FUTURE SCENARIOS: PREDICTING OUR ENVIRONMENTAL FUTURE

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Summary

This paper, which focuses mainly on Japan, summarizes future scenarios for our environment on the basis of a broad survey of existing knowledge on each of several topics. Studying the state of the world and making predictions based on the facts are

important parts of the decision-making process that allows us to address upcoming environmental problems. The scenarios in this article are only a few particular combinations from the thousands of possibilities. The article covers environmental topics such as waste management, reduced emissions of greenhouse gases, ultraviolet radiation, the global food supply, the energy crisis, soil contamination, nuclear power plants, nuclear fusion, solar power satellites, and global warming. Each topic is introduced with a timeline, and a brief overview of the present state and future challenges related to the environmental problem in Japan is presented. The scenarios, choices, and recommendations indicate that the decisions required to begin solving these environmental problems must be made as soon as possible to avoid the worst outcomes, not only for Japan but also for the global community.

1. Introduction

It used to be that "environmental problems" meant pollution. Especially for pollution problems such as mercury poisoning, it was clear who the victims and the polluters were, and what remedial measures and remediation actions were to be taken. However, as times changed, the problems became more complex and the solutions more difficult. With air pollution, for example, people end up in the ambiguous position of being both victim and polluter at the same time, making it impossible to solve a problem by traditional means such as the victim suing the polluter. In addition, we have had to consider a greater diversity of problems as it becomes increasingly clear that the Earth's resources—and indeed, the Earth itself—are finite and that problems and their solutions can be entangled in complex ways. For instance, using large amounts of energy to deal with pollution would lead to broader problems, such as global warming and the depletion of energy resources. This, in turn, shows that we are confronted with dilemmas such as "the economy or the environment" in which one environmental issue is being pitted against another.

The pollution that arose after World War II started giving people a clear awareness of environmental problems. However, the history of such problems has been very short, and the changes in environmental problems themselves have happened quickly. The public thus has a great diversity of perceptions and thinking about environmental issues. Predictions of the future are important, but their outcomes always contain uncertainty. Nevertheless, it is still necessary to list all the conceivable future impacts on our lives and then to explore them from many different angles. Many of the environmental problems we face now could continuously affect our future, and fundamental solutions will be impossible if we adopt myopic policies that employ only temporary expedients to solve the problems. At the same time, we must recognize that making different assumptions will lead to different predicted outcomes. Depending on the people who are making the predictions and their points of view, predicting the future will involve different choices in terms of the time period and the items that are predicted. Listing all the possibilities is certainly not a task that one person can do. It must instead be carried out by experts in a variety of disciplines through their research and discussions, and such discussions must transcend disciplines, countries, and regions.

On the basis of this perception, the Ministry of Education, Culture, and Sports in Japan awarded a Grant-in-Aid for a priority-area research project called "The Man-Earth

System" from 1993 to 1997. Experts from various disciplines came together and discussed the environmental problems that could occur in Japan from 2000 to 2050, and explored what measures might be effective in dealing with them. Table 1 sets out the forecasts that were made from the results of these discussions.

2005	• Waste incineration is restricted. Only the incineration of completely separated single types of waste is allowed. • Serious shortage of final waste disposal sites in Japan. Illegal dumping of industrial wastes continues.
2010	• Japan's greenhouse-gas reduction targets, as determined at COP 3, prove ultimately impossible to fulfill. • There are many genetic and reproductive abnormalities believed to be attributable to dioxins. • UV radiation is definitely becoming stronger. Skin cancer and other effects are evident. • A worldwide food supply crisis emerges. The reason is not global warming, but rather that the United States, China, Russia, and Australia have all experienced low temperatures at the same time. This might be the result of climatic extremes.
2020	• Crude oil prices skyrocket, and an energy crisis emerges. Although not as bad as the first oil shock in the 1970s, energy prices steadily rise. As more people begin depending on coal as their energy source, precipitation becomes more acidic. Emissions of vanadium, manganese, and other elements begin to increase. The vitality of Japanese industry drops precipitously owing to the energy crisis. Pollution makes a comeback owing to the economic depression and reduced environmental investment by companies. Due to higher energy prices and other factors, business trips abroad are largely curtailed.
2030	• Japan at last manages to prohibit the use of lead, except when it can be totally recovered by recycling. There is a shortage of metals that are mined along with lead. Total recovery of mercury is also finally required. • Soil contamination resulting from the disposal of obsolete, formerly state-of-the-art electronic equipment becomes a problem. A particular issue is the improper disposal of gallium arsenide and the wastes from its manufacturing equipment.
2050	• Crude oil production drops to half of its high point, which occurred in 2030. There is no choice but to rely on nuclear power to make up the difference. • A solar power satellite finally goes into orbit. Growth of the space industry has brought the population living in space to 4000 people, but there are concerns about the effects of cosmic radiation on their health. • Impacts of global warming are readily apparent. The mean sea level has risen by about 20 cm. As a result, the Maldives, other island nations, and low-lying regions such as Bangladesh are suffering from its severe damage.

