

ABSTRACT

Methane (CH₄) is an important greenhouse gas with a global warming potential 25 times higher than carbon dioxide (CO₂). Landfill is one of the major contributors to global CH₄ emission and is estimated to be 500-800 Mt CO₂ eq/year. Previous studies have shown that microbial oxidation of CH₄ in landfill cover soil can be enhanced using substrates that are rich in organic matter, such as compost. Methanotrophs are a group of bacteria that utilize CH₄ as its sole carbon and energy source. Therefore this study is aimed to characterize the physiochemical properties of biocover material, while identifying the potential methanotrophic bacteria from landfill cover soil. It is also intended to evaluate a comparative assessment of the CH₄ efficiency of the biocover material under controlled conditions for bottle and column experiments with the addition of potential methanotrophic bacteria. Compost has been identified as the best biocover material based on the associated physiochemical properties and their ability to oxidize 4% of CH₄ within 4 days. Three types of methanotrophic bacteria were isolated from landfill soil and identified as *Methylomonas* sp, *Methylococcus* sp 1 and *Methylococcus* sp 2. *Methylococcus* sp 1 showed the highest CH₄ oxidation capacity when compared to *Methylomonas* sp and *Methylococcus* sp 2 which took only 24 hours for complete CH₄ oxidation. Batch experiment with addition of individual cultures and mixed cultures to the compost carried out at different parameters indicated higher CH₄ oxidation capacity at 35°C and 40°C, pH 6 and at 60% v/v moisture level. Addition of *Methylococcus* sp 1 showed the highest CH₄ oxidation activity at the rate of $8.33 \times 10^3 \mu\text{g g}^{-1}\text{h}^{-1}$ while the CH₄ oxidation rate with addition of *Methylomonas* sp was $4.16 \times 10^3 \mu\text{g g}^{-1}\text{h}^{-1}$. Addition of *Methylococcus* sp 2

showed 75% lower activity compared to *Methylococcus* sp 1 and 50% lower activity compared to *Methylomonas* sp. Bacterial count at end of the experiment showed highest count for *Methylomonas* sp and *Methylococcus* sp 1. Statistical analysis ($P < 0.05$) showed significant increase in CH_4 oxidation with the addition of *Methylomonas* sp and *Methylococcus* sp 1 to the compost at optimum temperature, moisture and pH when compared to the control. Column experiment carried out with addition of potential methanotrophic bacteria to the compost at different column height showed highest CH_4 oxidation activity at 60cm with the addition of *Methylomonas* sp and *Methylococcus* sp 1 and the comparison with control also showed 50% increase in the CH_4 oxidation activity. The experiment carried out at different incubation temperature and moisture content showed highest CH_4 oxidation at the temperature of 35°C to 40°C and 60% moisture level which are similar to batch experiment. Kinetic studies using Michaelis Menten equation for batch experiment at optimum parameters showed highest potential CH_4 oxidation rate with the addition of *Methylococcus* sp 1. Addition of methanotrophic bacteria to compost showed an enhancement and significant increase in the CH_4 oxidation under optimum parameters which are also similar to tropical conditions. A biocover with 60cm column height is potentially the best height for optimal CH_4 oxidation.

ABSTRAK

Gas Metana (CH_4) merupakan gas rumah hijau yang penting dengan potensi pemanasan global 25 kali lebih tinggi daripada karbon dioksida (CO_2). Tapak pelupusan merupakan salah satu penyumbang utama kepada pembebasan CH_4 global dan dianggarkan 500-800 Mt CO_2 persamaan / tahun. Kajian terdahulu telah menunjukkan bahawa pengoksidaan mikrob CH_4 dalam tanah penutup tapak pelupusan boleh dipertingkatkan dengan menggunakan substrat yang kaya dengan bahan organik, seperti kompos. Bakteria Metanotrofik adalah kumpulan bakteria yang menggunakan CH_4 sebagai karbon tunggal dan sumber tenaga. Oleh itu kajian ini bertujuan untuk mencirikan sifat-sifat physiochemical bahan *biocover*, di samping mengenal pasti bakteria methanotropik yang berpotensi dari tanah penutup tapak pelupusan. Ia juga bertujuan untuk menilai perbandingan kecekapan CH_4 bahan *biocover* bawah keadaan terkawal untuk botol dan *column* eksperimen dengan penambahan bakteria Metanotrofik yang berpotensi. Kompos telah dikenal pasti sebagai bahan *biocover* yang terbaik berdasarkan sifat-sifat yang berkaitan fisiokimia dan keupayaan mereka untuk mengoksidakan 4% CH_4 dalam tempoh 4 hari. Tiga jenis bakteria Metanotrofik telah diasingkan daripada tanah tapak pelupusan dan dikenalpasti sebagai spesies *Methylomonas*, spesies *Methylococcus* 1 dan spesies *Methylococcus* 2. Spesies *Methylococcus* 1 menunjukkan kapasiti pengoksidaan tertinggi CH_4 apabila dibandingkan dengan spesies *Methylomonas* dan spesies *Methylococcus* 2 yang mengambil masa hanya 24 jam untuk pengoksidaan CH_4 lengkap. Eksperimen kelompok dengan tambahan individu dan campuran kompos dijalankan pada parameter yang berbeza menunjukkan kapasiti pengoksidaan CH_4

