Research Program: Overview

Health and Environmental Safety Research Program

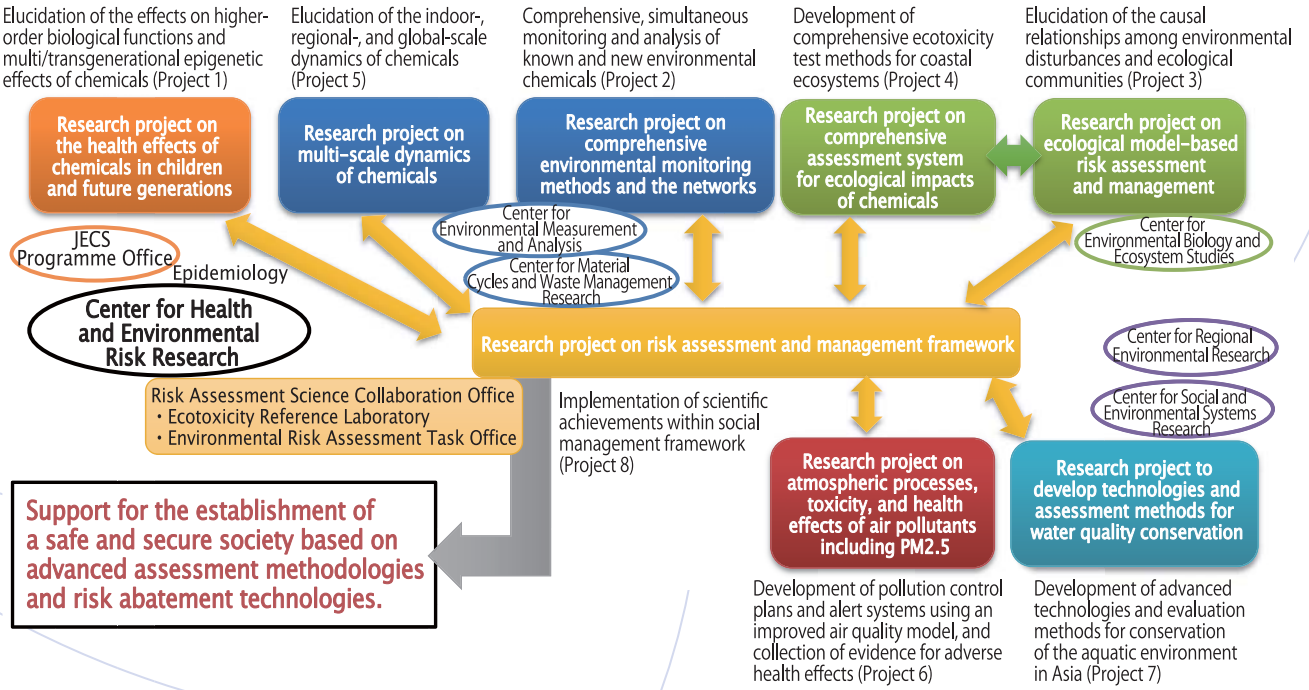
Systematic development of risk sciences to achieve the goal of safe and secure society

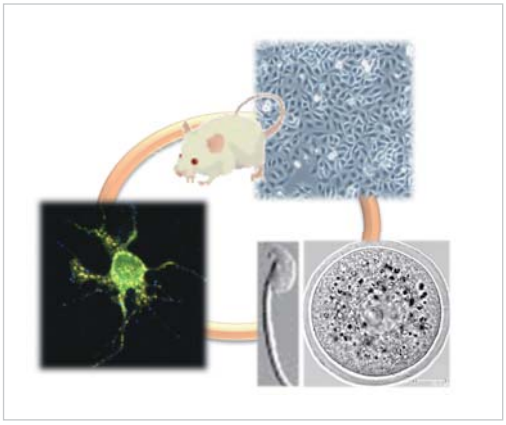
To ensure the establishment of safe and secure society, we must address current environmental concerns regarding chemical contamination and ensure that major environmental pollution events, such as the outbreak of Minamata disease in Japan, do not happen again. This is the basis of establishment of all other sustainable goals of low-carbon society, sound recycle-oriented society or society in harmony with nature. The aim of this research program is to provide scientific support through development of new findings on hazard, analytical technologies, fate processes and models, and abatement technologies, and also advanced risk assessment methodologies and management framework for environmental chemicals. To achieve this aim, the program is using a multi-faceted, systematic approach to find out new insight of health and environmental hazards, develop methods for assessing health and environmental risks, and abatement technologies to the risks, posed by environmental chemicals. The program is examining the effects of chemicals on higher-order biological functions and multi/transgenerational impacts, developing new systems for assessing the ecological impacts of chemical bioaccumulation and advanced high-throughput chemical analyses to obtain a more comprehensive understanding of the dynamics of environmental chemicals. In addition, the project is examining the atmospheric processes and the adverse health effects associated with exposure to PM2.5 and other air pollutants, and developing advanced methods for the conservation of regional aquatic environments.