Table 1. An environmental forecast for the twenty-first century.

The following sections examine the current state (around 2002) of the items in Table 1 and relevant research results, and explore mainly how life in Japan will be affected.

2. 2005: Overwhelmed with Waste

2.1. Restrictions on Waste Incineration and a Move toward Complete Separation of Wastes

The dioxin concentration in Japan's air is far higher than that in other countries, owing to a delay in taking remedial action. Ordinary dioxin concentration is expressed with unit of pg-TEQ (10^{-12}g-TEQ). The toxicity of dioxins varies depending on type of dioxin. TEQ means value equivalent to 2,3,7,8-TCDD. Japan's urban dioxin concentration averaged 0.37 (pg-TEQ/m^3) in 1996, compared with 0.09 in the United States (1995) and 0.12 in Germany (1995) (Liem and Zorge, 1995). In Sweden, the concentration was only 0.024 (1993) because the country adopted advanced remedial measures (Liem *et al.*, 1993). Belated action on waste incineration is the main reason for the high concentration in Japan. About 80% of total dioxin emissions come from the incineration of municipal solid waste (MSW), and about 10% come from industrial wastes incineration (Environmental Agency, Japan, 1996). Japan must take swift action to reduce emissions from incinerators. Two conceivable approaches to reduce the emission of dioxins from incinerators would be control by means of an improved incineration process and control by means of sorting wastes before incineration. Sorting wastes is probably the more effective of these two approaches as a means of reducing emissions.

The formation of dioxins during the incineration process is known to depend on such conditions as incomplete combustion during incineration, flue-gas cooling, and the scrubbing temperature. It follows that waste incineration facilities require thorough combustion control and flue-gas treatment systems that use a variety of technologies.

Dioxins are formed when the wastes to be burned contain chlorine. Therefore, reducing the amount of chlorine (and specifically the amounts of vinyl chloride and plastics) in wastes will result in the production of fewer dioxins and lower concentrations of each. However, although some have pointed out a correlation between the hydrogen chloride concentration in wastes and the dioxin concentration in incinerator ashes and flue gas, others claim that there is no direct connection between waste quality and dioxin formation. In other words, there is still some disagreement on the relationship between waste quality and dioxin formation.

Nevertheless, separating vinyl chloride from plastics does offer hope of reduced emissions. Burning wastes that contain high amounts of plastics generally produces more heat and makes combustion difficult to control, which in turn increases the possibility that dioxins will form. So the best course of action at present seems to be separation of plastics and other wastes that make combustion difficult to control. Consequently, more nearly ideal combustion conditions for minimizing dioxin formation will be attained. Moreover, plastics can often be recycled, turning a potential waste problem into a potential resource.

In fact, a number of cities have succeeded in considerably mitigating their dioxin concentrations by separating out plastics, and that trend is likely to continue. Some of the plastics separated from trash, however, are being sold as solid fuel. Of course this merely shifts the site of dioxin formation to a different place, making it important to focus future efforts on plastic reuse.

2.2. A Serious Shortage of Final Waste Disposal Sites and the Continuation of Illegal Dumping

For the last few years, the annual amounts of wastes generated in Japan have remained fairly stable at about 50 million t of MSW and 400 million t of industrial wastes (Fig. 1). In 1996, 77.1% of MSW was directly incinerated, and 12.6% was sent to intermediate processing; about 38% of industrial wastes are recycled. The final amounts of MSW and industrial wastes that must be disposed of are thus reduced to 26% and 20% of the original total, respectively.

