Research Center for Material Cycles and Waste Management
National Institute for Environmental Studies

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http://www-cycle.nies.go.jp/

Research Center for Material Cycles and Waste Management

循環型社会・廃棄物研究センター

National Institute for Environmental Studies

Introduction

Mass production and mass consumption characterizing our society in the late twentieth century is often blamed for its negative legacy of mass disposal. One solution to this problem is promoting the establishment of a "sound material-cycle society." Warnings about waste problems began not long ago in about 1980. In Japan, countermeasures against the mechanism of waste generation which is attributable to the structure of industrial society and consuming society were officially built into the system with the Waste Management and Public Cleansing Law amended in 1991. This amendatory law added conceptions of "reduction of waste generation" and "recycling" to the conventional waste policies based on "stabilization, minimization, and energy utilization," and given higher priority on those conceptions. Later on, the Basic Environment Law was enacted (1993), and an environmentally sound material cycle, harmonious coexistence, participation and international activities were worked out as the basic principles of the Basic Environmental Plan determined under the basic law. In 2000, the Basic Law for Establishing a Sound Material-Cycle Society came into effect as a basic law base on the sound material cycle principle. This law determined that "the following subjects should be prioritized in the following order: reduction of waste generation, reuse, material recovery, heat recovery, and appropriate disposal." This law can be understood as Japan's constitution in terms of establishing a sound material-cycle society. In order to achieve the aims of this legislation, many technological, institutional and systemic issues need to be tackled.

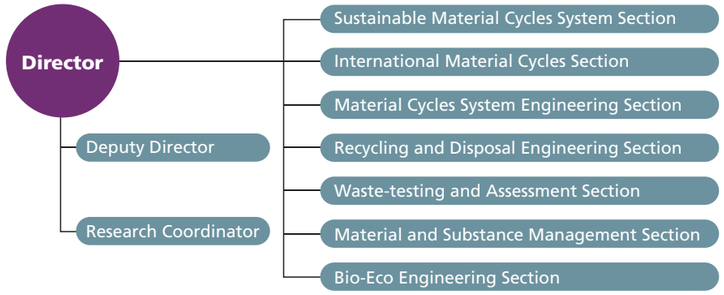
Against such a background, the Basic Plan for Establishing a Sound Material-Cycle Society was developed under the pertaining Basic Law during the period of the first five-year plan of the National Institute for Environmental Studies (2001-2005). In addition, institutional improvements were achieved during the same period including the enforcement of the amended Waste Management and Public Cleansing Law and various recycling promotion laws. However, a need to enhance waste reduction, etc. is still growing with similar volumes of waste generation registered for the last several years, although declines in final disposal volume are being observed for both municipal and industrial waste.

Roles and goals of the Research Center

The Research Center for Material Cycles and Waste Management (hereinafter, the Center) has promoted its research activities in a bid to set in society desirable material cycles, in which utilization of natural resources as well as generation of waste are reduced, recycling of materials is established, and appropriate waste management is ensured with care to preserve the environment since its foundation in April 2001. The Center has also proposed proper ways in terms of sound material cycles and waste management practices in a sound material-cycle society (see the achievements made during the first five-year plan period listed on P.21).

The Center considers that its basic roles will not change for the period covered by its second five-year plan (2006-1010). It will promote research activities to realize a socio-economic system based on sustainable cycles by lowering environmental loads through improvement of resource and energy utilization efficiency and the establishment of sound material cycles, wherever possible, in the entire steps of socio-economic activity including resource extraction, production, distribution, consumption and disposal. Since the materialization of a sound material-cycle society as contemplated here is an issue of importance not only to Japan, but also to international society, it will also promote research activities with the construction of an international research network in mind. On the basis of research achievements made to date, the Center will promote research to realize a low-environmental-load society in the near future, placing more emphasis on the "Establishment of a sound material-cycle society."

Organization



▶P03

History

Jan. 1938:	Launch of the National Institute for Public Health
Mar. 1974:	Launch of the National Institute for Environmental Studies
July 1990:	Change of the designation of NIES in Japanese
Apr. 1992:	The National Institute for Public Health launches new Department of Waste Management Engineering
Jan. 2001:	Ministry of the Environment is established as part of administrative reforms of the Japanese government (Centralization of waste administration) NIES launches new Waste Management Research Division (Integration and transfer of the Waste Management Engineering Department from the National Institute for Public Health)
Apr. 2001:	NIES becomes an Independent Administrative Institution NIES launches the Research Center for Material Cycles and Waste Management
Apr. 2006:	Change of the designation of the Center in Japanese (but remained unchanged in English)

Five-year plan: A medium-term plan on which the operation of an independent administrative institution is based. In the case of the National Institute for Environmental Studies, such a plan is formulated as a five-year plan to achieve "medium-term objectives" determined by the Minister for the Environment.

Outlines of "Priority Program: Sustainable Material Cycles"

At NIES, we have determined the four priority research programs that the Institute should, with a view to ensuring the global environment's soundness and establishing a sustainable society, promote intensively and integrally in its second five-year plan (covering 2006-2010) to contribute to the environmental policies of the government with the definite vision of the environment and society ten years later. One of the four programs is "Priority Program: Sustainable Material Cycles," in whose promotion the Center plays a main role.

"Priority Program: Sustainable Material Cycles" comprises the following. In addition to these, there are associated research projects promoted chiefly by other research units within the NIES.

1. Core research projects

Four projects are undertaken to achieve the core research objectives of the priority research program. Through these projects, we will develop material cycle technology systems to underpin a science- and technology-supported nation and propose policy options to further 3Rs (waste reduction, reuse and recycling) promotion in line with international society so that we may ensure that the cyclical use of resources and the treatment and disposal of waste are subjected to appropriate management. In this way, we will show an exemplary embodiment of a sound material-cycle society required in the near future, and push the transition into such a society.

1. Designing and evaluating material cycle systems and policy/management techniques for the near future ▶P05
2. Management of hazardous and valuable substances in life cycles of materials and products ▶P07
3. Developing win-win resource-recycling technology for waste biomass ▶P09
4. Establishing appropriate management networks and technological systems to support sound international material cycles ▶P11

2. Research activity to ensure appropriate waste management practices

Following the first five-year plan, we will promote survey and research activities based on proactive/long-term standpoints so that we may ensure safe, reassuring waste management. Our activities will be responses to emerging and important issues on waste management in cooperation with related administrative organs and research institutes. We will also develop elemental technologies supporting a future sound material-cycle society.

1. Establishment of safe, reassurance, and appropriate waste treatment and disposal technology to support a sound material-cycle society ▶P13
2. Integration of testing, assessment and monitoring techniques ▶P14
3. Integration of appropriate waste treatment technology for liquid and organic waste ▶P15
4. Measures against negative legacies caused by inadequate waste management ▶P14

3. Promotion of fundamental research ▶P15

We will promote fundamental research including studies on discarded asbestos risk management and the development of fundamental technologies concerning material cycles and the building of databases relating to material cycles and waste disposal.

Outlines of research laboratory and equipment

1. Research Laboratory of Material Cycles and Waste Management ▶P16

The Research Laboratory of Material Cycles and Waste Management was established in March 2002 for conducting comprehensive studies on waste reduction, recycling, appropriate waste treatment, risk control, and so on. It is equipped with several experimental plants, such as recycling plant of organic waste, thermal treatment plant and simulation plant of landfill, and the latest equipment for physical, chemical and biological analyses. The Center is using this Research Laboratory to conduct research on realizing a sound material-cycle society.

- Structure: Steel-Reinforced concrete, three-story building
- Total floor area: 4,200 m²
- Completion date: March 2002
- Major facilities:
  - 1F: Resource-Recycling Plant, Thermal Treatment Plant, Landfill Simulation Plant, etc.
  - 2F: Chemical Analysis Laboratory for Recourses, Homoiothermal Room for Physicochemical Experiments, GC/MS Room, Biological Analysis Laboratory, etc.
  - 3F: Staff rooms, meeting room, etc.

2. Other research facilities ▶P20

The Center's research activities are conducted not only at the Research Laboratory of Material Cycles and Waste Management. To conduct environmental studies, it is imperative to go out into the field to observe actual phenomena taking place there and obtain reliable data. For example, we are conducting research on a final disposal plant at a demonstration site and promoting liquid waste restoration/improvement technology development by constructing a demonstration plant. We are also engaged in field surveys and on-site, interview surveys from time to time.

Major achievements made during the first five-year plan period ▶P21

This section provides outlines of the major achievements made in research completed during the first five-year plan period ending 2005.

