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Sustainability analysis of bio-based and biodegradable plastics

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Abstract

Plastics are essential materials widely used in the society with annual production of 14 million tons in Japan. They have three major environmental issues: oil use, CO_2 emission, and long persistency. The nature of plastics could violate Sustainable Principle (SP) offered by the Natural Steps: SP1) Concentrations of substances extracted from earth's crust are not systematically increasing and SP2) Concentrations of substances produced from society are not systematically increasing. To mitigate sustainability issues of plastics, bio-based and biodegradable plastics have attracted attentions. Bio-based plastics made from renewable resources are carbon neutral. Biodegradable plastics are decomposed by microbial decomposition. The production of them was about 16,000 tons in 2004 making up merely 0.1% of the total plastics production. Polylactic acid (PLA) accounts for the half of the production in prospect of demand for components of bio-based plastics. Recently, the major trend is the shift from oil to biomass but biodegradable plastics also should have more attention considering long persistency of plastics. Therefore, this study aims to clarify the benefit of bio-based and biodegradable plastics from sustainability view point and to present some approaches to encourage the use of them.

Some plastics get out from social control and are discharged into the natural environment. Adverse effects of these uncontrolled plastics have been observed in the marine environment. Review on marine pollution by waste plastics found that fragmented plastics had been accumulating in the marine biota probably due to the continuous release of waste plastics from land. It is quite difficult to estimate how much plastics become uncontrolled. However, on the assumption that only 1% of the plastics stocked in the social system would be lost, 10,000 tons of plastics would be uncontrolled. That means 100,000 tons of plastics might accumulate in the environment in 10 years. This is a certain amount with a comparison to the assumption of wastes on Japanese beach, 30,000 tons (Fujieda et al., 2007). Plastics released to the natural environment will remain there until they are recovered, so the risk of uncontrolled plastics should not be

underemphasized.

PLA is obtained from lactic acid which is efficiently produced from fermentation of starch. Literature review and market report showed its good property and production capacity. The speed of degradation in the natural environment is slower than other biodegradable plastics, but PLA have good compostability. LCA result published shows that PLA requires less process energy than other conventional plastics from agriculture to pellet (Vink et al., 2003). To understand the benefit of biodegradability, evaluation of PLA was attempted by using the concept of Sustainable Process Index (SPI). SPI aims to quantify the degree of sustainability focusing on the process. The impact is explained in the area required to sustain the process in sustainable condition (Krotscheck and Narodoslawsky, 1996). To explain the differences between PLA and conventional plastics, the concept of A_p, which is area required to dissipate substances under the natural concentration not to alter the quality of the environmental compartment, was applied to think the long persistency. To computate A_p, the natural concentration of plastics were necessary. However, plastics are anthropogenic substances that do not exist naturally in the environment. Thus, there is no 'base' concentration for plastics. That means no matter how the concentration is low, plastics are altering the quality of the environment. Therefore, it was impossible to obtain required area to dissipate plastic pollution under sustainable condition. However, qualitative cost and benefit should not be understated when we think about sustainability. The shift to biodegradable plastics is fundamental solution to make plastics production sustainable.

Many applications of PLA have been in practice thanks to technological development. Food packaging is one of the most promising fields making use of compostability of PLA. Since phosphate rock found in only some countries is depleting and the price is surging, there is a need to make use of domestic organic resources for sustainable agriculture. Composting of PLA food packaging with food waste can omit the separation process of them, so it must be attractive for packed food. Thus, an approach on convenience stores was discussed. Compost acceptors and incentives to recover sufficient wastes are important to work the composting process.

Estimation of acceptable compost showed enough potential to accept recycled compost from the whole of food waste in Japan. Recycled compost from convenience stores in Tokyo is acceptable within the region. Application of recycled compost has just started and experience of application to ensure its quality is not enough. Thus, local governments should use it for public green to accumulate more experience of application. Much potential was found to accept compost in public parks in Tokyo.

There are mainly two ways to dispose of general wastes from business activities: 1) businesses bring wastes in disposing facilities of local governments by themselves and 2) businesses delegate waste disposal to another operator with license of collecting wastes. Businesses have to pay the bring-in fee to bring waste in facilities for the former and treatment

fee for the latter. Analysis of treatment fee revealed that composting looked expensive because the bring-in fee bore only some portion of incineration cost. It was also indicated that composting operators might be in disadvantageous condition even after selling compost since the bring-in fee was exempted for waste collecting operators. To give the economical incentives for composting and distribute the responsibility of waste treatment, the bring-in fee should be corrected to bear the actual incineration cost. By doing so, businesses will make more effort to decrease waste production. To encourage composting, the bring-in fee is preferable to meet the equations;

$$(\text{Cost of incineration}) < (\text{Bring-in fee}) < (\text{Limit price})$$

$$(\text{Composting cost}) - (\text{Compost sales}) < (\text{Exempted bring-in fee})$$

Here, limit price is the line that people do not dump waste illegally.

In conclusion, the review on marine pollution and attempt to evaluate the long persistency of plastics by using SPI concept clarified the qualitative benefit of biodegradable plastics. Analysis of treatment fee revealed that composting looked expensive because the bring-in fee bore only some portion of incineration cost. The benefits of composting are brought about after use of products, so the social system needs to convert the benefits in price. The correction of treatment fee is one possible way. The technical challenges of PLA have been overcome by the effort of researchers and businesses. On the other hand, to change the social system could be more difficult and take time. Since Japanese government shows the strategy to create recycling-oriented society and make use of biomass, consistent approaches are required especially focusing on waste management.

References

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