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Waste management for a sustainable society

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Introduction

Globally, in keeping with the UN initiative, most countries are aware of the transition toward a sustainable society and are seriously attempting to attain it. Basically, a variety of natural resources is extracted from nature to produce commodities and services to create a better quality of life. The principle of sustainability lies in material conservation. The major cause of the continued deterioration of the global environment is the unsustainable pattern of consumption and production, particularly in industrialized countries, according to Agenda 21, the action plan for sustainable development adopted at the 1992 Rio Earth Summit. Hence, there is a need to scrutinize every aspect of human life dealing with material conservation. This article discusses the approaches to be adopted for a strategic solid waste management system that may contribute to a sustainable society.

Global trends in waste generation

At Okayama University, studies are being pursued to estimate waste generation on a global basis up to 2050. Basically, solid waste generation has always been related to the economic status of a community. Hence, the quantity of waste generation per person is correlated with the GDP of various countries around the world. Based on population estimates by the Population Division of the United Nations and the GDP predicted by the World Bank, the solid waste that is likely to be generated from municipal and industrial activities up to 2050 is estimated and presented in Fig. 1. It can be seen that in 2000, global waste generation was 12.7 billion tonnes, and this is expected to rise to 27 billion tonnes in 2050.

According to data available from the Ministry of the Environment, Japan, material consumption has been estimated up to 2050. Based on these values, global material consumption has been conservatively estimated to increase to around 100 billion tonnes in 2050. This huge amount of material either may not be available for extraction from the Earth or may exert excessive pressure on natural ecosystems, and thus it is essential to reduce the quantity of material consumption and also the quantity of wastes, essentially to sustain human life on the Earth. In this endeavor, one of the essential measures is to streamline the systems for waste management so as to reduce waste generation to the maximum extent possible. In Japan, systems are being evolved to support a sustainable society

Evolution toward a sustainable society

Municipal solid waste disposal by municipalities and regional governments in Japan was initiated upon the promulgation of the Dirt Removal Law in 1900. Enacted after epidemics of dysentery, plague, and other infectious diseases, this law aimed at overcoming sanitary problems in cities. In 1954, the Public Cleansing Law was introduced to secure a hygienically sound living environment, followed by the Waste Disposal and Public Cleansing Law in 1970. These two laws constitute the main framework of the present waste management legislation. The Waste Disposal and Public Cleansing Law, which passed the Diet during its "Pollution Session," along with other environmental protection laws, widened the regulatory coverage, extending it from municipal solid wastes to industrial solid wastes generated by industrial activities. Thus a complete legislative framework for environment conservation was established.

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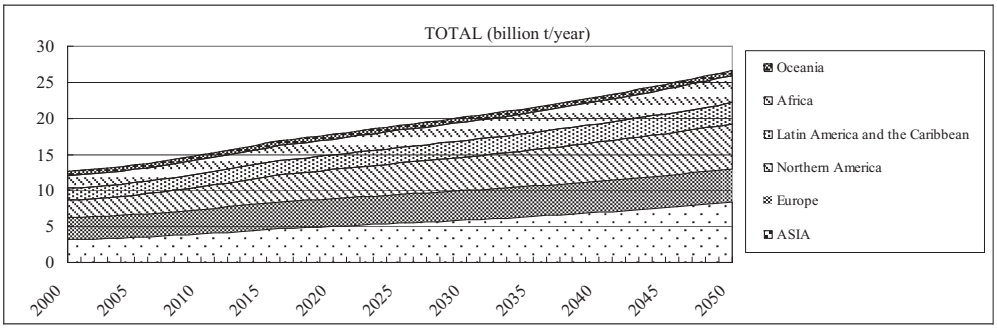

Fig. 1. Estimated solid waste generation on a global basis from 2000 to 2050

Since the enactment of the Waste Disposal and Public Cleansing Law, the Japanese people's lifestyle and economic structure have undergone drastic changes against a background of economic affluence, with resultant quantitative growth and increasing diversity in the nature of wastes. Mass production and mass consumption in human society have resulted in the depletion of forests, mineral resources, and other natural resources; global warming; acid rain; depletion of the ozone layer; ocean pollution; and other forms of degradation of environmental quality. It has been realized that waste disposal holds the key to a sustainable society.

The earliest actions related to waste management were public hygiene measures, including those for preventing infectious diseases. A shift was subsequently effected to environment hygiene measures to maintain urban functions and to preserve a living environment. Today, waste disposal is quite significant for the purpose of a sustainable society.