Introduction of research sections

Sustainable Material Cycles System Section

This section will study a future vision of a sound material-cycle society and establish policy objectives for material cycles as well as design institutional measures to achieve these objectives. It will also undertake the development of system analysis techniques to understand/analyze socio-economic structures comprehensively as a basis of such research activities and databases to facilitate such tasks as well as the development of indicators for the measurement and evaluation of product and service production/consumption structures. In particular, this section will clarify associated problems through the accurate documentation of material flows, which will permit a quantitative presentation of environmental loads arising from such material flows. This section will also promote research activity with emphasis on the elucidation of changes taking place in material flows when various measures are implemented and study resultant resource-saving and environmental loads mitigation effects to support the implementation of a core research project, "Designing and evaluating material cycle systems and policy/management techniques for the near future."

Material Cycles System Engineering Section

This section will promote design and development of technological system for material cycles supporting a sound material-cycle society, conducting research on integrated system design, development, and evaluation of 3R technologies covering the entire life cycles of recyclable resources and waste. In particular, it will promote evaluation studies, employing such techniques as life cycle assessment and cost analysis, with emphasis on the implementation of a core research project, "Designing and evaluating material cycle systems and policy/management techniques for the near future," and with the optimization of integrated system design. Further, it will set development objectives with the entire system taken into consideration and undertake technology development including the development of required elemental technologies composing the system and evaluation studies. It will also expand the scope of research activity to study desirable technology policies and management practices at a regional or national level for the smooth development of a material cycle technology system.

International Material Cycles Section

This section will promote studies to develop an appropriate international material cycle system, while preventing the exportation of pollution and environmental impacts in connection with the international trade of various goods and materials. In the Asia region, the cyclical use of end-of-life products and materials (recyclable resources) exported from Japan is increasing on an international scale. In the course of the promotion of a core research project, "Establishing appropriate management networks and technological systems to support sound international material cycles," the actual states of international material cycles and the environmental impacts associated with them will be studied. Concurrently with the development of evaluation techniques such as indices, other countries' policies and socio-economic statuses will be surveyed and factors affecting international material cycles and problems will be analyzed. Then, an appropriate management network for the Asia region will be designed and policy options proposed in cooperation with experts from other countries.

Material and substance management section

For the recycling of resource materials, this section will promote studies on the appropriate management of chemical substances contained in waste taking into account their advantages (value) and disadvantages (hazard). In particular, material flows and behaviors in the use, disposal and recycling processes will be analyzed from both value and hazard aspects especially for plastics, metals and recycled materials. Release into the environment, risks and resource values of the substances will be evaluated. These research activities support the core research project, "Management of hazardous and valuable substances in life cycles." Further, a safe and secure recycling system will be constructed by assessing measures and a system for the promotion of recycling, the regulation of hazardous substances contained in products, and the recovery of useful resources. In addition, this section will also contribute to "Measures against negative legacies caused by inadequate waste management" through its research activity addressing POPs.

Recycling and Disposal Engineering Section

This section will promote research activity with emphasis on technology for the proper treatment and disposal of waste, recycling technology as an elemental technology contributing to material cycles, and technology to recover energy and valuable materials. It will play a central role in a core research project, "Developing win-win resource-recycling technology for waste biomass," and undertake the development, design, and demonstration of a technology and system that permit efficient recovery of energy and valuable materials from waste biomass. Further, it will evaluate disposal facilities ensuring environmental security and conduct studies on final disposal systems to control the quality of waste for landfill disposal so that we may establish safe, reassuring, appropriate waste treatment and disposal technology to support a sound material-cycle society. In addition, it will study and develop novel, fundamental technology foreseeing the future.

Waste-testing and Assessment Section

This section develops and applies the analytical techniques necessary for studying hazardous chemicals or valuable substances contained in products, recyclable resources, wastes, and recycled products and the behaviors of hazardous chemicals produced in the process of material cycles. To achieve these goals, this section will focus on the integration of testing, assessment and monitoring techniques as research activities such as appropriate pretreatment methods for various types of samples before high-sensitivity instrumental analyses, analytical quality control of bioassays officially adopted as dioxin-screening methods, the development of analytical procedures for waste products comprising composite materials, the development and application of simplified test methods suitable for routine analyses, the harmonization of testing methods for soils, waste and recycled products considering various countries' standardized testing methods.

Bio-Eco Engineering Section

This section will conduct studies on measures for liquid and organic waste reflecting considerations for material cycles and proper disposal. It will play an active roles in core research projects, "Developing win-win resource-recycling technology system for waste biomass" and "Establishing appropriate management networks and technological systems to support sound international material cycles," as well as "Integration of proper waste treatment technology for liquid and organic waste" promoted as research activity to ensure adequate waste management practices. It will propose environmental low-load-type technology systems, etc. through technology development for the recycling of, energy recovery from, and proper disposal of biomass contained in waste such as domestic waste water and raw garbage, promoting research activity with objectives to contribute to waste management policies both in Japan and overseas.

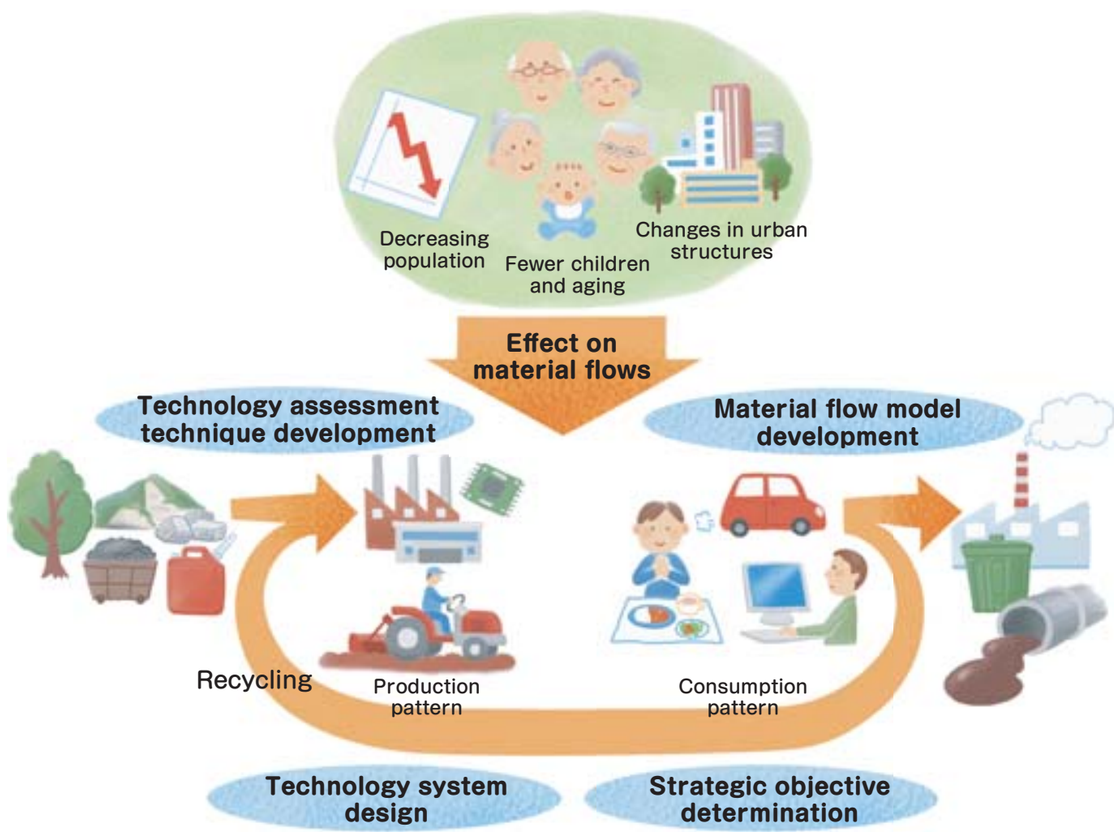
Core research project 1

Designing and evaluating material cycle systems and policy/management techniques for the near future

A future vision and associated conversion scenarios and specific road maps to realize the transformation into a sound material-cycle society are needed at various administrative unit levels such as national and local level as well as at various subject levels such as citizens, administrative authorities and industry. For this reason, this research project envisages technology and socio-economic systems in a sound material-cycle society 10-20 years in the future and promotes research activity with the objective of providing conversion scenarios and specific road maps based on strategically determined targets.
This research project comprises three sub-themes.