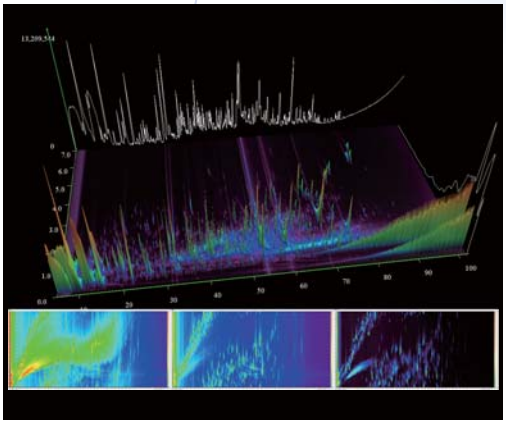
The program comprises the following eight research projects:

- Project 1 is assessing the health effects of chemicals in children and future generations, and is examining the effects of chemicals on the development of immune and metabolic diseases, developmental neurotoxicity, and multi/transgenerational epigenetic inheritance.
- Project 2 is developing comprehensive environmental monitoring methods and networks, and is developing multicomponent simultaneous analysis and non-targeted analysis methodologies for the detection of biological effects and elucidating the potential chemical contaminants.
- Project 3 is developing ecological risk assessment and management based on ecological models, and is developing models to elucidate the causal relationships between environmental disturbances and ecological communities to predict environmental disturbances within ecosystems.
- Project 4 is developing a system for the comprehensive assessment of the ecological impacts of environmental chemicals, and is developing advanced methodologies for determining the ecotoxicity of environmental chemicals, assessing the integrity of coastal ecosystems, and determining the effects of mixtures of chemicals on the environment.
- Project 5 is examining the dynamics of chemicals on several spatio-temporal scales by developing analytical techniques and global-scale models for investigating the movement of toxic heavy metals through the environment, by examining the emission and behavior of chemicals on the regional scale, and by examining the dynamics of chemicals on the indoor scale.
- Project 6 is examining the atmospheric processes, toxicity and health effects of air pollutants including PM2.5 to propose pollution control plans, to collect evidence of adverse health effects and to construct alert systems.
- Project 7 is developing improvement technologies and assessment methods of water quality for the conservation of aquatic environments.
- Project 8 is developing an advanced risk assessment and management framework, and is developing a novel framework for assessing and managing the risks posed by environmental chemicals through interdisciplinary discussions on strategies and social actions.

By combining the research outcomes of these eight projects, the program aims to establish advanced systems for the detection and assessment of the health and environmental risks posed by known and new environmental chemicals for which there is currently no established approach, as well as to develop comprehensive and rapid monitoring and prediction systems and management technologies for environmental chemicals.

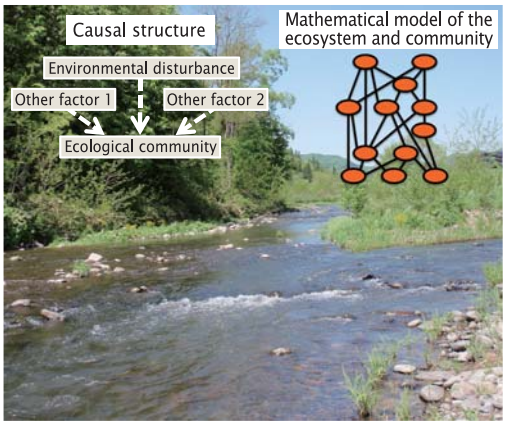


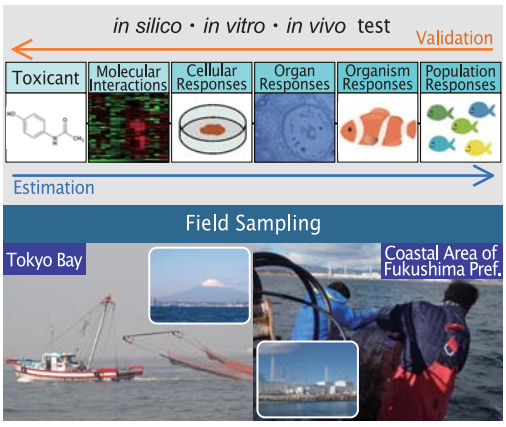




Left: Evaluation of the health effects of chemicals in children and future generations. This project will examine the risks to higher-order biological functions and the multi/transgenerational epigenetic effects of chemicals, and develop a new evaluation system for health risk assessment (Project 1)

