River Basin Environmental Risk Assessment System

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Abstract

We have developed the River Basin Environmental Risk Assessment System. This system can predict and evaluate chemical concentrations in river water using PRTR (pollutant release and transfer registers) chemical effluent data, industrial site accounting data, and weather data (rainfall, etc.). It can also assess the effects on human health and the ecosystem.

1. Introduction

Besides being a source of fresh water and fish, rivers are increasingly being seen as symbols of a good living environment for the local population. It is therefore becoming more and more important to know the true status of chemical pollution of river water and underground water and to understand the mechanisms of chemical movement and decomposition in order to manage chemical risks in wetlands. To meet those needs, we have turned our attention to the river flow basins that are managed by local governments and by branches of the national government and developed the River Basin Environmental Risk Assessment System for assessing chemical concentrations in the drainage system from PRTR[*1] effluence data on chemicals from industrial plants and from environmental data obtained from other sources including weather data and river hydraulics data. This system also evaluates effects on human health and the ecosystem.

2. System overview

The overall structure of the system is illustrated in **Fig. 1**. It comprises three subsystems: an information management system, a river quality assessment system for assessing water quality and risks, and an information publishing system for publishing risk information. The system exchanges data with previously developed environmental accounting systems and performs atmospheric chemical concentration assessments and coupling analyses to assess chemical concentrations in order to arrive at a total environmental quality that includes air, river, and soil (surface layer) quality.

2.1 Information management system

This is a global service management system that controls the execution of processing by simple manipulation of the input data and processes the numerical output of the computation modules so that the results can be presented to the client in an appropriate format. It comprises an input processing module, information management module, access control module, access interface module, environmental disaster response module, and output processing mod-

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*1 PRTR (pollutant release and transfer registers) system has been implemented in Japan since the Law Concerning Reporting, etc. of Releases to the Environment of Specific Chemical Substances and Promoting Improvements in Their Management (Law for PRTR and Promotion of Chemical Management) was enacted in 1999. Under this law, businesses are required to report annually their own releases and transfers of the listed 354 chemical substances that may be harmful to human health and may impair the life and growth of animals and plants. The government then compiles both the data reported by businesses and the estimated data notified by the outside into a report for publication.

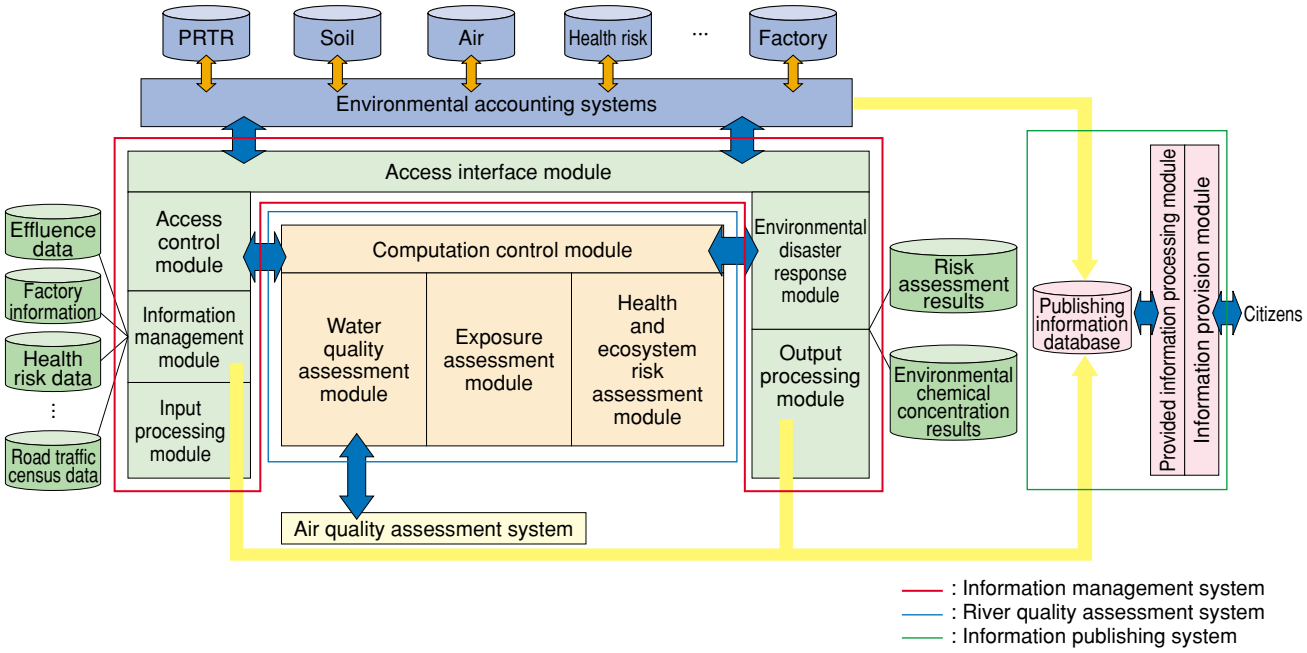

Fig. 1. Overall structure of the basin environmental risk assessment systems.

ule. It has eight main functions and some minor functions. The main functions are as follows.