Projecting resource utilization and waste generation based on a material flow model and evaluating conversion scenarios to realize near-future visions

With the anticipated industrial structure, population pyramid, changes in people's lifestyles, and trends in policies relating to energy, industry, medical services and waste in the near future taken into consideration, we will develop a material flow model to express the effect of these social factors on material flows. Using this model, we will project and evaluate resource utilization and waste generation anticipated in the near future and determine strategic targets for the transformation into a sound material-cycle society. Using this model, etc., we will estimate and evaluate the effect of shifting to technology systems and policies in the near-future visions and associated conversion scenarios designed under other sub-themes. Through such processes, we may show the feasibility of achieving targets and anticipated problems in each conversion scenario and produce the outputs that indicate the directions of policies to be taken for progress toward near-future visions.



Designing and evaluating technology systems in a sound material-cycle society in the near future

We will design and evaluate material cycle technology systems sized to different spatial scales to cover biomass and depleting metal resources, which are expected to become an issue in the near future. We will employ life cycle assessment (LCA), life cycle cost analysis (LCC), and other assessment techniques to evaluate environmental loads and cost. In the meantime, we will review 3R technologies for plastics used in packaging and containers, home electric appliances and various information apparatus, which are subject to review under the respective recycling promotion laws. Through this activity, we are planning to propose near-future material cycle technology system visions.

Designing, developing and evaluating policy/management techniques to contribute to the transformation into a sound material-cycle society

With the ideas of a sound material-cycle society and the established objectives taken into consideration, we will design, develop and assess the validity of policy/management techniques concerning 3Rs. More specifically, we will design an index system and develop environmental accounting techniques in waste management to facilitate the national and local governments to measure progress made in the transformation into a sound material-cycle society, formulate material cycle- and waste management- related plans and implement their management practices. Further, we will evaluate the effect and validity of respective recycling promotion laws from such viewpoints as the optimization of material flows, extended producer responsibility (EPR), burden sharing, the provision of economic incentives and comparison with other systems for further integration of material cycle and waste management policies. Through this activity, we believe that we will be able to contribute to the national government's next basic plan for establishment of a sound material-cycle society, the formulation of material-cycle and waste management plans by local governments, and the indication of a direction for desirable waste management- and recycling-related law systems.

Core research project 2

Management of hazardous and valuable substances in life cycles of materials and products

A product consisting of diverse chemical substances is recycled as resources or processed/disposed of as waste at the end of its life. In a sound material-cycle society, we need to reduce waste generation as much as possible and on top of this, recycle/reuse waste as recycled materials. To realize such a society, we must avoid additional pollution risks from the inadequate reuse of or the process of recycling products (waste) containing hazardous substances as far as possible. For this reason, it is necessary to identify whether each type of waste is reusable, recyclable, or suitable for recycling use. In the meantime, research on recycling and utilizing resources effectively, while ensuring their safety in the recycling processes, is also important. This research project will investigate substances' behaviors, environmental risks and values as resources in their utilization, disposal and recycling processes and scientifically evaluate the effect of implementing measures to promote recycling, regulate hazardous substances, and recover valuable materials from both value and hazard points of view so that the recycling use of resources and the treatment and disposal of waste may be properly undertaken in society. More specifically, the project will focus on the following three themes, targeting major substance groups of interest under the domestic recycling promotion laws or from international material cycles.

Study on chemical management measures for plastics

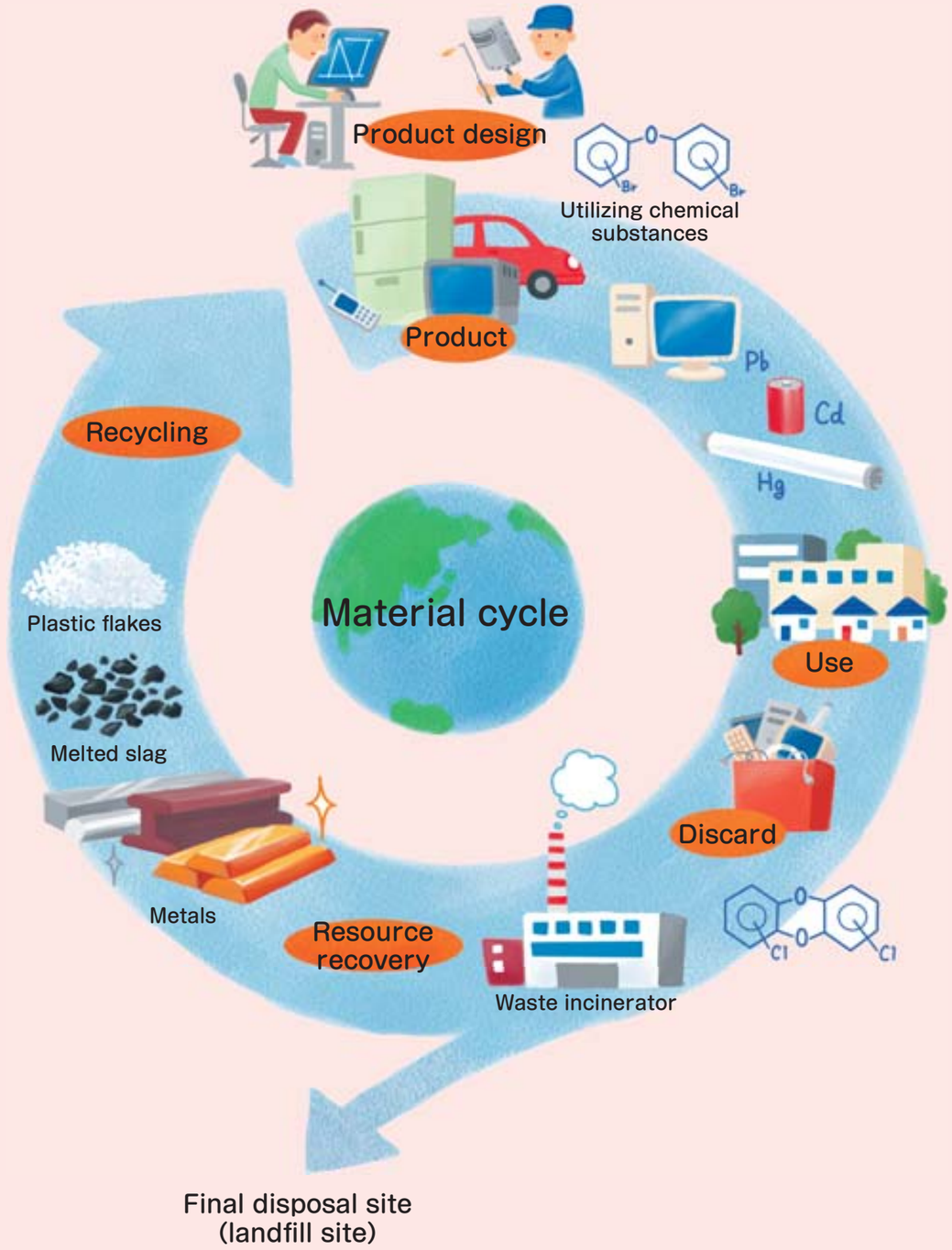
Taking note of the hazard of chemical substances employed for their usefulness such as brominated flame retardants and other additives contained in plastic products, we will investigate their process behaviors and control measures, and evaluate their advantages/disadvantages compared with their substitutions. Further, we will establish analytical methods for target substances and try to identify the risks that must be controlled or managed based on basic researches including toxicity evaluation and field surveys. Then, we will propose substance management measures effective in both useful and hazardous aspects of substances through their life cycles.

Study of management measures for valuable and hazardous metal recycling and disposal processes

We will propose methods of recovering metals from waste by quantifying hazardous metals released into the environment and the feasibility of valuable metal recovery. We will establish the analytical methods for products, accumulate information on metal contents, and also develop the detailed material flows of metals. For hazardous metals, we will check environmental release, methods for reduction and the quality of recycled products in their recycling or disposal processes. For valuable metals, the feasibility and cost performance for recovery will be studied for each material and product such as cars, electronic and electric appliances, OA machines, batteries, printed circuit boards, and catalysts. Through these studies, we will propose management methods to achieve both increasing recovery rates and decreasing risks for metals.

Establishing control method on environmental safety quality for recycled products

We will establish determination methods on environmental safety quality level and organize them as guidelines, by proposing safety quality control methods and standard test methods for recycled products originated from waste. This research activity will specifically address recycled products for construction materials, which are used in particularly large quantities. We will promote this research with water pollution events as our major concerns. More specifically, we will establish and standardize several types of leaching tests depicting water pollution risks and develop assessment frameworks by combining leaching test results and numerical models representing pollutant generation and transfer. Further, we will propose guidelines on determination methods for safety quality level. Validity of the frameworks and determination methods is checked through environment-simulation experiments.