Currently, solid waste management has acquired national status. There are several professional bodies catering to the needs of experts and professionals. On the educational front, the government has sponsored a center of excellence (COE) program, under my leadership at Okayama University, for research and development and an education training program in the field of strategic solid waste management for a sustainable society. The Japan International Cooperation Agency (JICA) has been organizing international seminars and training programs. There are several research institutes undertaking dedicated research on waste management. A sizable amount of resources is expended on this activity and there are established industries to provide technological support to the system.

Current practices

Basic principles

Households and business enterprises control the generation of municipal solid waste at source, where the waste originates. Recyclable components of such waste are disposed of separately, to facilitate recycling.

Municipalities and waste disposal agencies, both of which dispose of waste, separate useful components from the collected waste and put them in a recycling route. In some cases, where material recovery is not an appropriate measure because of the technical and/or economical difficulty involved, volume reduction by intermediate treatment such as incineration should be promoted as a measure to prolong the remaining service lives of landfill disposal sites. The energy derived from the incineration should be used for resource conservation. The ultimate residue is then subjected to environmentally sound final disposal.

Disposal of municipal solid waste

Japan is quite densely populated in comparison with other countries of the world, and its industries and population are concentrated in cities. As expected, in large cities the waste generation density is high, but space resources are very scarce. The difficulty in acquiring suitable land in such cities for waste treatment or disposal sites increases every year. Pronounced difficulty in such land acquisition is encountered in the case of final disposal sites, which demand a very large space. In Japan, additional efforts have, therefore, been made to reduce the amount of generated waste by various intermediate treatments. Incineration, a process which can reduce the volume of waste and is hygienic for biological hazards, is utilized extensively. Municipal authorities collect solid waste, as well as the bulky refuse discharged from households. In addition, some small-scale business waste (such as leftover food from restaurants and gardeners' organic refuse) is brought directly to facilities run by the municipal authorities.

The quantities of waste disposed of at municipal facilities throughout Japan added up to approximately 52 million tonnes in 2001, i.e., about 1.1 kg of waste is generated per capita per day. Another portion of generated waste (2.8 million tons) is retrieved through private routes (such as by the self-governing organs of local communities) as a valued resource. In 2001, 78.2% of the total quantity of waste discharged was directly incinerated and 12.1% was separated and crushed or put in a high-speed composting process or other treatment. Thus 90.3% of discharged waste was subject to some form of intermediate processing. Material recovery by local municipalities was 2.3 million tons and promotion of intermediate processing led to a decrease in the quantity of waste disposed of at landfill sites from 11.3 million tons in 1998 to 9.95 million tonnes in 2001 (see Fig. 2). To prolong the service lives of landfill sites, many municipalities incinerate the entire quantity of combustible waste.

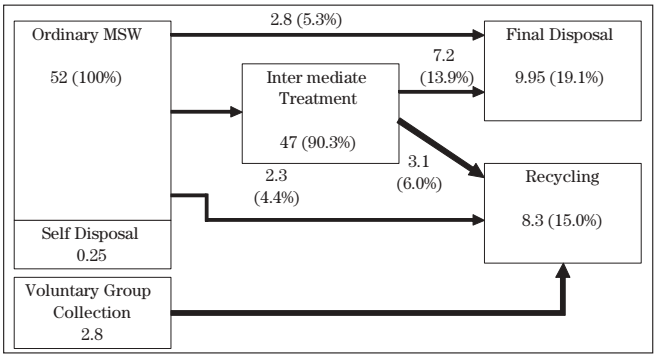

Fig. 2. Municipal solid waste (*MSW*) disposal flow in Japan (2001) (Source: Generation and Treatment of MSW 2001, Ministry of the Environment, March 2004)

Some municipalities request citizens to separate municipal solid waste (MSW) into combustibles and noncombustibles, or waste which, if incinerated, may have negative effects; consequently, it is simply disposed of as landfill. Organic household waste is a major source of garbage; accordingly, home composting plays an important part in waste reduction. Municipalities collect waste paper, glass, metal, and other materials as recyclable items or separated waste. Part of such waste is further screened and recycled at the appropriate recycling facilities, while bulky waste (large items such as home electric appliances or furniture) containing plastics, glass, metal, and other materials is crushed and then different substances of value are separated and recycled.

Challenges in solid waste management

Incinerators and dioxins

Since the emission of dioxins as a result of waste incineration has been drawing keen attention from society, it has become necessary to protect people's health by prevention and eradication of environmental pollution by dioxins. This has called for the formation of a new legal framework capable of covering the standards, necessary controls, and measures to be taken on polluted soil. With this background, the Law concerning Special Measures against Dioxins was promulgated in July 1999 and enforced in January 2000. Accordingly, various standards have been set up.