1) A service management function for client authentication, control of the computation function module's execution, and status monitoring
2) An authoring function for searching external databases (XML-based environmental accounting systems), extracting the required information, and converting the data to an appropriate format for passing to the computation modules
3) A river modeling function that provides a tool kit for use in constructing a model of water inflow from the catchment area
4) A pollution source modeling function for estimating the effluence source
5) An assessment control and operation function for calculating the amount of water flowing into a river, calculating the river water volume, assessing the amount of chemicals taken into an organism's body (exposure assessment) and their effects on people and the ecosystem (risk assessment), and searching databases, etc.
6) An output function that provides client services and prints out forms using WebGIS (Web-based geographic information systems) and passes data to the information publishing system and other such functions
7) A disaster response function for supporting disaster prevention efforts by rapidly estimating the source of effluence and the scale of the pollution, etc. when an accident occurs
8) A function for connecting with the air quality assessment system

In addition to the above major functions, minor functions include a data input support function, accounting data extraction and input support function, and external data input support function. The data input support function supports the authoring function (**Fig. 2**). The accounting data extraction and input support function efficiently searches for and retrieves information about chemical effluence sources, geographical information, weather information, and the monitoring data used in the water and soil chemical concentration analysis from the environmental accounting system database and prepares a data set in a suitable format for simulation. The external data input support function retrieves external data (such as weather information and river water level data provided by the River Information Center, etc. that is used in the water quality and soil assessment calculations) mainly from online sources and automatically converts it to input data for the calculations.

2.2 River quality assessment system

The river quality assessment system calculates the

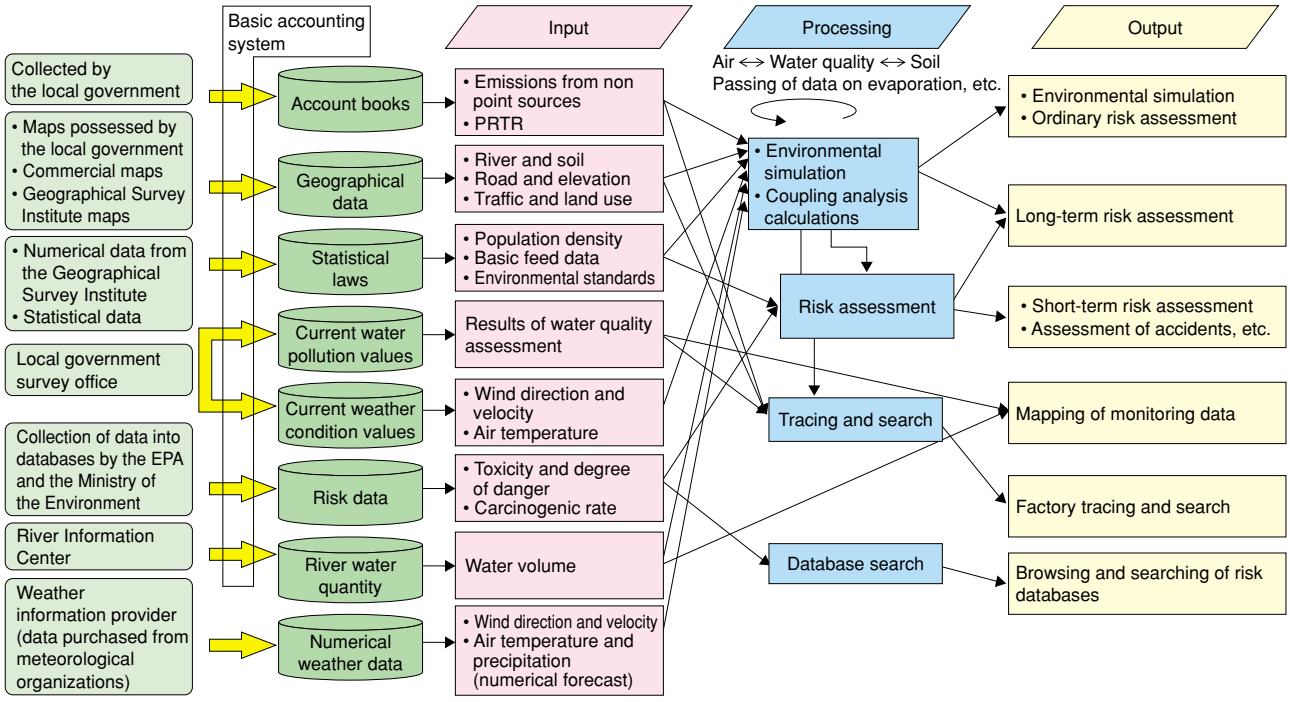

Fig. 2. Input/output data and its processing.