Core research project 3

Developing win-win resource-recycling technology for waste biomass

Technology has played a significant role in waste treatment, disposal and recycling and will play an increasingly important role in the construction of a sound material-cycle society or development as a science and technology based nation. There is, however, a growing need for a technology that helps promote material cycles and contributes to the prevention of imminent global warming. For this reason, this core research project aims at developing a material cycle technology that can make a win-win-type contribution to both waste management and global warming prevention, focusing on waste biomass, which accounts for a large portion of waste and is still underused in most cases.

Specific targets of this project include a technology system to recover potential fuel materials as a source of energy, a technology system to recover and utilize useful materials, and material cycle systems permitting fuller exploitation of upper-stream distributing (artery) systems. They constitute three sub-themes; the first and second are to develop elemental technologies, and the third is primarily to develop a system.

Recycled energy utilization technology system

We will promote research by grouping waste biomass into low-moisture-content biomass and high-moisture-content biomass.

Mainly targeting low-moisture-content waste biomass, we will develop a technology system to ensure the satisfactory operation of a pyrolysis gasification -gas -reforming process at low temperature as an elemental technology for a regional-level recycled energy utilization system. With this technology, useful gas elements constituting sources of energy such as hydrogen, carbon monoxide and methane will be generated and utilized in power generation systems including fuel cell systems, and in this way, the achievement of both proper waste disposal and contribution to global warming prevention (win-win-type application) will be targeted. Apart from gas production, we will also promote research to develop highly efficient, energy conservation, resource conservation methods for both fuel conversion technology and separation/refining technology in connection with liquid fuel (biofuel) production. Further, we will aim at constructing a recycling system based on biofuel through demonstration tests of the developed technologies.

On the other hand, for high-moisture-content biomass such as raw garbage and livestock waste, we will develop optimal elemental technologies for microorganism-induced reaction applied-type, hydrogen and methane fermentation systems and associated advanced water treatment systems with a view to applying such systems at regional level. We will work out criteria to accept biomass in a fermentation process, determine fermentation process operation conditions and a recycling manual, and develop a carbon recycling-type system reflecting considerations for economic viability, life cycle assessment, etc. Through this activity, we aim at promoting the construction of a regional recycling network.

Material recovery and utilization technology system

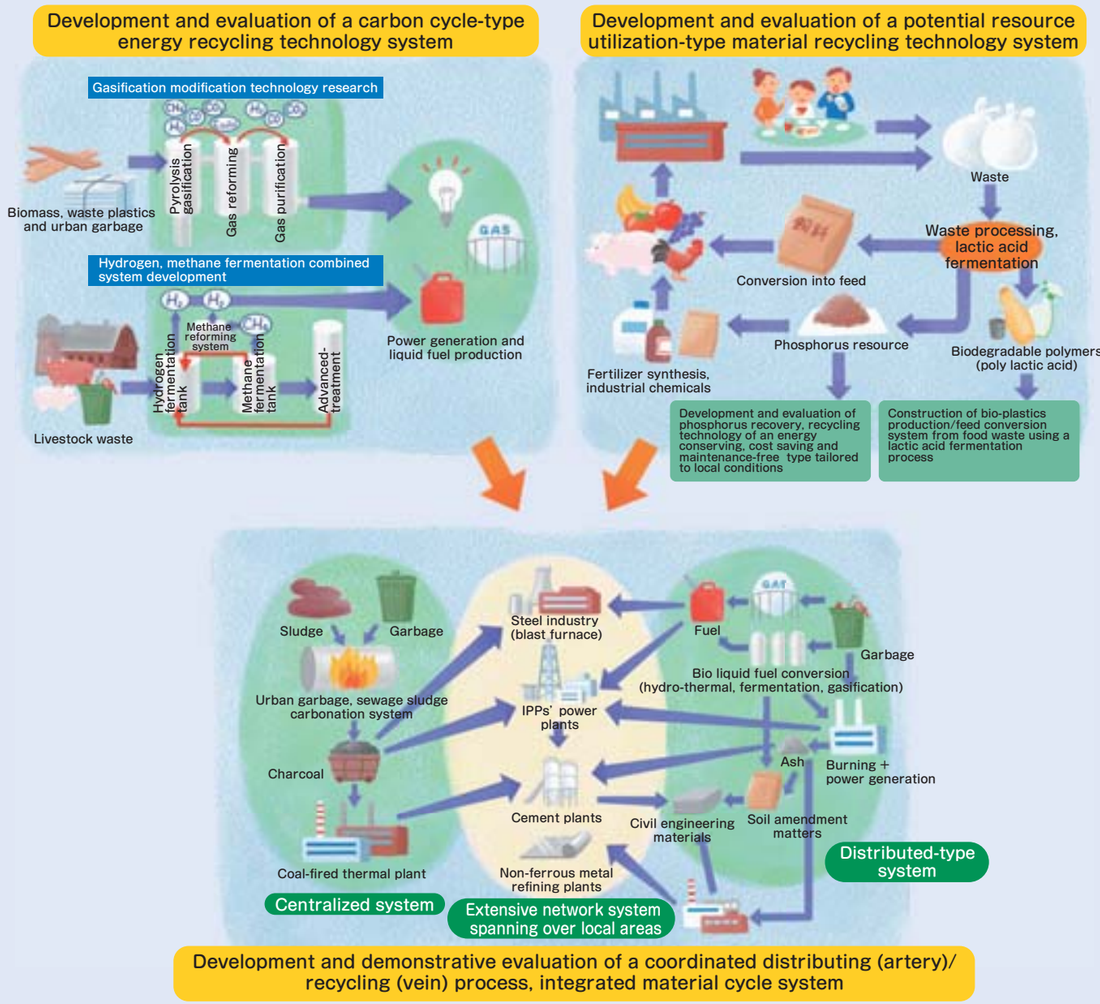
We will promote research, focusing on two major themes.

One is the R&D of a new technology system to deal with food waste and to recycle waste biomass for utilization as feed and biodegradable plastics (zero-emission system involving cascade-type C, N, P element utilization) by further improving conventional recycling technology such as biomass conversion into compost, biogas or charcoal. More specifically, we will use raw garbage generated from businesses for lactic acid fermentation using specific lactobacilli and develop a technology to recover L-lactic acid from filtrate and various biodegradable plastics products and a technology to totally convert residues to feed for their utilization in poultry production, etc. After feed quality and its effect on fowl are assessed in actual feeding tests, a model farm demonstration experiment will be conducted for development as a business model.

The other is R&D to design and develop an optimum system to deal with phosphorus resources contained in liquid organic waste by combining the development of a phosphorus recovery/recycling technology system using the adsorption dephosphorization method, iron electrolytic dephosphorization, or the like with a sludge compaction process, etc. We will conduct research especially to develop a comprehensive technology system based on characteristics analyses made in a distributed-type system model area by establishing quality control measures reflecting considerations for the scale of operations; liquid waste properties; the distribution, marketability and utilization characteristics of recovered phosphorus; and so on with the objective to achieve further integration, efficiency improvement and downsizing of the target system and put a recovery-refining technology system to practical use.

Combined production (artery)/waste processing (vein) systems, integrated material cycle system

In adding waste biomass to material cycles as a new fossil fuel substitution, we will promote research to design and demonstrate a combined production (artery)/waste processing (vein) system in major production (artery) systems such as the steel, cement, power and other basic material and energy industries, which have accepted copious waste and by-products from industries and played an essential role in an integrated material/energy cycle systems. More specifically, we will design a rational system matching local conditions by identifying the quantity of biomass available in the area. We will also conduct research on the development of conversion technology using hydro-thermal reaction, etc., the elucidation of behavior of interfering substances coming from the input waste in material production processes, the establishment of control conditions against them, etc. We will include in our research targets outcomes from the aforementioned elemental technology development as well as a feasibility study for commercialization by finally conducting system design and demonstration projects in a model area.



