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, chemistry, and biotechnology, 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 target of research in this field is to develop technologies for predicting and assessing atmospheric and marine environments in order to respond to problems such as air pollution associated with thermal and nuclear power plants and the marine dispersion of radioactive materials.

- The effect of building downwash*1 was investigated by numerical simulation to help determine a reasonable stack height in thermal power plants. By clarifying the relationship between the stack height and the surface concentration of exhaust gas, an approximate equation that expresses the relationship between the maximum surface concentration and the stack height was proposed to easily estimate the stack height necessary to effectively disperse exhaust gas (V12003).

River and Coastal Environment

The target of research in this field is to develop technologies for investigating, predicting, and assessing hydrospheric environments in order to solve related environmental problems. These environments include aquatic environments, such as rivers and reservoirs, which are affected by hydraulic power plants, as well as environments near coastal power plants, such as thermal and nuclear power plants.

- A model that considers the habitat environment of benthic organisms such as aquatic insects in rivers (physical habitat simulation model - PHABSIM) was incorporated into a tool for predicting and assessing river environments that can be used in updating water usage rights and supporting sediment throwing in hydropower dams. A method of efficiently monitoring the change in river environments using biological indicators was also developed.
- We developed a method of estimating the water temperature and velocity of submerged thermal discharges on the sea surface for various discharge conditions with the aim of rapidly assessing the dispersion area of discharges from thermal and nuclear power plants. Using this method, we developed a simple simulation technique to easily estimate the dispersion of thermal discharges on a PC and verified its applicability (Fig. 1) (V12018).

Biological Environment

The target of research in this field is to develop methods to prevent electrical accidents caused by biofouling organisms, birds, and animals as well as to prevent forest soil erosion causing soil runoff to rivers and reservoirs in order to reduce the labor required to maintain power plants and resolve related environmental problems. The risk of electromagnetic fields on health is also analyzed.

- Barnacles and golden mussels attach themselves to water intake channels in maritime power plants and the water pipes of hydroelectric dams, respectively, and inhibit the flow of water. We clarified the effects of chlorine and ozone on preventing such attachment through examinations under various water quality conditions and obtained the basic knowledge necessary to develop practical preventive techniques.
- We exposed rats to intermediate frequency magnetic fields at the intensity higher than international exposure guidelines for general public. After exposure, no significant changes were observed in body weight, blood chemistry, and histopathology of the organs. The results suggested that intermediate-frequency magnetic fields generated from home appliances have no adverse effects on human health (V12001).

Biotechnology

The target of research in this field is to develop technologies that use microorganisms to reduce and recycle waste and to treat drainage water. Technologies to create an energy-efficient environment for plant-growing factories and to utilize renewable energy are also developed.

- A numerical calculation model for assessing the thermal and air environment within plant-growing factories was developed as a means of saving energy in such factories using heat pumps. The applicability of the model to small greenhouses was verified (V12004).

- The fuel characteristics of plant oil produced from Jatropha used in diesel engines for power generation were assessed with the aim of utilizing biomass as fuel for power generation. The fuel characteristics comparable to those of light oil were obtained by reducing the viscosity and other factors of plant oil (V12014).
- We improved the pretreatment method for samples to be tested using microbiosensors that detect mercury in water discharged from coal-fired power plants. This increases the likelihood of creating a simple method of monitoring mercury concentration below the maximum allowable level set for discharged water and controlled landfill sites (V12010).

Environmental Chemistry

The target of research in this field is to develop effective technologies for utilizing byproducts, such as coal ash and desulfurization gypsum, generated at power plants as well as low-cost technologies for managing and treating trace elements in effluents discharged from power plants in order to support the high-load and stable operation of coal-fired power plants.

- A pretreatment method for rapidly and ultrasonically eluting mercury in coal ash was established to support its management. This has led to the realization of quantitative analysis (0.01-1.0 mg/kg) by inductively coupled plasma optical emission spectrometry (ICP-OES), which has been adopted by many power plants (V12002).
- A technique was developed for stabilizing heavy metals in industrial waste such as fly ash under alkali conditions. This uses our method developed for synthesizing hydroxyapatite from desulfurization gypsum as a raw material*2.

*1 A phenomenon in which the surface concentration of gases increases when such gases enter the vortices and downflow generated behind buildings.
*2 Joint research with Kurita Water Industries Ltd.

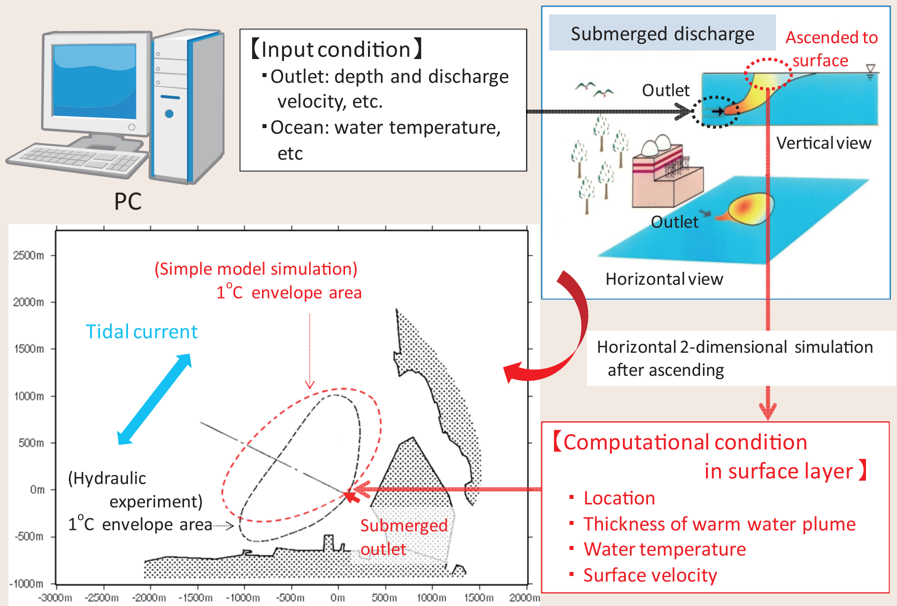

Fig. 1: Simple simulation method developed for submerged discharge and comparison with experimental results

The dispersion of submerged thermal discharge is complicated. The results of a hydraulic model experiment and a three-dimensional model are used to estimate the area of water temperature increase resulting from the dispersion of submerged thermal discharges. In the developed method, the location, velocity and water temperature of a submerged thermal discharge ascended to the sea surface are estimated for different discharge and hydrographic conditions to easily predict the dispersion area of the thermal discharge at surface layer. The 1℃ temperature increase area observed in the simulation was practically consistent with that of the hydraulic experiment with a tidal current in the sea (left figure). The developed method is more cost-effective than hydraulic experiments and three-dimensional simulations and can greatly reduce the calculation time, making it effective for examining marine strategies at the planning stage.