Microbial modulation of methane emission in landfill sites

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Landfill as a source of methane emission

• Landfilling of solid waste will inevitably remain the most widely utilised management method in Australia despite a significant effort in the reduction, reuse and recycling.

• Methane (CH_4), with a global warming potential of 25 times greater than carbon dioxide (CO_2) (IPCC, 2007), is the most dominant gas emitted in most landfill sites through microbial methanogenic process.

• Although CH_4 generation in large landfills can be collected by active CH_4 extraction systems, substantial amounts of CH_4 are still emitted to the atmosphere, especially in small-scale landfills in regional areas.

• Global CH_4 emissions from landfill sites are estimated to contribute 30-70 Tg, which is around 11% of the total anthropogenic CH_4 emission to the atmosphere (Figure 1).

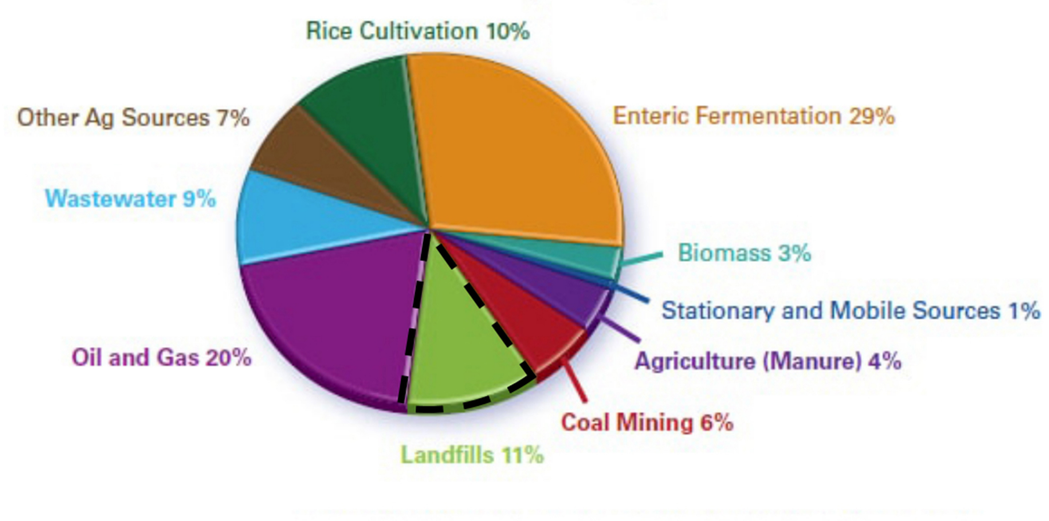

Figure 1. Global anthropogenic emissions of Methane by Source (U.S.EPA, 2010)

Methane production and consumption process in landfill sites

• Landfill sites produce Greenhouse Gases (GHG) such as CH_4 and CO_2, and odorous compounds such as volatile fatty acids (VFAs) as a result of the decomposition of putrescible waste (Figure 2).

• At landfill sites, as CH_4 gas diffuses into soil covers, aerobic methane-oxidizing bacteria utilise it as a main substrate, releasing CO_2 and H_2O (Figure 3).

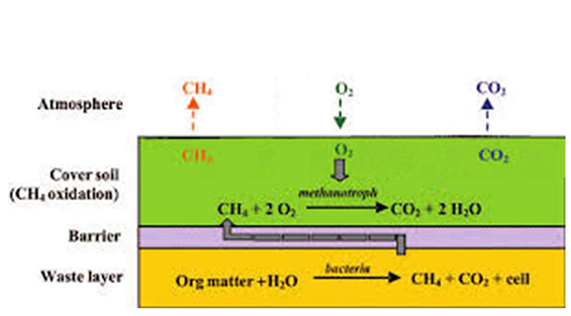

Figure 2. Methane emission and oxidation in cover soil (Chiemchaisri, 2011)

