Abstract of Dissertation

論文の内容の要旨

title of dissertation

Integrated Numerical Approach to Optimizing Design and Operation of Self Turning Composting

(自己切返しコンポスト発酵槽の設計・運用を支援する統合数値解析システムの開発と検証**)**

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The biochemistry and microbiology of composting is still essentially considered a 'black box' process. This stems, in part, from the inherent complexity of the composting process, which is heterogeneous in nature and is directly influenced by factors such as feedstock composition and structure, and chemo-physical control parameters. This degradation process is accelerated through air flow inside the compost matrix. Hence, this research focuses first to identify the mechanisms of aerobic degradation in context of thermo-chemo-physical view. This incorporated knowledge in association with degradability of organic waste is targeted to implement in facilities development of large scale Self Turning Reactor (STR) composting system. And, in order to develop this sustainable large scale composting, it is necessary to incorporate the power of computational mathematics of composting process, which can improve understanding, provide feasible solutions to barriers of degradation mechanisms and reduce the need for costly large scale experimentation. Once the analytical system will be optimized to consider the most critical mechanisms of organic substances, the goal on implementing the large scale STR composting will ahead to the next process.

Accordingly, this research proposes to address how the microstructure of compost matrix affects the degradation mechanisms in presence of air. Small scale experiments of composting are planned and designed accordingly with considerations of ability to degrade organic waste, faster degradation, favourable environment of degradability with recycle compost, optimum turning to release inhibitor and amount of waste to be degraded. It is found that the degradation of organic substances accelerates in presence of air with combination with releasing inhibitor during turning operation. Again, the use of recycle compost in the composting process, indeed, favors the microbes to inoculate faster inside the compost matrix.

To quantify the acquired behavioral knowledge for the purpose of developing facilities for large scale STR composting system, thermo-physical air transport model is proposed to enhance the

analytical system, BioDuCOM. This model of convective movement of air considers the relative exchange of heat energy between different states of particles with considerable hypothesis. The applicability of proposed model is verified with several experimental results considering thermodynamic approach of material science.

On the other hand, composting relies upon the inter-related activities of a diverse range of micro-organisms to convert organic waste substrates into a stabilized material (compost), which is humic substances (humus) and contain useful plant nutrients. In most feedstock, the principal source of carbon and energy is derived from lignocelluloses. Cellulose activities in composting materials have been widely studied and correlated to decreases in cellulose content. Humification (the process of forming humus) is complex and thought to involve a number of degradative and condensation reactions involving lignins, carbohydrates and nitrogenous compounds. To quantify this knowledge of this degradation, the carbon-nitrogen-oxygen (CNO) model has been proposed with necessary hypothesis. This model assists to demarcate the typo of different sources of wastes, in general. The thermo-chemo-physical models incorporating CNO models are verified with necessary composting experiments in small scale. None but the less, the verification of this series of experiments lead to integrate the intrinsic models / equations with fundamental microbial kinetics to produce a dynamic model of the composting process, for which bridging between analytical system and the large scale composting process is achievable.

Furthermore, an engineering composting system where all the necessary operations of composting including degradation process are considered systematically is proposed in order to ensure a sustainable composting technology in the municipal waste management (MSW) system. The STR composting unit is instituted with other necessary system components of engineering composting facilities considering automation of composting process, less period of degradation and conserve land use but results high efficiency.

Hence, an integration of analytical system in application to compost engineering will propose optimize composting system ever before.