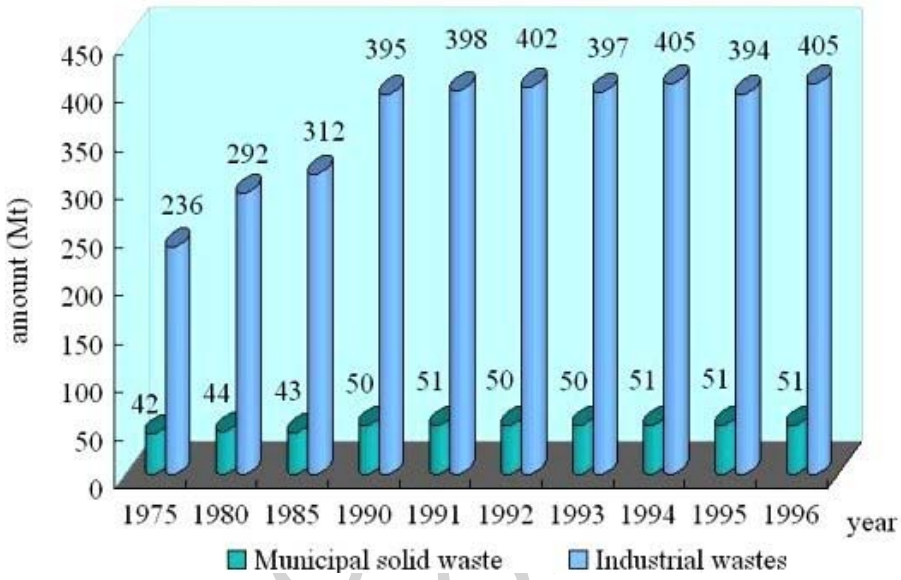

Figure 1. Progress in the annual amounts of disposal in Japan. (Environmental Agency, Japan, 1997)

In 1998, the average remaining usable lifetime of the final disposal sites for MSW in Japan was 8.5 years. The national average for industrial waste sites was 3.3 years, versus 0.8 years in the Tokyo area, clearly indicating that disposal space is at a premium (Environmental Agency, Japan, 1999). New disposal sites are being developed every year, but because of site contamination and other problems, people living near these sites have vigorously resisted their development in recent years, making it more difficult year by year to secure new sites. The problem is especially acute for industrial wastes. According to Ministry of Health and Welfare statistics, disposal sites will be full by 2008 if wastes continue to be generated at the current rate (Fig. 2). In the latter half of the 20th century, much waste was dumped on the coast in order to create more land for development. There must be areas where the intertidal zone is narrow and of little interest where inert waste could safely be dumped, thus turning a liability into an asset.

Can such an outcome be avoided? In 1998, the following three types of industrial wastes were produced in the highest volumes:

- Sludge

- Animal excrement
- Construction and demolition (C&D) wastes.

Together, these three categories accounted for about 80% of all industrial wastes being generated, and they accounted for about 60% of the total being sent to final disposal sites even after recycling and reduction (Environmental Agency, Japan, 1999). The biggest problem is what to do with sewage sludge and C&D wastes. The Ministry of Construction statistics suggest that the proportion of Japanese households connected to sewerage in 1995 was 54%, and reached 62% in 2000 (Ministry of Land, Infrastructure and Transport, Japan, 2001). As the connection rate increases, so will the amount of sludge being generated. Meanwhile, the buildings put up during the construction boom of the 1970s and 1980s will be finishing their 30- to 40-year life spans and become C&D wastes, which will, therefore, increase over the present levels.