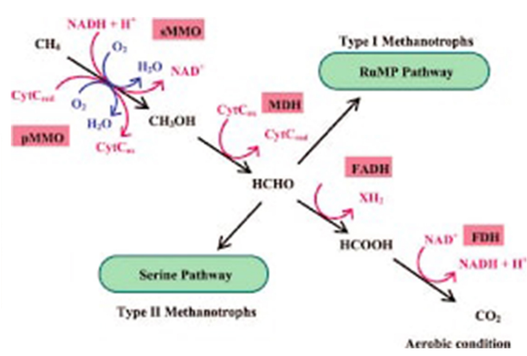

Figure 3. The pathways of CH_4 oxidation (Tanthachoon, 2008)

Phytocapping as methane emission mitigation

• Phytocapping is gaining popularity to mitigate the environmental impacts of leachate and greenhouse gas emission from landfill sites.

• Phytocapping of landfills has proved to support CH_4 oxidation in the soil covers through aeration in the root zone and by diffusion of exudates that enhance methanotrops in the soil layers.

• In this system, soil and vegetation grossly help maintain the hydrological balance and simultaneously oxidise CH_4 in the soil layers (Figure 4, 5).

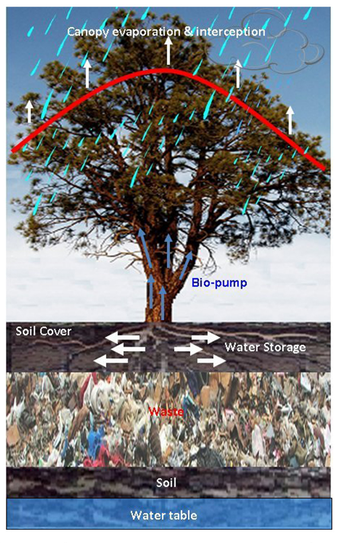

Figure 4. Various processes to reduce leachate generation in phytocapping landfills (Venkatraman, 2010).

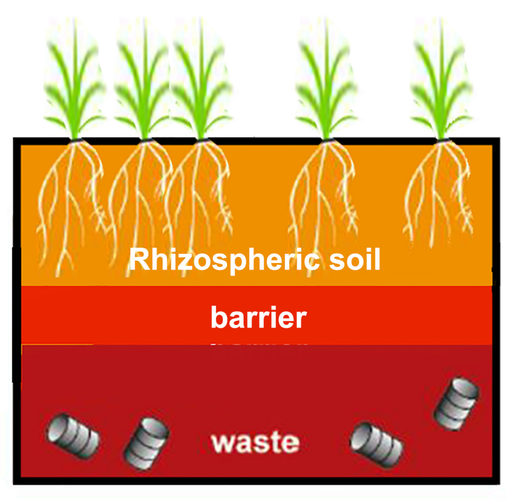

Figure 5. Phytocap technology can enhance CH_4 bio-oxidation by increasing methanotrophic bacteria activity in rhizospheric soil.

Aim of research

• To improve the efficiency of CH_4 oxidation in landfill cover using phytocapping assisted by soil amendments.

• To test the interactive effect between soil amendments and vegetation on microbial CH_4 oxidation to determine optimal conditions for methanotrophic bacteria.

Methodology

• Closed Chamber technique will be used to monitor CH_4 emission from landfill sites capped using phytocapping technology.

• The effect of rhizosphere on CH_4 oxidation will be examined using microcosm study.

Expected outcomes

• Identification of factors to improve soil chemical and physical properties to enhance CH_4 oxidation.

• Identification of vegetation species that effectively contribute to methane oxidation in soil.

• Optimisation of soil and phytocapping vegetation conditions to enhance CH_4 oxidation at landfill sites.

References

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• Lamb, D.T., et al. (2014) Phytocapping: An Alternative Technology for the Sustainable Management of Landfill Sites, Critical Reviews in Environmental Science and Technology, 44:6, 561-637.