yang lebih tinggi pada suhu 35 ° C - 40 ° C, pH 6 dan pada tahap kelembapan 60% v / v. Penambahan species *Methylococcus* 1 menunjukkan aktiviti pengoksidaan CH₄ pada kadar tertinggi, 8.33 X 10³ µg g⁻¹h⁻¹ manakala kadar CH₄ pengoksidaan dengan penambahan spesies *Methylomonas* adalah 4.16 X 10³ µg g⁻¹h⁻¹. Penambahan spesies *Methylococcus* 2 menunjukkan aktiviti 75% lebih rendah berbanding dengan spesies *Methylococcus* 1 dan aktiviti 50% lebih rendah berbanding spesies *Methylomonas*. Kiraan bakteria pada akhir eksperimen menunjukkan bilangan tertinggi dengan penambahan spesies *Methylomonas* dan spesies *Methylococcus* 1. Analisis statistik (P <0.05) menunjukkan peningkatan yang ketara dalam pengoksidaan CH₄ dengan penambahan spesies *Methylomonas* dan spesies *Methylococcus* 1 untuk kompos pada suhu, lembapan, dan pH optimum. *Column* eksperimen dijalankan dengan penambahan bakteria metanotrofik yang berpotensi untuk kompos pada ketinggian yang berbeza menunjukkan pengoksidaan CH₄ tertinggi pada ketinggian 60cm dengan penambahan spesies *Methylomonas* dan spesies *Methylococcus* 1 dan perbandingan dengan kawalan juga menunjukkan peningkatan sebanyak 50% dalam aktiviti pengoksidaan CH₄. Eksperimen yang dijalankan pada suhu berbeza dan kandungan lembapan menunjukkan pengoksidaan CH₄ yang tertinggi pada suhu 35 ° C hingga 40 ° C dan kelembapan 60% tahap yang sama kepada kumpulan eksperimen. Kajian kinetik menggunakan persamaan Michaelis Menten bagi eksperimen kelompok pada parameter optimum menunjukkan potensi kadar pengoksidaan CH₄ yang tertinggi dengan penambahan spesies *Methylococcus* 1. Penambahan bakteria metanotrofik pada kompos menunjukkan peningkatan yang ketara dalam pengoksidaan CH₄ di bawah parameter optimum yang juga sama dengan keadaan tropika. *Biocover* dengan ketinggian 60cm adalah berpotensi untuk pengoksidaan optimum CH₄.

ACKNOWLEDGEMENT

First of all, I would like to thank God and Guruji for being with me throughout the entire journey in completing my research successfully.

My sincere gratitude goes to my supervisor Professor Dr Agamuthu Pariatamby who dynamically guided me throughout my research studies.

My special thanks for funding Research project by IPPP (PS297/ 2010A), and UMRG grant (RG143/11SUS) and Ministry of Higher Education (MyBrain15) for providing me scholarship.

I am also thankful to Dr. Fauziah Shahul Hamid, Dr Abioye Peter, Lim Boon Tien, Siva Shangari, Emenike Chijioke, Theepa, Arezoo, Siti Zubaidah, Leong Hong Yeng, Nizam, Kasapo and also my other fellow lab mates and friends for their valuable co-operation and advice.

Last but not least, I would like to thanks my parents (Mr Barasarathi and Mrs. Vanaja) and my sisters, Puvaneswari and Mangeikarasi for their endless supports in completion of my studies.

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LIST OF SYMBOL AND ABBREVIATIONS

ASTM - American Society for Testing and Materials

GHG - Greenhouse gas

GWP - Global Warming Potential

LFG - Landfill Gas

NMVOC's - Non methane volatile organic compounds

VOC - Volatile Organic compound

CO₂ - Carbon dioxide

CH₄ - Methane

NH₄ - Ammonium

H₂S - Hydrogen sulphide

O₂ - Oxygen

H₂O - Water

C - Carbon

N - Nitrogen

NH₃ - Ammonia