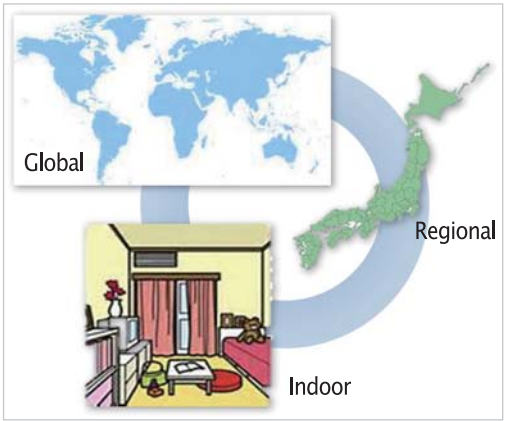
Right: Three-dimensional total ion chromatogram (3D-TIC) constructed by using in-house software to combine multi-dimensional gas-chromatography /high-resolution time-of-flight mass spectrometry and 2D-TIC data for specific components contained in an air sample (Project 2)

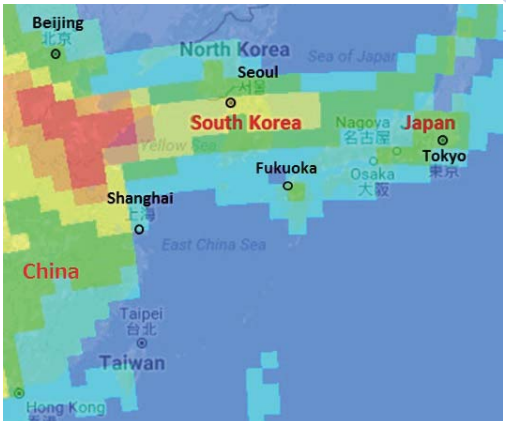




Left: We are developing mathematical and statistical models to assess and manage the ecological risks posed by environmental disturbances based on the identification of causal relationships (Project 3)

Right: The ecological impact of environmental chemicals will be evaluated from the molecular to the field level (Project 4)





Left: We are developing methods to understand and predict chemical dynamics on several spatio-temporal scales (Project 5)

Right: Spatial distribution of PM2.5 mass concentration as simulated by the Visual atmospheric ENvironment Utility System (VENUS: http://envgis6.nies.go.jp/osenyosoku/) Red, high concentration; blue, low concentration (Project 6)

Left: Pilot-scale test of domestic sewage treatment technology in Bangkok, Thailand (Project 7)

Right: Interdisciplinary discussion on chemical risk management (Project 8)

Project 1

Research project on the health effects of chemicals in children and future generations

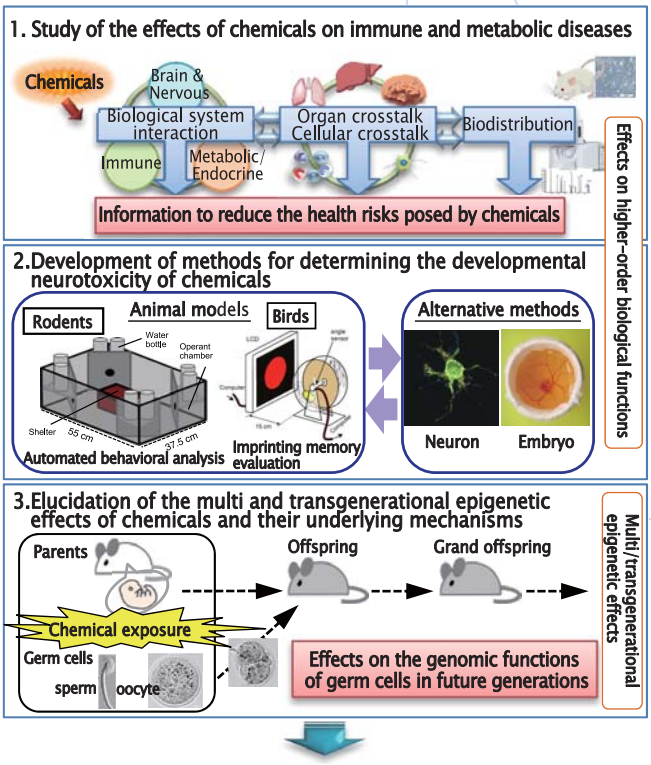
The prevalence of allergies, lifestyle-related diseases, and neurodevelopmental disorders is increasing worldwide, and dramatic increases in exposure to chemicals are potential risk factors. The aim of this project is to evaluate the health effects of exposure to chemicals in children and future generations, to elucidate the underlying mechanisms of these effects, and to create a new evaluation system to assess these health risks. To meet this aim, we are examining the risks posed by chemicals to higher-order biological functions (e.g., immune system, metabolic/endocrine system, brain and nervous system) and their multi/transgenerational epigenetic effects by using animal models and cultured cells.

The project comprises three lines of research. The first is the evaluation of the effects of low-dose exposure to chemicals on the development of allergic and lifestyle-related diseases in children and future generations by elucidating the underlying mechanisms of these effects and their effects on interactions among biological systems, organ or cellular crosstalk, and biodistribution.

