Project of Integrated Compost Science(Introduction of New Project)

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Vast amount of organic waste are being generated continuously by human activities in forests, hilly-mountainous areas, agricultural fields, coastal areas, and urban areas. The wastes accumulate in the field, and will result in not only global environmental pollution but also depletion of limited organic resources. I believe that a circulation system for the recycling and appropriate reuse of organic wastes should be developed breaking out of this situation as soon as possible. "Composting" is one of the suitable method for the circulation system, which has been traditionally implemented in Japan.

The compost processes in conventional composting methods can be a cause of ammonia volatilization resulting in acid rains. The application of large amount of composts with low nitrogen content result in excess assimilation of phosphoric acid in the field. In addition, there are concerns that these phenomena could cause eutrophication of water systems, thus leading to serious environmental destruction.

The acid composting technology for food wastes developed at Tohoku University inhibits ammonia volatilization and indicates the potential for developing environmentally friendly compost. However, only this acid composting technology cannot develop a recycling system for organic wastes. Compost safety should be assessed by analyzing the components of the compost produced. It is also necessary to assess both the functionality and availability by the actual applications of the compost. We have been investigating these issues at the Field Science Center, Graduate School of Agricultural Science, Tohoku University. Moreover, in terms of the cost performance, which is a major problem at the actual applications of the compost, we are trying to adjust the problem by analyses based on a standpoint of both social and natural sciences such as the satellite imaging, economics and LCA analysis.

Many laboratories in Graduate School of Agricultural Science have been studying compost for many years. In 2004, they initiated a project—"PICS" (Project of Integrated Compost Science)—in collaboration with several laboratories of the Graduate School of Engineering. In 2005, the Graduate School of Agricultural Science formulated an agreement with Miyagi Prefecture to establish a regional alliance research project—"PICS Miyagi." The achievements of the project were accepted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan. MEXT awarded the PICS study entitled "Development of Ecological Recycling System for Organic Resources" a "Grant-in Aid for Special Education and Research on Integrated Collaborative Project." This project will be conducted from fiscal year 2007–2011. In order to establish integrated compost science as a key factor in the recycling of organic resources, we conducted studies under this project by combining the research and development capabilities of our university. Further, we developed composting technology and investigated practical applications of this technology in cooperation with Miyagi Prefecture.

Furthermore, we studied the requirements of local communities. We promoted environmental education in these communities as well as technological transfer in these communities. We attempted to construct a model for a novel recycling system not only for local markets but also for global markets.

Background

In integrated ecosystems that range from forests to coastal areas including urban areas, a large variety and volume of organic wastes are generated by humans—the producers and consumers of organic substances. If organic waste is not properly disposed, it can easily cause environmental contamination such as soil contamination, nitrate contamination, or groundwater eutrophication. We cannot afford to dump the organic components in wastes

because of the scarcity of natural resources in Japan. However, presently, there is no system for the effective recycling and appropriate reuse of organic wastes. Therefore, it is very important to work toward building a society that has a sustainable recycling system. Hence, it is essential to develop composting technology that is based on returning wastes to the soil and the reuse of organic components in wastes.

In Japan, composting has been traditionally implemented to recycle wastes produced by human activities. The process of conventional type composting method can result in acid rains due to ammonia volatilization. Because the conventional compost has low nitrogen content, a large amount of compost should be used, resulting in the excess phosphoric acid in arable fields. In addition, these phenomena cause unresolvable problems such as eutrophication of surrounding water systems. Moreover, the functions of compost components have not yet been thoroughly investigated, and the applications of composting technology have not been effectively determined. Therefore, the composting technology requires further development to be applied on a global scale.

It is important to establish systems for both the production and practical applications of compost. These systems should have minimum environmental burden and at the same time should be able to maximize the intrinsic functions of the compost.

Purpose

The purpose of this project is to effectively compost various organic wastes generated in integrated ecosystems; to establish an environment-friendly recycling system, which can be applied on a global scale; and to develop a research and education center for integrated compost science.

Our objective is to integrate disciplines such as pedology, environmental microbiology, and economics, which have traditionally been studied separately and to establish an academic system, which is based on the practical application of field sciences.

In combination with research facilities in Miyagi Prefecture and in other organizations, we train technical experts and researchers in highly advanced composting techniques and in integrated compost science.

Our aim is to raise the academic standards in Tohoku University as well as to promote its research achievements that are related to the recycling of organic wastes by utilizing large-scale research facilities in Miyagi Prefecture and other organizations.