In this law, coplanar polychlorinated biphenyls are newly included in the substances defined as dioxins in addition to polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), and establishment of a tolerable daily intake (TDI) and the environmental quality standards for air pollution, water pollution (including pollution of bottom sediments), and soil pollution was required as reference points for official measures to be taken. The facilities which may generate dioxins were designated by a government ordinance and the standards for gas emission and effluent were set up for the individual facilities.

As a result of repeated examinations, the TDI of dioxins was determined to be 4 pg-toxicity equivalence (TEQ)/kg/day, and environmental standards in air, water, and soil were set at 0.6 pg-TEQ/m^3, 1 pg-TEQ/l, and 1000 pg-TEQ/g, respectively. Of the effluent and emission standards for control of specific facilities, the standard for effluent into water is 10 pg-TEQ/l. The standard for emission into the air varies with the kind and capacity of each facility. Waste incinerators having a burning capacity of 50 kg/h or more fall into a category of specific facilities requiring their own limits. The strictest standard is 0.1 ng-TEQ/m^3, which is applied to newly constructed waste incinerators having a capacity of 4 tonnes/h or more.

PCB issues

Used polychlorinated biphenyls (PCBs) have been stored in containers for long periods. As a result, there is concern about the release of PCBs into the environment due to: (1) corrosion of PCB containers, (2) durability of PCB containers in enclosed indoor systems, (3) damage due to earthquakes and/or fires, (4) breakdown of PCB regulation due to the bankruptcy of companies in charge of the storage and control of PCBs. According to a survey conducted by the Ministry of Health and Welfare, a certain amount of PCBs that has been stored at various plants or facilities is lost or goes missing over time.

Strict control of PCBs will be required through disclosure of the possession of PCBs; the application of appropriate control methods according to the storage method, density, and volume of PCBs; and the establishment of a public inspection system. Currently, new chemical treatment technologies are being developed. Therefore, in order to promote PCB waste treatment, it is necessary to expeditiously construct treatment facilities. Several chemical treatment facilities have been built to dispose of all PCB waste in Japan.

Illegal dumping

An accumulation of illegally dumped waste was discovered in the northern part of Japan and this became the topic of heated debate. Who should take responsibility for cleaning up the waste? The contamination had come from a large number of drums that contained chemical waste. In Japan there are about 70000 industrial waste management companies. Ninety per cent of these companies are engaged in the collection and transportation of waste to the disposal facilities. However, in order to make money, some of them choose the easy way to dispose of waste, namely illegal dumping.

There is a very serious problem on Teshima Island in Kagawa prefecture in the western part of Japan. Half a million tons of industrial waste such as shredder dust has been transported to this dumping site and the citizens are worried about environmental pollution. The Governor of Kagawa prefecture has agreed to take responsibility for the

cleanup program, which is now being implemented. Originally, the waste management company stated that the dumped items were recyclable and that almost all of them could be recovered, but many were found to contain hazardous waste.

Extended producer responsibility approach

At the OECD, a new public policy instrument called Extended Producer Responsibility (EPR) was studied as a major means for constructing a successful worldwide waste management system. The major responsibilities for manufacturers and distributors in the past were worker safety at the production and distribution stages, the prevention and management of pollution emissions from the manufacturing process, and industrial waste management. Recently, however, product liability – the legal civil responsibility of a corporation for a product that is dangerous to the customer – has also become an important responsibility.

EPR entails still wider responsibility, including liability for management of a product after consumption. EPR is based on a new strategy for promoting the internalization of all environmental and other "external" costs related to the entire life cycle of a product.

Japan prepared for the introduction of EPR with the promulgation of the Packaging Waste Recycling Law on June 16, 1995. The aim of this new law was to introduce a new recycling system under which business enterprises would be obligated to take back and recycle the packaging and other containers from their product. Some of the used home electric appliances that are discharged from households are crushed and the metals used in them are recovered. But most of these old appliances are disposed of at landfill sites. To remedy this situation, the Home Electric Appliance Recycling Law was promulgated on June 5, 1998, requiring producers to take back and recycle their home electric appliances discharged as waste. Home electric appliance manufacturers are supposed to establish a system for dismantling disposed television sets, refrigerators, washing machines, and air conditioners and for recycling the iron, copper, aluminum, and glass therein.