In the second line of research, we are developing advanced methods for assessing the developmental neurotoxicity of chemicals to provide information that can be used as the basis of epidemiological studies. Our testing methods include behavioral tests in animal models, tissue distribution evaluations, and alternative animal testing methods using avian embryos, embryonic stem cells, and induced pluripotent stem cells.

In the third line of research, we are examining the multi/transgenerational epigenetic effects of chemicals and their underlying mechanisms by examining genomic functions and epigenetic changes in germ cells.

By combining these three lines of research, we will contribute to the management of chemicals and the protection of children and future generations from the health risks posed by chemicals.



Project 2

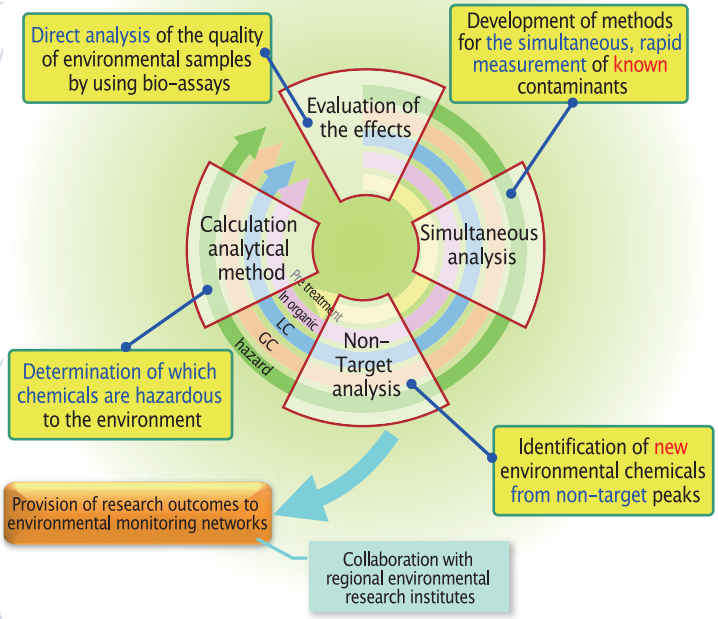
Research project on comprehensive environmental monitoring methods and the networks

The increasing production and use of chemical substances by industry has led to increases in the release and accumulation of chemicals in the environment. Therefore, new approaches are needed to comprehensively detect known and new hazardous chemicals in the environment. To develop advanced networks for the monitoring of environmental chemicals that affect human health and the environment, this project comprises four lines of research.

In the first line of research, we are developing liquid chromatography/mass spectrometry-based measurement methods to simultaneously detect a wide range of known contaminants. In the second line of research, we are developing high-resolution mass spectrometry-based measurement systems to simultaneously detect and analyze known and new chemicals in the environment. In the third line of research, we are developing a battery of bioassays that can be used to examine the toxicities of mixtures of chemicals in environmental samples. In the fourth line of research, we are developing new mathematical and computational analyses to assess the effects of complex mixtures of chemicals in organisms and the environment.

This project is being conducted in collaboration with several regional environmental research institutes. The new analytical methods developed will be shared with these institutes with the aim of establishing an advanced, systematic environmental monitoring network to assess emerging ecological and health risks posed by chemicals.

For the comprehensive identification and analysis of a variety of environmental chemicals, we are developing bio-assays and advanced analytical techniques that can rapidly detect pollutants and determine their influence on the environment and can be applied to the real world.



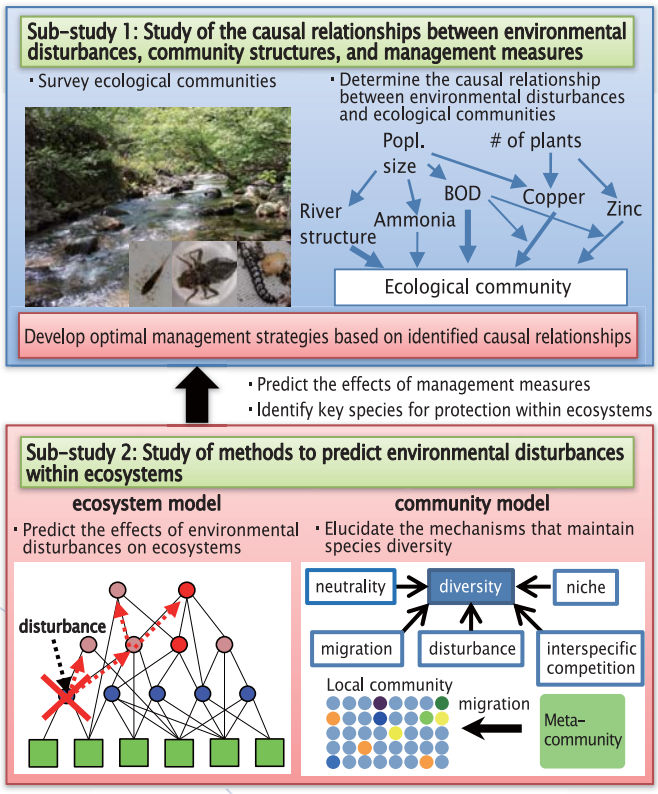
Project 3

Research project on ecological model-based risk assessment and management

To manage the ecological risks resulting from environmental disturbances caused by chemicals, it is essential to first understand the causal relationships between environmental disturbances and ecological communities. However, monitoring data generally only show correlations between ecological disturbances and the ecological community. If we select management measures to reduce ecological risks based only on these correlations, ecological risk management is often not successful.

