Basic Technology Subjects

# Environmental Science Research Laboratory

## Brief Overview

The Environmental Science Research Laboratory has promoted basic research on atmospheric, river, coastal and marine environments as well as biology, and chemistry, for the construction and stable operation of electric power facilities, establishment of a low-carbon society, and reduction of various environmental risks associated with the electric power industry.

## Achievements by Research Theme

### Atmospheric and Marine Environment

The research objectives are to develop technologies for predicting and assessing atmospheric and marine environments in order to deal with environmental problems associated with nuclear power plants, such as air pollution and the marine dispersion of radioactive materials.

- A numerical fluid dynamic model that can simulate the dispersion of emission gas in a stable atmosphere using thermal stratification was developed to assess the effects of atmospheric stability*1 on the dispersion of emission gas in the vicinity of reactor buildings of a nuclear power plant. The developed model enables the prediction of the dispersion of emission gas in a strongly stable atmosphere in a shorter time and at a lower cost than wind tunnel experiments.
- A biogeochemical process was incorporated into our high-resolution regional ocean model on the scale of the North Pacific Ocean to assess the marine dispersion of radioactive nuclides that easily adsorb onto biogenic particles. The new model reproduces the role of phytoplankton and enables the accurate assessment of the sedimentation behavior of radioactive materials (V14009).

### River and Coastal Environment

The research objectives are to develop technologies for monitoring, predicting, and assessing inland and coastal water environments in order to solve problems related to electric power utility. These environments include rivers and reservoirs affected by hydraulic power plants, as well as coastal environments near thermal and nuclear power plants.

- A method for analyzing the coastal current pattern and its frequency was developed by combining SOM (Self-Organizing Map)*2 with flow observation using ocean radars. This method reduces the number of observation points with a conventional velocimeter, and is expected to cut down the cost of oceanic observation in the environmental impact assessment of coastal power plants (V14015).
- The purpose of this research is to develop a tool for the comprehensive assessment of river environments that can be used for updating water rights and supporting sediment throwing in hydropower dams. A method for assessing the primary productivity of algae that is a key indicator of river ecosystem health, was developed by continuously monitoring the dissolved oxygen (DO) concentration in river water (V14011).

### Biological Environment

The research objectives are to develop technologies for addressing problems related to biofouling and jellyfish and for preventing accidents at power facilities caused by birds and mammals, and thus contribute to realizing a stable power supply and its effective maintenance. Biological effects of power- and intermediate-frequency magnetic fields are also examined to increase the general public's understanding of their possible human health risks.

- Short-circuit accidents may be caused by birds and mammals that come in contact with transmission and distribution wires and enter substations. The research team developed a technique for specifying species of birds and mammals through the DNA analysis of feces and feathers left at accident sites as well as a technique for detecting birds by videography at night as well as day. These techniques can be used to prevent accidents in accordance with the type and behavioral characteristics of the animal (R14015).
- Golden mussel, an invasive adhesive bivalve, causes clogging of water supply pipes at hydraulic power plants. Our research team investigated control measures for this species conducted at overseas electric power plants and developed antifouling methods using ozone and a copper alloy strainer. The selection of optimal antifouling methods for each power plant based on this knowledge can contribute to preventing problems caused by the adhesion of bivalves and reducing the amount of organic waste which occurs at a regular cleaning (V14010).

### Bioengineering

The research objectives are to develop technologies related to the economic treatment of transformers contaminated with trace polychlorinated biphenyls (PCBs), to the advanced utilization of unused carbon resources, and to the agricultural application of heat pumps.

■The research team formulated guidelines on the circulative cleaning technologies for transformers contaminated with trace PCBs. The guidelines can be commonly applied to various companies involved in power generation and used to specify the technical items, such as the environmental assessment and the determination of cleaning conditions, required to apply for permission from the Ministry of Environment to install treatment facilities.