プロジェクト4

Core research project 4

Establishing appropriate management networks and technological systems to support sound international material cycles

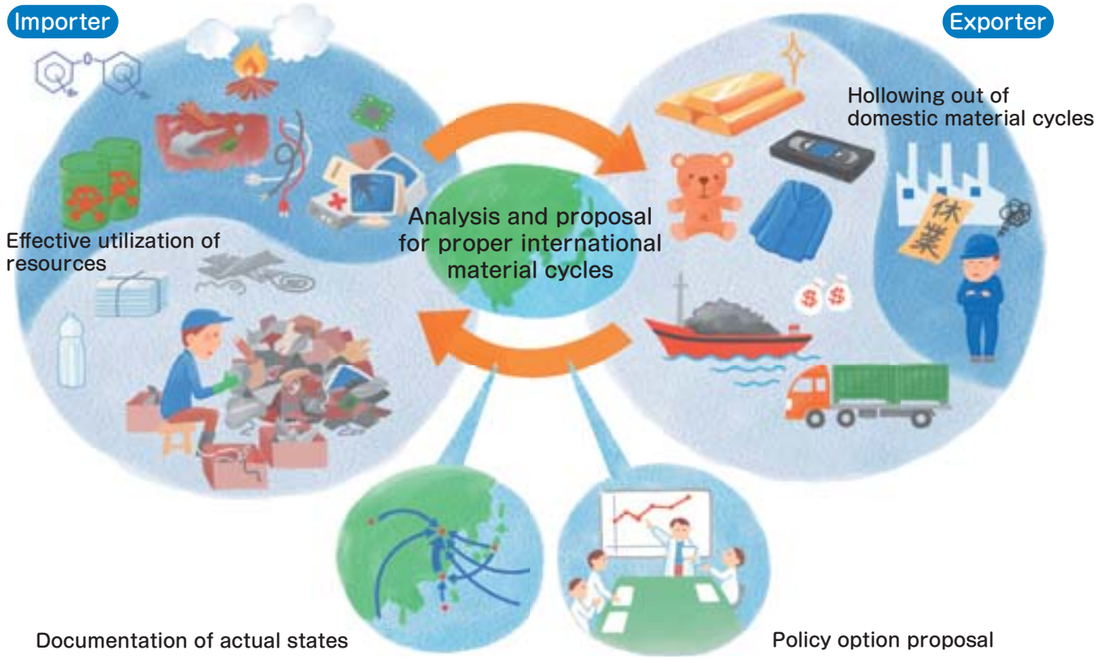
On the increase in recent years are cases in which end-of-life products and materials regarded as waste in Japan are utilized as resources in other countries in the Asia region, and recyclable resources traded internationally are increasing in quantity. In the meantime, waste generation in Asian countries is also increasing with their economic growth, including residues after the utilization of recyclable materials.

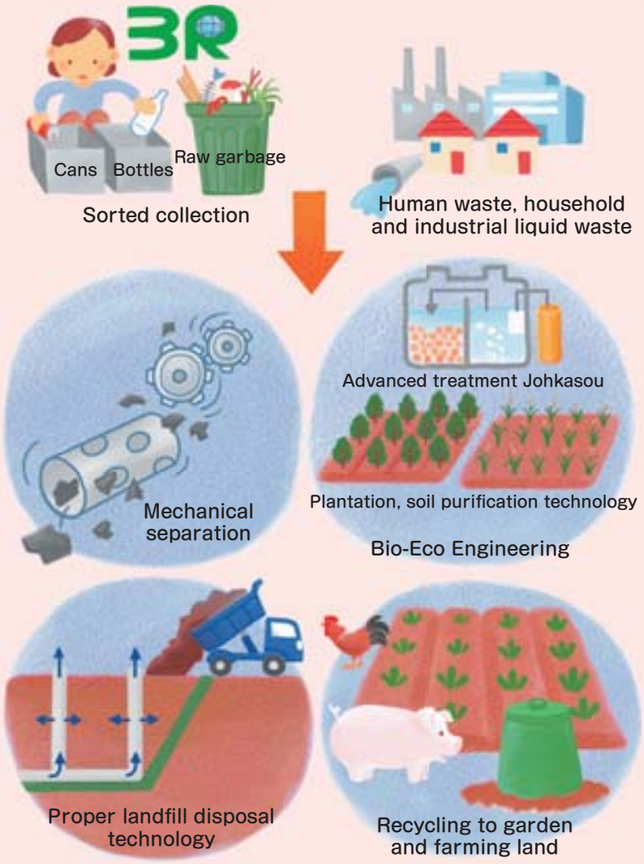
In this research project, we will analyze international material cycle systems together with understanding of the actual states of material cycles and waste disposal in Asian countries consisting mostly of developing countries so that we may make our contribution to the promotion of sound material cycles in the Asia region. Further, we will develop and evaluate technology systems suitable for developing countries to achieve both proper waste disposal and global warming prevention as a measure from a technical aspect. We will construct an appropriate management network and technology systems to promote sound material cycles in the Asia region by combining the above-mentioned measures. For example, we may develop an international material cycle evaluation technique reflecting the actual states of international material cycles and environmental impacts, propose low environmental impact technology systems for several cities in Asia and a method to commercialize a clean development mechanism (CDM).

This research project comprises the following three sub-themes.

Designing and evaluating an appropriate management network through the analysis and the development of evaluation technique of material cycle systems in the Asia region

We will perform a comprehensive analysis including background factors while clarifying the actual states of international material cycles. With three aspects, pollution risks, resource potential and economy, in mind, we will develop a method to evaluate international material cycles. More specifically, we will identify the current and potential environmental impacts caused by or in connection with material cycles and develop a method to evaluate international material cycles including index representations of environmental impacts, while making an analysis of related factors such as regulation, supply-demand and cost, so that we may promote proper international material cycles. We will design and evaluate a network for appropriate material cycle management in the Asia region and finally propose related policy options.





Identifying environmental impacts caused in the process of recycling in Asian countries

We will endeavor to identify the states of pollution caused by persistent organic pollutants (POPs) and inorganic pollutants such as mercury in the process of recycling and using E-waste (waste electronic and electric equipment). Through field surveys and joint research efforts with local researchers, we will examine methods of collecting soil and other samples, testing and analyzing them, and evaluating toxicity and monitoring and study survey methods suitable for understanding of environmental impacts in Asian countries. Through this activity, we will grasp outlines of environmental impacts caused by material cycles and utilize the findings for the development of emission factors (inventory) and the examination of possible countermeasures.

Developing and evaluating a technology system to achieve both appropriate waste disposal and global warming prevention in developing countries

As technical measures for solid waste management, we will propose several schemes tailored to local situations to introduce a collection system with a separation at the source and supplemental technologies such as mechanical sorting and biological treatment in order to avoid the disposal of organic materials and hazardous substances to landfill. Further, we will integrate methods to monitor and estimate greenhouse gas emissions from waste landfill sites and design a model to estimate the effect of introducing improved practices and technologies such as waste sorting and collection, the biological treatment and the semi-aerobic landfill, etc. for the project design of a CDM.

As for technical measures to deal with liquid waste, we will take note of differences in the properties of sewage and unused biomass from those observed in Japan and the insufficient development of recycling systems especially in China. Then, we will design and develop a Bio-Eco system suitable for developing countries considering material cycles for liquid waste and evaluate the feasibility of its application to local conditions. Through this activity, we will establish a technology system to achieve both greenhouse gas reduction and recycling of sludge and biomass such as residual plant bodies resulting from the integration of sewage treatment and processing and put incentive policies in place to propagate such a system.

Research activity to ensure appropriate waste management practices

Establishment of safe, reassurance, and appropriate waste treatment and disposal technology to support a sound material-cycle society

It is imperative to implement the 3Rs for us to establish a sound material-cycle society. On the other hand, we cannot obtain safety and reassurance without treating/disposing of waste appropriately.

In Japan, we treat of more than 80% of the municipal solid waste with advanced thermal treatment technologies (incineration with power generation or gasification and pyrolysis system) of which we can boast to the rest of the world. One of themes covered in this reach activity is to develop maintenance and management technologies to ensure satisfactory performance of these treatment facilities from several viewpoints including operation safety, environmental loads, recovered material quality and economy.