The aim of this project is to examine the causal relationships between environmental disturbances and ecological communities and to select the most effective management measures by using field surveys. We are developing an ecosystem model to predict the effects of environmental disturbances on ecosystems; this model incorporates ripple effects caused by species interactions. In addition, we are developing an ecological community model to understand the mechanisms that maintain species diversity, and thereby predict the effects of disturbances on ecosystems. Together, these two models will allow prediction of the effectiveness of management measures and identify the key species to protect within ecosystems. We are also developing ecological models to assess and manage ecological risks caused by environmental disturbances that incorporate the uncertainty inherent in causal relationships.

The outcomes of this research project will provide methods for precisely assessing and effectively managing the ecological risk posed by environmental disturbances. In addition, current chemical management practices do not include established methodologies to assess ecological risks that simultaneously affect aquatic and terrestrial ecosystems, and the outcomes of this project will provide the basis for enhancing current ecological risk assessment and management.



Project 4

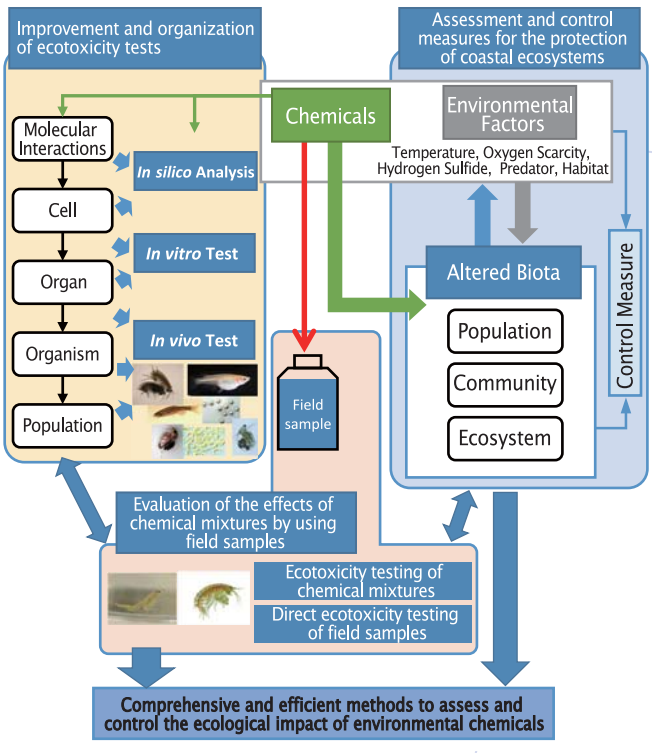
Research project on comprehensive assessment system for ecological impacts of chemicals

To manage the increasing diversity of chemical substances, the development of new or improved ecotoxicity tests using *in silico* (analysis with models such as Quantitative Structure Activity Relationship (QSAR)), *in vitro*, and *in vivo* we performed.

The aim of this project is to develop a comprehensive system to evaluate and manage the ecotoxicity and to develop test guidelines based on mechanisms of action and adverse outcome pathways by using an integrated approach to testing and assessment. The project is also examining the influence of the composition of chemical substances on the environment by conducting whole effluent toxicity testing.

In addition, we use field studies, several lab experiments, and mathematical models to determine environmental parameters, such as hypoxia, and their association with changes in the biota at the population and community level in coastal ecosystems that have been polluted by chemicals such as Tokyo Bay and the Fukushima coastline. Furthermore, we are developing a field crossing-like countermeasure that will help to facilitate the recovery of coastal ecosystems.

The research outcomes from this project will be useful as the basis for the development of new techniques to evaluate and manage the environmental risks posed by chemicals. In addition, these outcomes will be essential for developing improved measures to hasten the recovery of coastal ecosystems from contamination.



Project 5

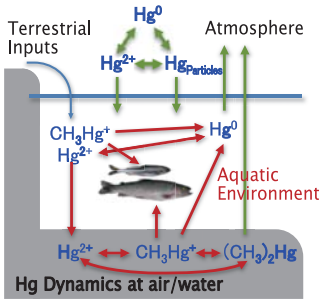
Research project on multi-scale dynamics of chemicals

To promote environmental safety, we need to efficiently and effectively manage a large number of chemicals, many of which have unique characteristics. The spatio-temporal scale on which we investigate the dynamics of environmental chemicals depends on each chemical's physico-chemical properties, applications, and effects on human health and the environment.