1. Proposal of environmental friendly compost production methods, and the development of new composting methods to drastically reduce ammonia volatilization
2. Investigating the features of the compost produced (features that increase crop growth rate and that protect plants against pathogens)
3. Assessment of compost recycling

Composting Study Group

The Composting Study Group mainly conducts analyses on the acidulocomposting.

1) Analyses of the changes in microbial communities during acidulocomposting.

Dr. Tokuzo Nishino (previously a Professor at the Graduate School of Technology, Tohoku University; currently a Professor at the Tohoku Seikatsu Bunka College) and Dr. Toru Nakayama et al. (Graduate School of Technology, Tohoku University) developed an acidulocomposting system with thermoacidophilic microorganisms as seed bacteria. In this system, lactic acid bacteria stably exist as the dominant microbial species. The acidulocomposting system they developed was issued a patent entitled "The composting method of organic waste (patent number: 2001-220275)." We improved this acidulocomposting system and analyzed the functions of the microbial communities in this system. After analyzing the culture conditions, functional microbes are isolated. Gene analysis is an effective method to understand changes in microbial communities. Microbial communities were analyzed by denaturing gradient gel electrophoresis (DGGE). We also used the clone library method to identify the dominant microbial species.

2) Acidulocomposting by laboratory scale facility.

We examined the conditions for acidulocomposting that were suitable for the organic resources to be composted.

Composting Safety Research Group

1) Survey on the analytical methods and heavy-metal analysis for the safety involved in composting.

We ascertain the chemical properties of various composting materials by means of elemental analysis, quantitative analysis of the fertilizer components, etc. These data are utilized for the composting system design.

2) Examination of the effect of compost on aquatic insects.

There is concern that compost eluates may affect river ecosystems at the site of compost application. Therefore, in this study, we assessed the effect of compost eluate on aquatic insects.

- •A literature review of the effect of chemical agents or other factors on aquatic organisms and insects in rivers.
- •Selection of aquatic insects for the assessment of compost toxicity.

3) Analyses on the disinfecting effects of compost to pathogenic microbes.

We developed monitoring methods to understand the dynamic state of pathogenic microbes in the composting process and identified these pathogenic microbes. Moreover, although pathogenic microbes are killed by high temperature during the composting process, it is necessary to clarify other microbial factors such as bacteriocins, bacteriophages, and antibiotics.

Availability and Functionality Assessment Research Group

Composting is an appropriate method for the circular recycling of biological waste.

When compost is mainly used for agricultural applications, it is important to maintain a balance between the recycling of organic resources and sustainable production. To achieve the abovementioned objective, this group assessed the availability and functionality of the compost and developed an efficient and practical technology for the environment-friendly recycling of biological waste.

Research Themes and Achievements

Analyses of the characteristics and functionality of acidulocomposting

Compost derived from acidulocomposting (n = 12) was compared with that derived from raw garbage (n = 11). The following results were obtained.

(a) Low pH value (4.9 in acidulocomposting vs. 7.0 in garbage domposting)
(b) High nitrogen content (4.5 vs. 3.0)
(c) Low C/N ratio (12 vs. 17)

The above results indicated that the acidulocompost had a high organic nitrogen and that organic substances were degraded. Furthermore, inorganic nitrogen will be easily supplied. We applied both composts to soils and surveyed the germination and growth rate of Komatsuna (Brassica campestris). When the acidulocompost was compared with the aerobically produced compost from garbage, most of the raw compost derived from garbage lowered the plant growth rate. This observation indicated the presence of organic substances that inhibited plant growth.

Compost Comprehensive Assessment and Study Group

- Study on comprehensive methods for the assessment of compost and on practical applications of organic resources

In our project "Development of Ecological Recycling System for Organic Resources," a resource recycling system is constructed by assessing the safety, functionality, and availability of compost. We characterize "the recycling system on organic resources for global symbiosis" and comprehensively assess the system.

1) Development of a technology for the economic efficiency assessment, including environment-friendly effects evaluated by LCA

Life cycle assessment (LCA) is a method used to quantify the environment burden of products generated during their life cycle, i.e., from production to disposal, which is mentioned as "from cradle to grave". Products or services that have an economic cost of production but a high environmental burden are not beneficial to the environment. We develop assessment technologies for the availability and the economic efficiency including the assessment by LCA. The economic efficiency assessment is conducted in cooperation with Composting Study Group.

2) Development of a broad-based assessment technology used to determine the amount of organic resources generated using remote sensing

The total mass of organic material that is produced by living organisms, i.e., biomass, has so far not been accurately quantified. Therefore, we developed a broad-based assessment technology to evaluate the amount of biomass produced by various scales of urban development such as prefectures, municipalities, and settlements by remote sensing.

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