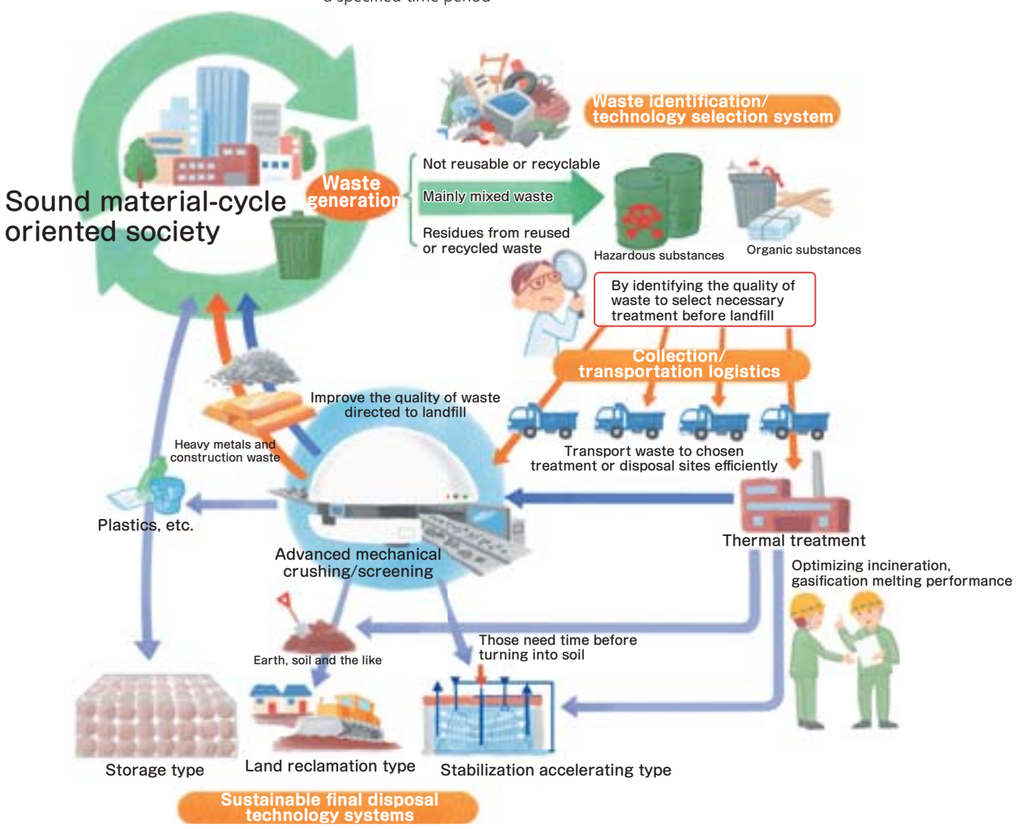
In the meantime, we cannot reduce waste to nil however hard we may promote the 3Rs. Waste left after all such efforts needs to be disposed to landfill. Another objective of this research activity is to establish a technology system to realize the ultimate concept of final disposal: "Only waste that turns into or can be transformed into soil should finally be buried."

Considering the above as the premise of our research, we have figured out three new types of final disposal sites.

1. Storage type: landfill site that will safely accommodate recyclable resources that are generated in large quantities but that are not valuable enough to justify immediate recovery at the time
2. Land reclamation type: landfill site that will permit unrestricted post-landfill use in a short time by accepting only inert waste whose quality is close to earth or soil
3. Stabilization accelerating type: landfill site that employs technologies to accelerate stabilization to ensure post-landfill use after a specified time period

We will develop a technology system which makes waste to be a quality suitable for the above mentioned landfill types. This system is consist of inspection and information management system to sort waste according to hazardous and degradable substance content and select treatment technologies required for them; a logistics design method to collect similar waste from diverse, distributed sources; and advanced pre-landfill technologies such as crushing and screening. We will also develop a technology system covering site selection, landfill structure, monitoring, leachate management, and quality control of construction and management to ensure final disposal site safety and reassurance. We will study about waste stabilization mechanisms, which provide the basis of such technology development.

We consider that our mission is to develop the above-mentioned technology systems, reflect them in the institutional system, and contribute to the establishment of a safe and reassurance society.



Integration of testing, assessment and monitoring techniques

In our society, wide variety of chemical substances have been produced and used to make our lives affluent. These chemical substances in products are either recycled as resources or disposed of as waste at the end of their lives. In a sound material-cycle society, we need to recycle resources originated from wastes, and for that purpose hazardous substances must be controlled adequately, too. We will promote the following fundamental research concerning the testing, assessment and monitoring of hazardous substances in concert with the priority program aiming at managing and controlling hazardous substances (core research project 2).

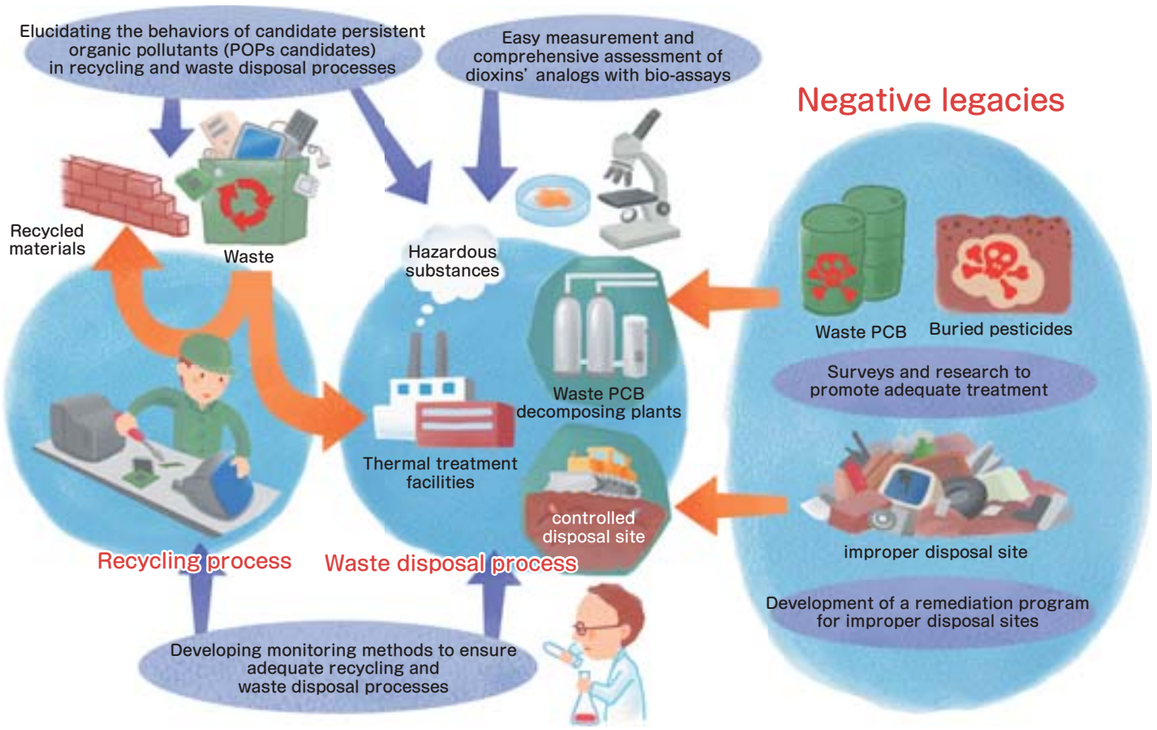
1. Understanding the behaviors of candidate persistent organic pollutants (POPs)
2. Developing simplified routine testing methods for checking safety of recycling and disposal processes and recycled product
3. Developing simplified measurement and comprehensive assessment of dioxins-like compounds by bio-assay test

Through this research, we will propose testing and assessment methods for checking hazardous substances in each life cycle stage of chemicals in products.

Measures against negative legacies caused by inadequate waste management

So-called negative legacies, which include chemical substances that were used in the past and that have not been treated adequately (waste polychlorinated biphenyl (waste PCB) and buried pesticides), and the disposal sites that were constructed in periods of insufficient regulation or scientific knowledge (improper disposal sites) are imminent threats to sound material-cycle society and require prompt remedies.

We will back up to clear negative legacies through the following research: (1) follow-ups of waste PCB treatment projects operating now; (2) surveys to ensure appropriate treatment of waste pesticides; and (3) development of design for a program to remediate contamination of improper disposal sites taking into consideration for environmental risks.