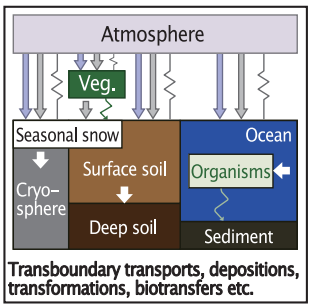
In this project, we are examining the dynamics of chemicals at various spatio-temporal scales by using state-of-the-art analytical techniques. We are also constructing mathematical models to better understand and predict the concentrations and dynamics of environmental chemicals. We aim to contribute to the development of new methodologies to manage the risks posed by environmental chemicals, as well as develop systems to evaluate the effectiveness of international treaties.

This project comprises four lines of research. The first involves accurate determination of the concentrations and isotopic fingerprints of toxic metals, especially mercury, in environmental samples to determine the sources, species transformation, and processes of bioaccumulation. The second line of research involves constructing models of the fate and transport of pollutants such as persistent organic pollutants and mercury through the atmosphere, oceans, terrestrial compartments, and biosphere on the global scale. The third line of research is the development of methods for estimating the emission levels, improving the Grid-Catchment Integrated Environmental Modeling System regional chemical fate model (G-CIEMS), and validating these methods and model. The fourth line of research is the elucidation and prediction of the pathways through which chemicals are emitted from products in the indoor environment by using experimental, mathematical modeling, and *in silico* estimation methods.

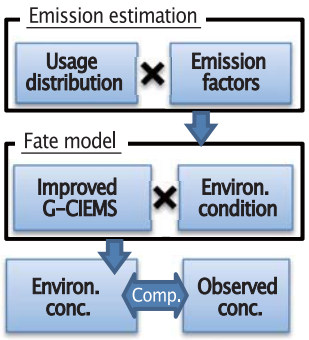
1. Tracking the movement of toxic heavy metals through the environment



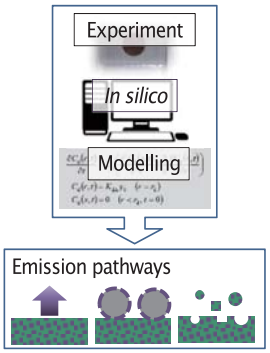
2. Modeling global-scale dynamics of environmental chemicals



3. Regional-scale emission and behavior of chemicals



4. Indoor-scale dynamics of chemicals



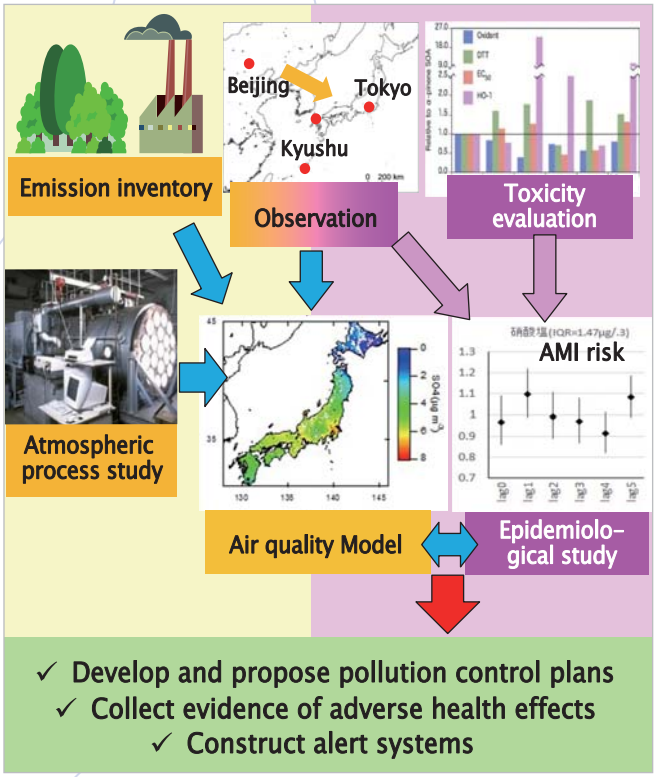
Project 6

Research project on atmospheric processes, toxicity, and health effects of air pollutants including PM2.5

Rapid economic growth in East Asia has resulted in a marked increase in energy consumption, leading to increased emission of air pollutants. High concentrations of PM2.5 have been reported in Japan, and their adverse health effects are now a major public concern. Based on a report published by the Central Environment Council, Japan, the main objectives for this project are determined to

1) understand the atmospheric processes of air pollutants, and develop and propose pollution control plans and mitigation strategies;
2) collect evidence of the adverse health effects associated with the mass and chemical compositions of PM2.5 and elucidate the current status of these adverse health effects in highly susceptible populations; and
3) construct alert systems for high concentrations of PM2.5.

