INFLUENCE OF OPERATIONAL PARAMETERS ON LEACHATE QUALITY AND GREENHOUSE GAS ABATEMENT IN THE AEROBIC-ANAEROBIC LANDFILL METHOD

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(好気嫌気化埋立工法の制御因子が浸出水水質及び温室効果ガス排出抑制に及ぼす影響に関する研究)

区　　分　：甲

論 文 内 容 の 要 旨

Most of the cities in developing countries facing problems related with solid waste disposal of high organic contents. Improper disposal of solid waste, generate leachate and gas are serious issues for environment which causing serious health problems as well. It is very necessary to minimize the environmental pollution caused by improper disposal and conventional way of landfilling for treatment of waste. Aeration induce in landfills can activated microorganisms, which can execute important functions for biodegradation and accelerate landfill stabilization. In an aerated landfill bioreactor, carbon and nitrogen were effectively removed from the solid waste and leachate. However, oversupply or ineffective aeration can decrease microbial activity and increase energy consumption. A balanced and effective utilization of both aerobic and anaerobic metabolic pathways of the microorganisms might be effective for accelerated stabilization. The Aerobic-Anaerobic Landfill Method (AALM), developed from wastewater treatment technology, is considered a novel landfill method. In this method, air is injected into an anaerobic-type landfill at intervals to create aerobic zones, whereby alternative aerobic-anaerobic conditions are created in the landfill during non-aeration period. It is expected that: first, the conversion efficiency of nitrogen can be accelerated due to the existence of alternative aerobic-anaerobic conditions; second, the aerobic zones/conditions may accelerate the decomposition of organic carbon as well as reduce the emission of greenhouse gas (GHG); and third, hybrid conditions may create biostabilized landfills, thereby reducing the need for expensive perpetual landfill aftercare and reduce the energy cost as well. In order to achieve the goals mentioned above, AALM has been adopted by supplying intermittent aeration in column bioreactors to make it environmentally and economically viable.

In Chapter 1, firstly, definition of MSW, the current status of MSW, including its quantity, composition and disposal strategies, were reviewed. Then, the chronological development of various novel landfill technologies, including their advantages and disadvantages, were also introduced. Finally, the objectives and structures of the study were presented.

In Chapter 2, the aerobic–anaerobic landfill method was evaluated by using intermittent aeration. In addition, the nitrification–denitrification process was assessed as a means of reducing the emission of greenhouse gases (GHGs) and improving the leachate quality during the degradation of the organic solid waste. The leachate quality and the gas composition in each of the reactors were measured during the experimental period (408 days). The aeration process entailed the injection of air into plexiglass cylinders (200 cm height × 10cm diameter), filled with fresh organic solid waste collected from a composting plant. Different aeration routines were applied, namely, continuous aeration (aerobic reactor A), aeration for three days/week (aerobic–anaerobic reactor B), aeration for 6 h/day (aerobic–anaerobic reactor C), and no aeration (non-aerated reactor D). It was found that aerobic reactor A produced the best results in terms of reduction of GHGs and improvement of the leachate quality. The aerobic–anaerobic reactor C was found to be more effective than reactor B in respect of both the emission of GHGs and the leachate quality; moreover, compared with aerobic reactor A, energy costs were reduced by operating this reactor. Therefore, it is concluded that, in the AALM, air injection with an effective intermittent aeration that could create effective aerobic-anaerobic conditions, enable to reduce environmental pollutions, accelerate the stabilization of landfill waste and simultaneously reduce the energy cost.

In Chapter 3, the transition period phenomenon was investigated during an intensive seven-day experiment conducted on the discharged leachate obtained from aerobic–anaerobic reactors B (3 days/week) and C (6 hrs./day). The experiment concerned the differences in the composition of the gas during the aeration and the non-aeration periods. It was found that the transition period between the aeration and non-aeration cycles, which followed the simultaneous nitrification–denitrification had a considerable effect on the leachate quality of both the reactors. The results indicated that AALM has the potential to reduce leachate pollutants and the emission of GHGs. Furthermore, the occurrence of simultaneous nitrification–denitrification presents the prospect that intermittent aeration could reduce landfill aftercare and energy costs.

In Chapter 4, it was initiated to demonstrate the features of N_2O production rate from organic solid waste during nitrification under three different temperatures (20, 30, and 40°C) and three oxygen concentrations (5, 10, and 20%) with high moisture content, high total organic carbon and ammonium concentrations. The experiment was carried out by batch experiment using Erlenmeyer flasks incubated in a shaking water bath for 72 hours. A duplicate experiment was carried out in parallel, with addition of 100 Pa of acetylene as a nitrification inhibitor, to investigate nitrifiers contribution on N_2O production. The production rate of N_2O in organic solid waste decomposition was in the range of 0.40-1.14 μg N/g DM/h under experimental conditions of this study. The rate of N_2O production at 40°C was much higher than the minimum at 30°C and nitrification was the dominant pathway of N_2O production. It was evaluated that optimization of O_2 content is one of the crucial parameters on N_2O production.

In Chapter 5, a field study has been done to investigate the production potential of N_2O inside the landfill by in-situ aeration in a closed landfill site. Air was injected into a closed landfill site and investigated the major N_2O production factors and correlations established between them. The in-situ aeration experiment was carried out by three sets of gas collection pipes along with temperature probes were installed at three different distances of one, two and three meter away from the aeration point; named points A–C, respectively. Each set of pipes consisted of three different pipes at three different depths of 0.0, 0.75 and 1.5 m from the bottom of the cover soil. Landfill gases composition was monitored weekly and gas samples were collected for analysis of nitrous oxide concentrations. It was evaluated that temperatures within the range of 30-40°C with high oxygen content led to higher generation of nitrous oxide. Lower O_2 content can infuse N_2O production during nitrification and high O_2 inhibit denitrification, which would affect N_2O production. The findings provide insights concerning the production potential of N_2O in an aerated landfill that may help to minimize GHG emissions with control of the operational parameters and biological reactions of N turnover.

Chapter 6 concluded all experimental results and based on the research results, the recommendations of future studies for optimization of the AALM were introduced.