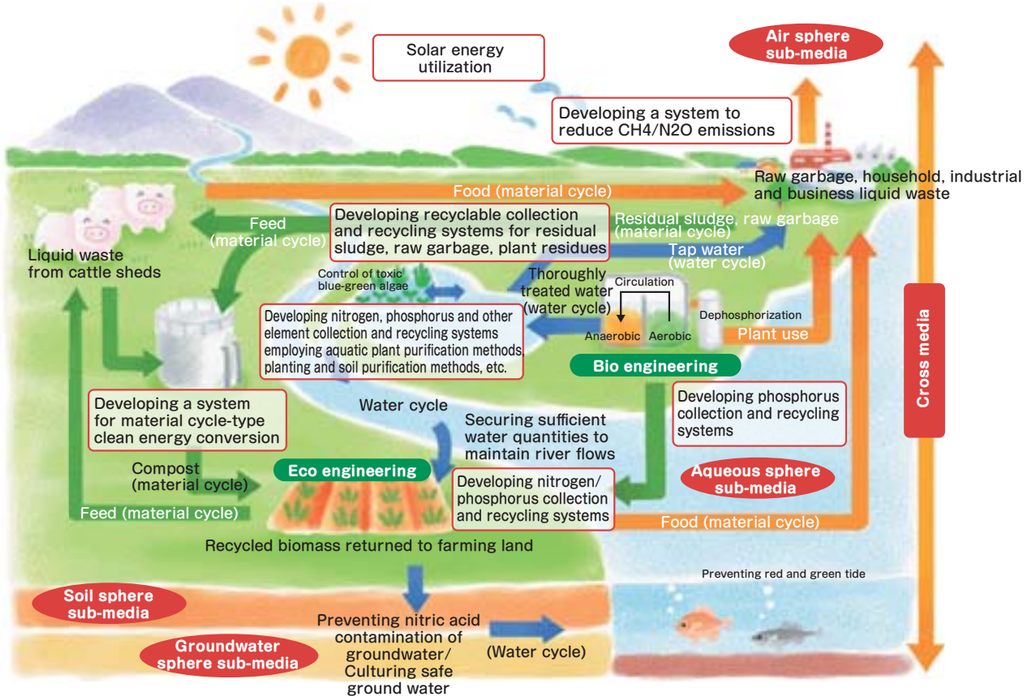


Research activity to ensure appropriate waste management practices

Integration of proper waste treatment technology for liquid and organic waste

In promoting the construction of a sound material-cycle society, it is imperative to give thorough, proper treatment to all liquid, organic waste generated from people's lives and industrial activities and minimize contamination loads on the environment to the extent possible.

For this reason, we will undertake research activity to establish efficient, thorough treatment methods to deal with liquid, organic waste such as sludge resulting from household and industrial liquid waste treatment processes. Specifically targeting raw sewage, household and disposer liquid waste, we will conduct research on system conversion technology to convert existing single/combined treatment Johkasou to advanced systems capitalizing on higher-performance treatment technology, better maintainability, and reduced infectious microorganism risks and technology development for advanced-treatment Johkasou. Taking advantage of joint research programs promoted with universities, publicly run local testing and research organs, and private businesses on an industry-government-university cooperation basis, we will conduct analysis and assessment using lab-scale and actual treatment plants to understand bio engineering such as Johkasou, etc., eco engineering concerning aquatic plant-soil purification technology, raw garbage-recycling systems, and so on including removal mechanisms and impacts on the ecosystem from explosive blue-green algae growth in treated water, etc. Further, we will develop adequate methods to evaluate the performance of such treatment systems with molecular biological analysis and microorganism risks taken into consideration and methods to evaluate the environmental improvement effect in the reduction of greenhouse gas emissions and the addition of nutrient salt removal functions. We will promote this research program in a bid to establish liquid, organic waste-recycling technology systems and technology/assessment manuals tailored to regional characteristics.



Promotion of fundamental research

We will develop the evaluation methods of the technology for treatment of waste asbestos to be harmless and provide scientific information for the adequate treatment and disposal of waste asbestos. Further, we will develop innovative technologies to recover useful materials such as rare resources contained in waste with a view to supporting a future sound material-cycle society. In addition, we will develop technological databases such as categorization of developing technologies and necessitate need in the material cycle and waste disposal processes and other databases covering material (product) flows including waste disposal and recycling stream, the chemical composition of recycling organic materials and recycled products such as slag in order to open to the public.

Introduction of Research Laboratories of Material Cycles and Waste Management

1F

Resource-recycling plants

This laboratory is used for the development and assessment of technologies and systems to recover resources from wastes. It is equipped with a lactic acid fermentation and product recovery plant to develop the technology for recovering valuable substances (such as lactic acid used as a source material for fermented feed and biodegradable plastics production) from raw garbage without emissions. The laboratory also has an ammonia absorption and recovery system to develop the technology for recovering ammonia using magnesium ammonium phosphate (MAP) from high nitrogen content liquid waste such as from a methane fermentation bio gasification plant, etc. We are studying elemental technologies, processes and operation conditions necessary for recovering resources from waste or recycling in a bid to commercialize or further integrate waste-recycling technologies and systems.

Thermal treatment plant

This room is for the assessment of material behaviors (gasification, volatilization, decomposition, chemical reaction, condensation, removal, etc.) in the process of thermal treatment (incineration) of waste. It is equipped with a kiln type main combustor which can observe the combustion process and secondary combustion chambers with variable residence time, as well as various devices for flue gas treatment, such as removal of acid gas using slaked lime or other chemicals, dust removal using fabric filter, and absorption and removal of hazardous substances using activated carbon layer. We are conducting combustion experiments using different kinds of waste under conditions (e.g. oxidation and reduction) to clarify chemical substances behaviors in thermal and flue gas treatment processes.

Introduction of Research Laboratories of Material Cycles and Waste Management

1F

Landfill simulation plants

This laboratory is used for clarifying the behavior of various substances in landfill conditions, assessing safety and stabilization, and developing technologies and systems for landfills. It is equipped with landfill simulation lysimeters, which have an on-line monitoring and automatic control system for temperature, moisture, and aerobic/anaerobic conditions to maintain environmental conditions close to those in actual landfills. In addition, there are high-precision scales just under the landfill columns for monitoring the changes in weight, thus permitting the precise calculation of mass balance. We are trying to clarify scientifically the changes and behaviors, such as leaching, that landfill and micro-pollutants contained therein show over a long time by using these simulation plants.

Sample preparation room for plant experiments

This room is designed for the preparation of samples by crushing and drying as a pretreatment for analysis of various types of solid waste and recycling materials. It is equipped with powerful and versatile crushers which can cover from hard (e.g. melting slag) to soft materials (e.g. waste plastics), and prepare samples having various particle sizes from rough to fine. Prepared samples are used for various purposes such as a leachability test of hazardous substances and the investigation of pyrolysis characteristics. Installed in a space completed with a vent duct for leak prevention and collection of odor are three large-sized dryers, which have sufficient capacity to dry a large amount of wet waste in a short time. They are used for pre-treating samples for garbage composition analysis, three-component analysis (combustibles, ashes, water), heat value analysis and elemental composition analysis performed in a dried state.

2F

Chemical analysis laboratory for resources

This laboratory is used for assessing recyclable resources in terms of the characterization and environmental impact of waste by instrumental analysis. It is equipped with instruments for analyzing organic compounds, including gas chromatograph-mass spectrometers, high-performance liquid chromatographs and a Fourier transform infrared spectrometer. In addition, there is a scanning electron microscope with energy dispersion X-ray analyzer to determine the elemental composition of the surface. Using these instruments, we evaluate the quality of recyclable resources such as melting slag through the observation of the surfaces and conduct research on the proper disposal of asbestos-containing waste by observing and counting asbestos fibers in the waste and their thermally treated residues.

Homoiothermal room for physicochemical experiments

This laboratory is separated into four rooms designed for physicochemical experiments under a constant temperature condition. It is equipped with pH controlling equipment for leaching tests and a chamber for exposure experiments. The pH controlling equipment is used for the pretreatment of recycling materials to simulate their general use conditions to investigate their environmental loads at various pH levels. It is used for estimating the environmental impact of recycling materials, such as melted slag, on water systems.

GC/MS room

This room was designed for determining trace amounts of organic components included in waste and related samples, mainly using the high-resolution gas chromatograph-mass spectrometer (GC/MS). A sample preparation room is also attached, where extraction and cleaning up of samples are conducted for precise measurement. Both rooms were designed to maintain the same conditions as a clean room to prevent contamination from a polluted atmosphere. We are developing reliable methods to determine trace amounts of PCBs (polychlorinated biphenyls), halogenated organic compounds such as brominated flame retardants and persistent organic pollutants in waste and related samples. We are also developing technologies for destroying these chemicals.

Introduction of Research Laboratories of Material Cycles and Waste Management

2F

Biological analysis laboratory

Continual comprehensive monitoring of various hazardous substances that may be included in waste or produced during waste-recycling and treatment is difficult with conventional chemical analysis only. The bioassay (or biotest), which uses cultured cells, microbes, fish or other organisms, is designed to obtain quick and comprehensive information on the harmful effects of chemical substances on living organisms, and so has been used as complementary method for whole hazard monitoring and assessment. This laboratory is equipped with constant-temperature aquariums for breeding and keeping aquatic organisms for tests, an isolated clean room for safely testing microbes, and micro-plate readers for detecting absorption, fluorescence and bioluminescence for simultaneously treating many samples. Using these instruments, we are developing reasonable sets of bioassay methods (i.e. "batteries") employing a range of living organisms from microorganisms to higher animals such as frogs and fish for the examination of waste and recycling resources. The batteries are also useful for monitoring the effects of chemicals in emissions from waste treatment, recycling and disposal facilities.