To achieve these objectives, we are developing an improved air quality model that incorporates data on chemical reaction processes obtained from laboratory chamber experiments, updated emission inventories, and comparisons of model data with observational data. With the improved air quality model, source apportionment studies are conducted to provide data for the development of advanced pollution control plans and alert systems are constructed for high concentrations of PM2.5. We are also conducting *in vitro* toxicity studies to find and categorize toxic chemicals contained in PM2.5, and epidemiological studies to elucidate the association between the various chemicals contained in PM2.5 and adverse health effects, especially within highly susceptible populations such as people with cardiovascular disease or pregnant women.



Project 7

Research project to develop technologies and assessment methods for water quality conservation

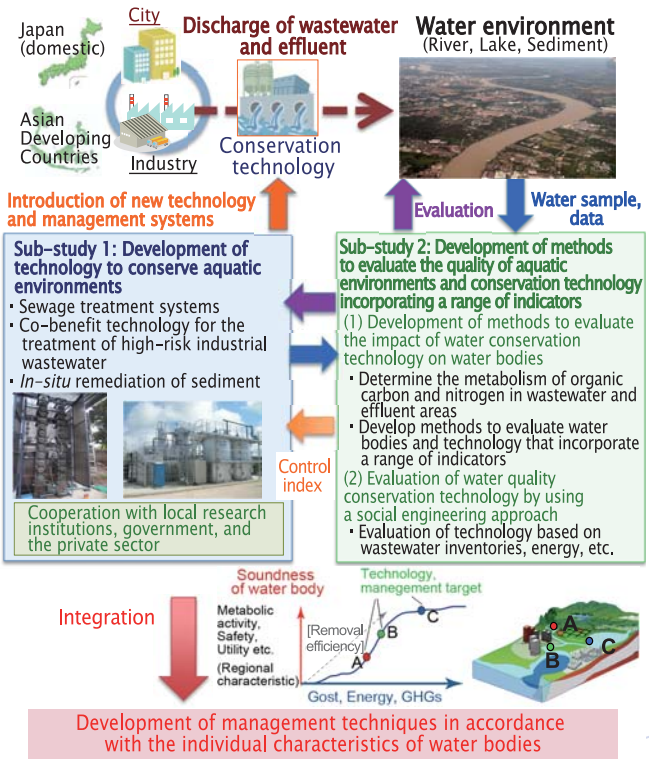
In many parts of Asia, the introduction of technologies for the conservation of the aquatic environment has been delayed due to economic constraints. Therefore, the effects of water pollution, such as the spread of infectious diseases, eutrophication, sediment deterioration, and emission of green house gases, are increasing.

The aim of this project is to develop technologies to conserve the water environment and evaluate the effectiveness of conservation projects so that effective water quality management can be conducted in areas under economic constraints.

This project comprises two sub-projects. The first is the development of technologies to conserve aquatic environments. In collaboration with local research institutions, governments, and the private sector, we are developing technologies to treat domestic sewage, co-benefit technologies to treat high-risk industrial wastewater, and technologies for *in-situ* remediation of sediment.

In the second sub-project, we are developing methods to evaluate and conserve aquatic environments by using a broad range of indicators. We are developing methods to evaluate the impact of water conservation technology on water bodies (e.g., by determining the metabolism of organic carbon and nitrogen in wastewater inflow areas), and we are developing methods to evaluate the quality of water bodies. In addition, we are evaluating the effectiveness of water quality conservation technologies by using a social engineering approach based on wastewater inventories, energy use, and greenhouse gase emissions.

By integrating these two sub-projects, we intend to establish a management system that will help conserve the soundness and regional characteristics of water bodies.



Project 8

Research project on risk assessment and management framework

Sound management framework to manage the risks posed by environmental chemicals to human health and the environment can be established by integrating the social context, public concern, and the accumulated social and natural scientific knowledge. The aim of this inter-disciplinary project is to develop a robust framework for the management of environmental chemicals that reflects both the social context and the latest outcomes from Projects 1 to 7. To achieve this aim, the project is developing risk assessment and management strategies that are acceptable to the public and incorporate the latest scientific information regarding the impact of environmental chemicals on human health and environment. The project is also developing an ecological management framework based on the comprehensive characterization of ecotoxicity by using newly developed system of testing protocols; environmental management of coastal, oceanic, atmospheric, and aquatic pollution that will incorporate new technologies as they become available; and a management approach that incorporates comprehensive monitoring methodologies to assess new chemicals as they arise from technological development. Those discussions need to be based on wide range of scientific disciplines covering natural sciences, social sciences and engineering and technology. We aim that Project 8 works to summarize scientific outcomes of all Projects into the context of sound chemical management in the society.