Apart from municipalities' separate collection of recyclables, local residents' groups for retrieval and other voluntary measures play an important role in recycling. To establish an optimum recycling system, it is essential to fully recognize the deficiencies and drawbacks of existing methods. A more efficient system must be worked out through close cooperation among the administrative authorities, citizens, and producers, each with a definite assigned responsibility.

Research orienting waste management toward a sustainable society

Continued efforts aim at innovating new concepts in the drive toward a sustainable society, addressing cost, technological approach, and philosophy. At Okayama University, we established the Center of Excellence for the 21st Century on Waste Management. The program name is Strategic Solid Waste Management for a Sustainable Society, under which research continues to address issues such as resource conservation efficiency, environmental preservation efficiency, and economic efficiency, toward the building of a sustainable society. Research topics include the development of the waste lifecycle assessment (WLCA), a powerful method of evaluating and selecting waste management methods and technologies for evaluating the harmfulness of solid wastes, for evaluating the safety of recycled products, for preserving resources through recycling, for reducing the burden on the environment, and for the treatment and disposal of solid wastes. The thrust areas of research include:

- developing planning tools for solid waste management
- developing safety assurance systems
- developing and accumulating appropriate treatment/disposal technology and 3R technologies to reduce, reuse, and recycle wastes
- training personnel for strategic waste management.

It will be necessary to build a base for research and education related to solid waste management not only for Japan but also for other parts of the globe.

National efforts toward strategic waste management for a sustainable society

The Johannesburg Plan of Implementation adopted at the World Summit on Sustainable Development in September 2002 calls upon nations to "encourage and promote the development of a 10-year framework of programs in support of regional and national initiatives to accelerate the shift toward sustainable consumption and production. These include identifying and implementing concrete activities, tools, policies, measures, monitoring and assessment mechanisms, and, where appropriate, life-cycle analysis and national indicators for measuring progress."

The plan also calls for the adoption of policies and measures aimed at promoting sustainable patterns of production and consumption and the application of the "polluter pays" principle. In March 2003, the Japanese Cabinet passed a resolution on the Basic Plan for Establishing a Sustainable Society, a society in which the use of natural resources is curbed and the environmental load is reduced as much as possible.

Promoting a less consumption-oriented lifestyle

In order to achieve these targets, the Japanese government intends, among other initiatives, further to develop laws and regulations for waste management and recycling; to promote a "slower," less consumption-oriented lifestyle by enhancing environmental education and learning and providing adequate information; and to accelerate the production of environmentally friendly goods and services through

the incorporation of Design for the Environment (and systems for the lease or rental of items).

Japan sees resource productivity as the most fundamental indicator of sustainable consumption and production patterns. Establishing such patterns is a challenge common to every country, and other nations might consider establishing common targets for resource productivity, as in the Basic Plan. Japan proposed the launch of an international joint research project to establish a common scheme to address the issues of material flow accounts and resource productivity in the Communiqué of the G8 Environment Ministers' Meeting held in April 2003 in Paris. In keeping with this policy, Japan also proposed the 3R (Reduce, Reuse, and Recycle) initiative at the G8 meeting held June 6–10, 2004, at Sea Island, Georgia, USA. Thus the Japanese government is making efforts to implement the Johannesburg Plan in collaboration with the international community. It looks forward to increasingly strong efforts in other countries as well.

Waste management for a sustainable society

The ultimate goal has to be a sustainable society. Pragmatically, this can be achieved by taking several steps simultaneously in the following manner:

- During manufacturing processes, it is necessary to reduce the quantity of wastes, reduce the use of harmful substances, and indicate the content of harmful substances in the product.
- During marketing, consumers should be provided with complete information about the product and the method of collection for the waste generated during and after consumption.
- As far as the use of various products is concerned, the use of recycled products should be promoted and also attempts should be made to prolong the economical life of every product.
- The waste collection and transportation system should be systematized for optimum performance.
- Waste treatment should be oriented to recover and reuse harmful substances to reduce environmental contamination.
- The standards for waste disposal by landfilling should be stringent. Also, it is necessary to clarify and review the standards for site abolition and management.
- Toward material conservation, it is necessary to expand the use and market for recycled products. It is necessary to internalize the environmental consideration in material use during manufacturing, consumption, and disposal.

Conclusions

Solid waste management has always been an integral part of human life and also has a strong influence on production and consumption patterns. It may also adversely affect the environment and may have long-term effects on human life. In order to reduce the adverse impacts of this system, there is an urgent need for a policy shift toward internalization of waste management in an effort to move toward attaining a sustainable society. In line with and in collaboration with the global community, we have to attempt to minimize material consumption, environmental pollution, and public health hazards resulting from waste management. Let us work together for a sustainable society.