■A pellet mixture of lignite (a low-quality coal) and biomass residues (rice bran, Jatropha oil cake, and eucalyptus chips) was prepared and its fuel characteristics were assessed with the aim of increasing the effectiveness of lignite. For a mixture of lignite and rice bran with a percentage of lignite of up to 50%, high formability and heat generation were achieved (V14008).

## Environmental Chemistry

The research objective is to develop low-cost technologies for the management and treatment of trace chemical substances, such as selenium in wastewater from coal-fired power plants, in order to support the high-performance and stable operation of coal-fired power plants. The effects and suitability of environment-related measures are assessed to reduce the environmental risks associated with thermal power plants.

■A biochemical treatment method involving a reduction process using microorganisms was developed for selenium in desulfurization wastewater from coal-fired power plants (Fig. 1). An on-site test using a small system demonstrated that the concentration of selenium in wastewater from a power plant could be reduced to lower than the regulation value (Fig. 2). The developed method is expected to reduce the costs of chemicals and the treatment of sludge to approximately half and one-tenth of those required for the conventional chemical treatment, respectively

■Nitrogen-sulfur (NS) compounds cause an increase in chemical oxygen demand and total nitrogen concentration, which are indices for the degree of pollution of wastewater from thermal power plants. An analysis technique for NS compounds was established towards their detection and quantification. The technique was confirmed to be useful for specifying NS compounds that cannot be removed by existing wastewater treatment facilities at coal-fired power plants (V14002).

*1 An index relating to the ease with which the atmosphere moves in the vertical direction. In general, emission gas is less dispersed in a strongly stable atmosphere.
*2 A type of neural network and multivariate analysis method that enables the pattern classification of multidimensional data through unsupervised learning.

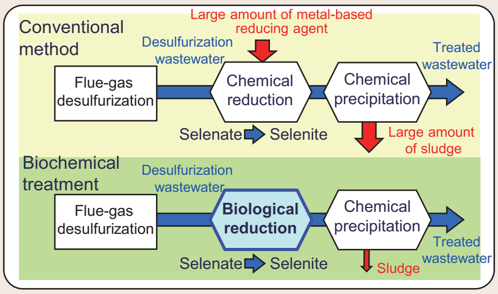


Fig. 1: Treatment process for selenium in wastewater from a coal-fired power plant

Conventional chemical treatment process (upper) and biochemical treatment process (lower). The conventional treatment process consists of two steps: (1) Selenate reduction through the addition of a metal-based reducing agent and (2) Chemical precipitation for selenite. The high costs of the reducing agent and the treatment of the resulting sludge were issues to be addressed.

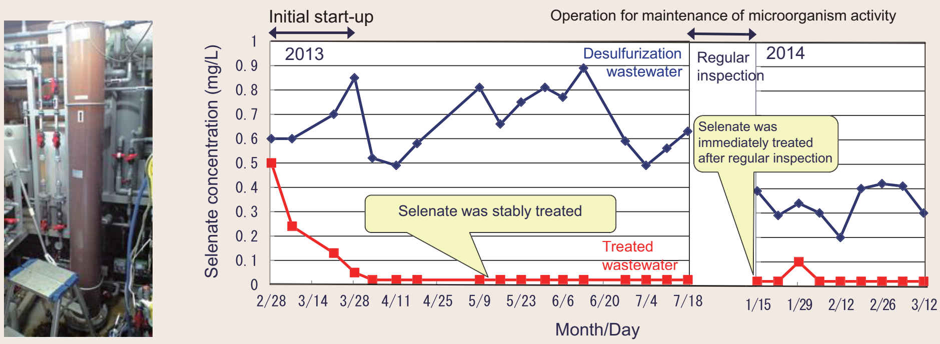


Fig. 2: Bioreactor for selenium reduction (left) and selenium treatment in on-site test at coal-fired power plant (right)

It took approximately one month for the acclimation of microorganisms at initial start-up. Afterwards, selenate was stably treated. Selenate was immediately treated after regular inspection (on January 15 and later).