Outcomes of projects 1 to 7

PJ1
- Newly established health impact outcomes
- Comprehensive characterization of ecotoxicity

PJ2
- Advanced fate forecasting methodologies
- Comprehensive environmental monitoring technologies

PJ7
- Health impact and countermeasures for atmospheric pollution
- Development of water-treatment technologies

- **Risk management framework in society**
- **Risk management with insufficient or uncertain information**
- **Technologies to achieve improved safety**

Social concern for a safe and secure society
- Public understanding of the hazards posed by environmental chemicals
- Uncertainties within scientific data
- Feasibility of new countermeasures

Research centers participating in the research program

Center for Health and Environmental Risk Research http://www.nies.go.jp/risk_health/index-e.html

Contributing to reducing the risks posed to human health and the environment

Through cooperation with institutes in the fields of environmental risk and environmental health research, the Center for Health and Environmental Risk Research is dedicated to clarifying the risks posed to human health and ecosystems by environmental chemicals. The Center integrates activities in the fields of environmental risk research and environmental health research and the activities of the Health and Environmental Safety Research Program and of two projects administered by the Risk Assessment Science Collaboration Office and Japan Environment and Children's Study.

Center for Regional Environmental Research http://www.nies.go.jp/chiiki/en/index_en.html

Contributing solutions for regional environmental issues in Japan and Asia

Mankind's activities have substantial impacts on both mankind itself and natural ecosystems through environmental media such as the atmosphere, water, and soil. The Center for Regional Environmental Research is investigating the mechanisms by which regional environmental issues develop on multiple scales (local, urban, and trans-boundary) in both Asia and Japan, through research approaches such as extensive monitoring, robust modeling, and laboratory experiments, in order to establish a sound scientific basis for minimizing anthropogenic environmental impact. Furthermore, by integrating many of the outcomes thus obtained, we are developing solutions to such regional environmental issues and investigating how these solutions are applied to the real world.

Center for Environmental Measurement and Analysis http://www.nies.go.jp/sosiki/analysis-e.html

Contributing to the appropriate management of measurement data and the assurance of its reliability with revolutionary developments in environmental measurement technologies

We develop methodologies to better understand and monitor environmental conditions and changes, and to assess the biological impacts of environmental stress. We also forward measurement techniques and technologies which contribute to identifying the warning signs of new environmental deterioration by developing and optimizing our surveys and research. In addition, we implement research aimed at the development of techniques to preserve and use environmental samples and to further assure the reliability of measurement data and its appropriate management.

Center for Environmental Biology and Ecosystem Studies http://www.nies.go.jp/biology/

Contributing to the realization of biodiversity conservation and sustainable ecosystem services

We implement research to clarify the relationship between the structure and functions of diverse ecosystems and the impacts of human activities on ecosystems and biodiversity over a variety of spatial and temporal scales.

Center for Material Cycles and Waste Management Research http://www-cycle.nies.go.jp/index-e.html

Contributing solutions for sustainable usage of resources and the reduction of the environmental burden which accompanies that use

Our researches aim to contribute to: 1) Cyclical and efficient use of resources 2) Lessen the environmental burden occurred from waste On scales ranging from local to international, researchers examine the state and elucidate the mechanisms of resource use and associated environmental burdens arising from socioeconomic activities. They also conduct research on assessment methods and strategic proposals for transitioning to sustainable a sound material-cycle society. Researchers also develop and evaluate technologies for the appropriate treatment, disposal, and recycling of wastes and recyclable resources as well as the fundamental technologies needed for resource recycling and material management.

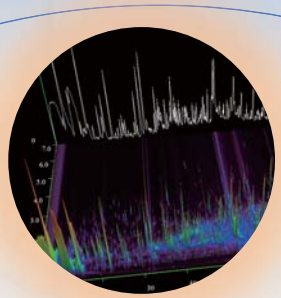
Fukushima Branch http://www.nies.go.jp/shinsai/

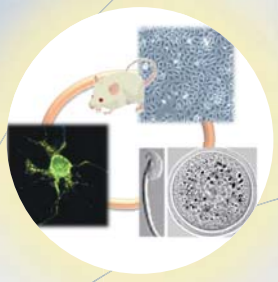
Center for Social and Environmental Systems Research http://www.nies.go.jp/social/en/index_en.html

The fourth five-year plan (2016-2020)
Health and Environmental Safety Research Program 2017.03

National Institute for Environmental Studies
Center for Health and Environmental Risk Research (Lead)

Address : 16-2 Onogawa, Tsukuba, Ibaraki 305-8506 JAPAN
URL : http://www.nies.go.jp/risk_health/index-e.html





The fourth five-year plan (2016-2020)

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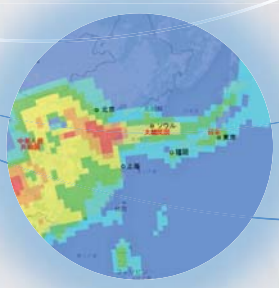

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