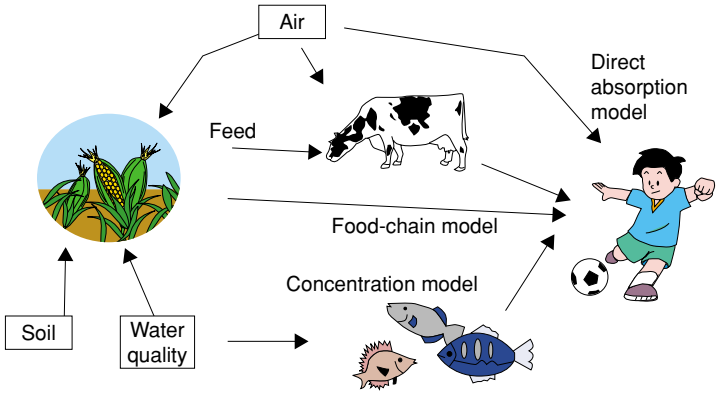

Fig. 3. Exposure assessment.

amount of water inflow to the river and performs risk calculations. As shown in Fig. 1, it has four components: a computation control module, water quality assessment module, exposure assessment module, and health and ecosystem risk assessment module.

The computation control module controls the computation and input/output files according to the request from the user (assessment scenario). The assessment scenario shows how humans are exposed to the chemical. Specifically, it shows the route that the chemical takes from the source to a person (**Fig. 3**). The results of the calculations are output to the file specified by the user and the output file is passed to the information publishing system.

As shown in **Fig. 4**, the water quality assessment system considers (1) effluence information (e.g., the source site, substance released, and amount released) required for the assessment that is extracted and estimated from information about effluents that spread point-wise as well as surface-wise, (2) weather information such as rainfall and wind velocity, (3) river flow information, and (4) the flow basin network

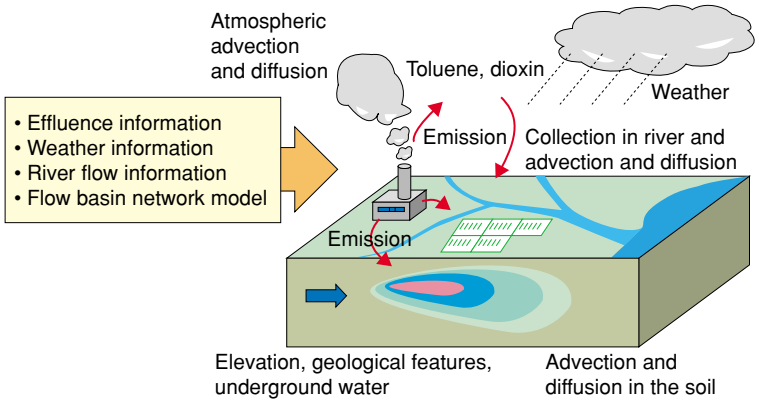

Fig. 4. Water quality assessment.

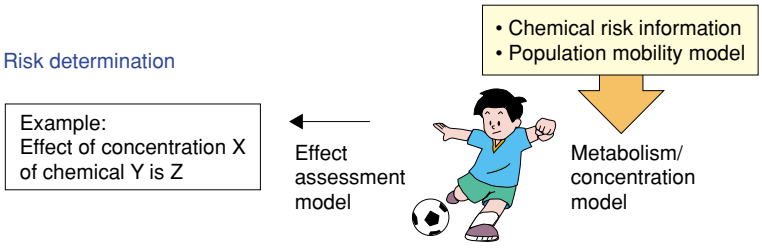

Fig. 5. Health and ecosystem risk assessment.

model (flow basin blocking, etc. that models the amount of precipitation inflow to the river) from the previous modeling of the region being assessed done by the information management system, and assesses the water quality (chemical concentrations and the COD (chemical oxygen demand) index of river water quality, etc.) of the flow basin and the river. It also coordinates with the air quality assessment system to perform a coupling analysis with the previous year's results for concentrations of volatile substances in the air received from the assessment system.

