan CH_4 di JSL adalah pelengkap antara satu sama lain. Pengaruh hujan terhadap pembebasan fluks CH_4 adalah penting. Selain itu, penggunaan campuran BSG dan kompos sebagai *biocover* telah meningkatkan pengoksidaan CH_4 melalui aktiviti mikrob di samping mengurangkan pembebasan CH_4 ke atmosfera.

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LIST OF SYMBOLS AND ABBREVIATIONS

ASTM - American society for testing and materials

C - Carbon

CH_4 - Methane

CO_2 - Carbon dioxide

DOC - Degradable organic carbon

DOC_f - Fraction of decomposable organic carbon

GHG - Greenhouse gas

GWP - Global warming potential

H_20 - Water

H_2S - Hydrogen sulphide

IDW - Inverse distance weight

LFG - Landfill gas

MCF - Methane correction factor

N - Nitrogen

NH_3 - Ammonia

NH_4 - Ammonium

NIMBY – Not in my back yard

NMVOC's - Non methane volatile organic compounds

O_2 - Oxygen

VOC - Volatile organic compound