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The Application of Artificial Neural Networks for Simulation of Biological CH_4 Oxidation in Landfill Bio-Covers

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Abstract

Biological methane (CH_4) oxidation in landfill cover system plays an important role in reducing CH_4 emissions from landfill sites into the atmosphere. The oxidation rate depends on different environmental factors, mostly temperature and moisture content. The non-methane organic compounds (NMOCs) present in landfill gas can affect the extent of biological CH_4 oxidation rates expected in the cover system. Artificial Neural Networks (ANN) are non-linear statistical modeling tools that can be used to model complex relationships between input and output data sets to find and learn their performance patterns. The purpose of this study is to develop a model based on ANN to estimate the CH_4 oxidation rates in landfill bio-covers under various levels of temperature, moisture content and NMOCs concentration. The best model for prediction of CH_4 oxidation rates was selected based on minimum errors and highest coefficient of determination values. The selected model successfully simulated the effect of each input data on the oxidation capacity of the bio-cover.

Keywords: *biological oxidation, methane, landfill cover, artificial neural networks, moisture content, temperature, non-methane organic compounds*

1. Introduction

Recent attention has been drawn to the increase in average global temperatures which was attributed to the growing greenhouse gases emissions mainly: carbon dioxide (CO_2) and methane (CH_4). One important source which adds to the anthropogenic CH_4 emissions is solid waste disposal. The biogas generated from biodegradation of solid waste in landfills, known as landfill gas (LFG), consists of CH_4, CO_2, plus trace amounts of non-methane organic compounds (NMOCs). Oxidation of CH_4 by methanotrophic bacteria within the landfill cover (LFC) provides a sink for these harmful fugitive emissions and is considered a significant biological process for attenuating fluxes of CH_4 to the atmosphere. The trace constituents of NMOCs present in LFG affect the CH_4 oxidation rates expected in LFC system. The experimental results presented by Albanna et al. [1] showed a decrease in CH_4 oxidation capacity of the landfill bio-cover with an increase in NMOCs concentrations. Therefore, NMOCs presence is critical and it should be to taken into consideration when simulating and/or predicting the biological CH_4 capacity of the LFC system.

Modeling the biological oxidation processes that occur within the LFC can be used to estimate the CH_4 oxidation potential of the methanotrophic bacteria under different environmental conditions; such estimation can successfully lead to the optimization of design parameters of an effective LFC system that will reduce the CH_4 emissions from landfill sites and open dumps to the atmosphere. The previous mathematical models [2-6] were developed based on transport-reactive simulation models and imparted quantitative perceptions of biological and physical processes, with reference to CH_4 transport, oxidation and reaction rates. However, these models were based on the flow of CH_4 alone into the cover matrix; NMOCs presence and their inhibition effects were not taken into consideration. There is definitely a need to develop a comprehensive landfill gas transport model that simulates the LFC system, evaluates the physical and biochemical processes, and includes NMOCs transport and oxidation, as well as their effect on CH_4 oxidation rates.

The complexity and the multi-factorial interactions between the various factors affecting biological oxidation of CH_4 and NMOCs in LFC system impose a challenge for simulating this system and the coupled processes using conventional mathematical methods. Recently, advanced methods, such as the artificial neural networks analyses, established their reputation as alternative modeling techniques. Artificial neural networks (ANN) are non-linear statistical data modeling tools; they can be used to model complex relationships between inputs and outputs and/or to find patterns in data and they can be utilized to solve many complex and real-world problems[7-9]. The power of ANN lies in implementing the learning algorithms of neural networks to describe the behavior of the system without the need to know the exact interrelationships [10]. The significant information processing capabilities of ANN approach, and the ability to learn from examples, make

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