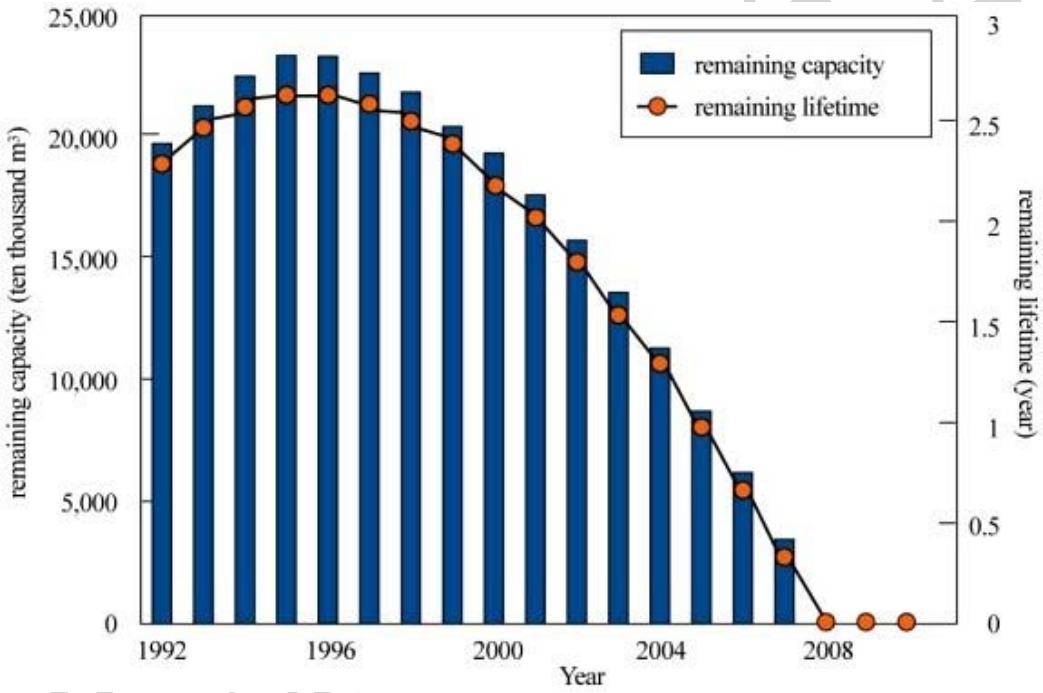

Figure 2. Remaining capacity of final waste disposal sites in Japan.
Source: Ministry of Health and Welfare, Japan; revised by authors.

As these figures show, the problem of industrial wastes is even more acute than that of MSW. In a bid to solve this problem, the government amended the Waste Disposal and Public Cleansing Law in 1997, which now emphasizes three areas: promoting waste reduction and recycling, improving the reliability and safety of waste disposal, and counteracting illegal dumping. In conjunction with this change, the Planning Commission of the Ministry of International Trade and Industry released an action plan in 1998 to promote industrial wastes reduction and recycling (Ministry of International Trade and Industry, Japan, 1999). The plan was composed of three documents: "Numerical Targets for Reducing and Recycling Industrial Wastes", "Survey on the Purchasing of Recycled Products", and "Guidelines on Proper Waste Management for Waste Generators".

Although these developments can be applauded as a first step towards a recycling-based society, recycling still faces many challenges. The first hurdle is cost. At present, hauling wastes to final disposal sites is much cheaper than recycling them. In cities such as Tokyo, the lack of disposal space makes disposal expensive, but in regional cities it is still far more advantageous to dispose of wastes. Also, the difference in disposal costs between regions increases the transportation of wastes.
Another problem is whether remedial measures will be implemented in time. A large number of tasks remain to be completed before we can develop products that can be easily dismantled into recyclable resources and develop recycling plants with appropriate separation technologies and equipment. Even if easily separated products can be developed in the near future, products manufactured before then will begin to enter the waste streams. For example, because Japanese buildings have a lifetime of 30 to 40 years, the waste stream will not change qualitatively for several decades. In additional, it will probably take nearly 10 years to develop plants for recycling and bring them into widespread use. With the limited remaining lifetime of existing final disposal sites, it may become impossible to safely dispose of some wastes.

As a result of the shortage of disposal sites and the increasing quantities of wastes, illegal dumping is becoming increasingly serious in Japan. In November 1990, 500,000 t of industrial wastes containing hazardous substances were found to have been dumped illegally on Teshima Island over a period of 13 years, and this became a matter of serious public concern. The dumping on this small, thinly populated island in the Seto Inland Sea revealed a problem of inter-regional unfairness, in which industrial wastes generated through urban activities are hauled into the countryside. A special survey performed by the Ministry of Health and Welfare from 1993 to 1995 found that, over these 3 years, the number of illegal dumping incidents increased sharply, from 274 to 679 (Ministry of Health and Welfare, Japan, 1997). Examining the results in terms of regional distribution, the study showed that such incidents were rare in Tokyo, but frequent in rural areas.

In other cases, illegal dumping affects other countries, too. In January 2000, the arrival of containers full of wastes in the Philippines caused a stir. The Basel Convention prohibits international trade in hazardous wastes, but hasty domestic action could further accelerate illegal dumping at both domestic and international sites, and Japan's international standing could be marred.

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Biographical Sketches

Toshiaki Ichinose was born in 1963. He is Executive Senior Research Scientist, Social and Environmental Systems Division, National Institute for Environmental Studies, Tsukuba, Japan. He is a

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