Material cycle information room

"Information" is playing an increasingly important role today. We are trying to improve the collection, storage, and dissemination of accurate information and analysis to support the establishment of a sound material-cycle society. This room is equipped with computers for analysis, a server for distributing information, a large plasma display, and others. These are used for our studies on: the analysis of material flows of resources, products and waste; the development of the LCA (life cycle assessment) method; support for the proper management of recyclable resources and waste with information technologies such as GIS (geographic information system) and remote sensing; and the establishment of an effective recycling system tailored to regional characteristics. These are also used for providing information on our activities including our research results.

Introduction of other research facilities

Final disposal demonstration site

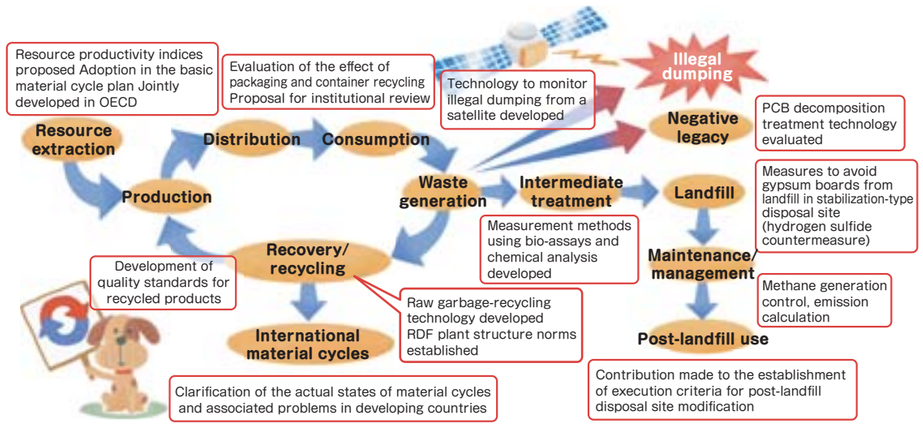
When waste is buried for landfill, substances contained in waste and their decomposition products are released into the environment as leachates and gases. Stabilization is a process in which gas generation is subdued and leachate quality improves. It involves complex mechanisms, because factors significantly affecting stabilization are not only chemical but also biological and physical. Since waste is coarse in size and diverse in kind, it is necessary to conduct a demonstration experiment with a pilot plant in parallel with laboratory experiments to understand stabilization mechanisms and test new technologies. For this reason, we have established four demonstration experiment pits measuring 5 m in diameter and 7 m deep in a final disposal site actually in operation and are promoting research to develop new final disposal technologies ensuring the safety and security of final disposal sites.

Bio- Eco Engineering research laboratory

This research laboratory is developed to provide a base for international research activities to solve environmental issues pertaining to both Japan and overseas countries. Introducing household liquid waste from an actual treatment plant through a vacuum sewer system, we are conducting research on the development, analysis and evaluation of recycling-type advanced-treatment Johkasou for liquid, organic waste including raw sewage and household liquid waste; energy recovery technology from biomass such as raw garbage; eco engineering using planting and soil purification technology; and so on. While various research programs are undertaken jointly with publicly run local environmental research institutes, universities, private businesses, and overseas research organs, international joint research projects are also being promoted with these research facilities utilized as the nucleus based on the Environment Ministers Meeting among Japan, China and Korea (TEMM), a Japan-China Environment Protection Agreement project, etc. Thus, this laboratory constitutes an important base for an international environmental research network including technical training and field training organized under JICA-KOICA joint training programs for trainees from Asian countries.

Major achievements made during the first five-year plan period (2001-2005)

The Research Center for Material Cycles and Waste Management was established in April 2001 and promoted survey and research activities until 2005 according to a five-year research plan (first five-year plan). The Center, formed as a research center in support of the government's environmental policies to address waste management recognized as an urgent, political issue, promoted survey and research activities and caused its research outputs to be reflected in policies determined by the Ministry of the Environment, etc. by making approaches from the following three angles.



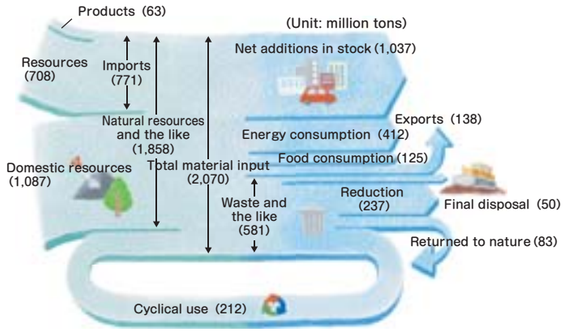
1 Assessment methods and infrastructure arrangement for a sound material-cycle society

We developed and studied methods to assess and analyze material flows and methods to compare various transformation paths as a compass to help our society transform into a sound material-cycle society.

We elucidated the amounts of resources and materials consumed, utilized and discarded in Japan as a whole.

We contributed to the determination of numerical targets in the national government's Basic Plan for Establishing a Sound Material-Cycle Society with material flow analyses and research on the indicators based on them.

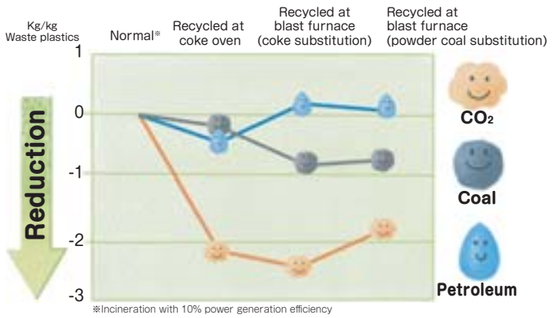
For the Basic Plan for Establishing a Sound Material-Cycle, visit
http://www.env.go.jp/recycle/circul/keikaku/



Japan' s material flow (2002)

The advantages and disadvantages of various transformation paths to a sound material-cycle society were examined by comparing their environmental loads.

For example, the environmental loads reduction effect of recycling plastic packaging and containers in the steel industry was compared and evaluated with the life cycle assessment (LCA) technique.



LCA assessment examples

2 Recycling, waste treatment and waste disposal technology

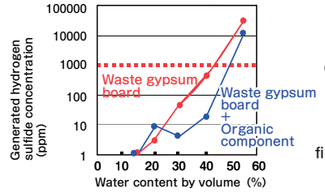
We conducted research and development on technologies to support recycling, proper treatment and disposal and their systems to promote effective waste utilization and safe treatment and disposal of hazardous substances.

We developed technologies to utilize waste effectively and recycle as resources.

We promoted technology development to obtain hydrogen, which can be used as an energy source in fuel cells, from waste by means of gasification through pyrolysis at a relatively low temperature as well as microorganism fermentation and endeavored to develop a system capitalizing on the regional characteristics of waste generation.

We studied the causes of waste-related accidents and worked out countermeasures.

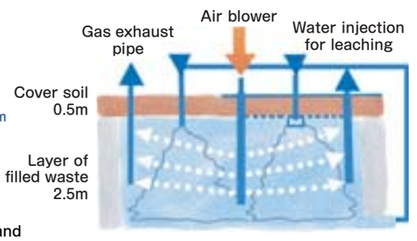
We elucidated the cause of high-concentration hydrogen sulfide gas generation in an inert waste-type disposal site and showed a solution to this problem.



Relation between water content in waste and generated hydrogen sulfide concentration

We promoted technology development to achieve safer, securer final disposal sites.

We developed stabilization acceleration technology to shorten the time period till aftercare termination.



Keep good drainage to keep low moisture content
II
Suppression of high-concentration hydrogen sulfide generation

3 Risk assessment and control during material cycle, waste treatment and disposal processes

We conducted research on the development of methods to detect hazardous substances and technologies to decompose them safely in the processes of recycling, treating and disposing of wastes.

We conducted behavior analysis and substance flow analysis of hazardous substances and studied control measures in the material cycle and waste treatment/disposal processes.

For example, as to brominated flame retardants which have accumulated in the environment and become our health concerns, we tried to identify their possible emission sources and information related to human risks (exposure pathways) by estimating emission factors and emission amount in various processes, and studied the emission release control technologies.

We developed rapid and cost-effective monitoring methods for screening hazardous substances in the material cycle and waste treatment/disposal processes.

As one example, bioassay methods using cells or biomaterials dealt in our research were adopted and applied as official simplified methods to measure dioxins in waste incineration gas and ash under Japanese regulations.

We conducted technology development to treat hazardous substances in wastes safely and properly.

With regard to polychlorinated biphenyls (PCB), which are very persistent and bio-accumulative in the environment, we conducted research on the development of decomposition technologies and analysed decomposition mechanism, which provided useful information to the PCB Waste treatment program promoted by the government.