The exposure assessment system assesses the amount of exposure of humans and the ecosystem to the chemicals on the basis of the water chemical concentration distribution that was calculated by the water quality assessment module and then estimates the amount of intake of the released substances and the amount of exposure. In addition to the amount of human exposure from breathing, there is intake via the food chain and from the water used in beverages. For the ecosystem, the effect is chemical exposure to the plants or fish. (Fig. 3).

The health and ecosystem risk assessment system takes the amount of exposure of people and the ecosystem to the chemical and the amount taken into the body that was calculated by the water quality and exposure assessment systems and compares them with values in a database of the effects of the chemicals on health and an ecosystem risk database to determine the human health risk and assess the effects on the ecosystem (**Fig. 5**).

2.3 Information publishing system

The information publishing system (**Fig. 6**) aims to use familiar consumer products as examples to help the public understand and take an interest in chemical information. It provides information about the chemicals contained in common products such as shampoo, detergent, air-freshener, and food/beverage items and the chemicals used in their production together with the environmental effects of those chemicals. That information is offered in forms that can be easily understood by the public. This system comprises a provided information processing module, information provision module, publishing information database, and various interfaces.

The provided information processing module creates environmental risk information concerning the

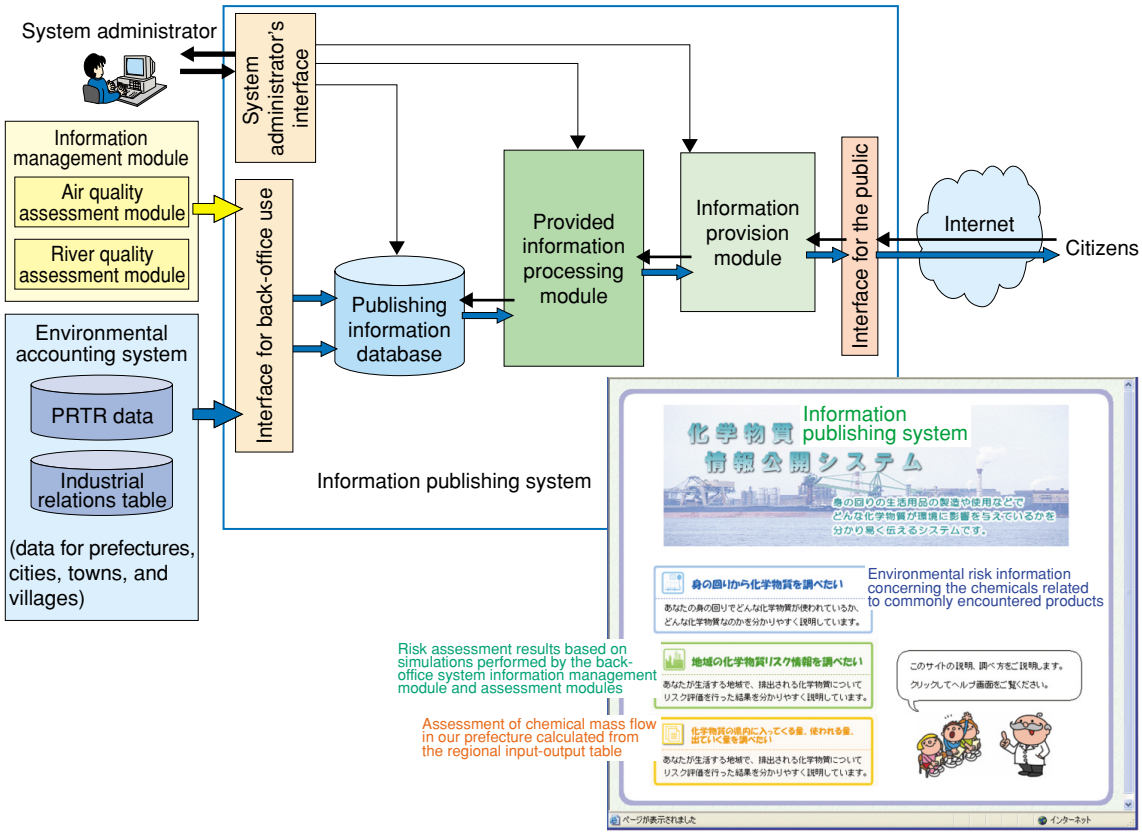

Fig. 6. Information publishing system.

chemicals related to commonly encountered products. In addition, risk assessment results based on simulations performed by the back-office system information management module and assessment modules are color coded according to the procedure book and processed for presentation in a visual format such as a table of indices for comparison so that the effects can be easily understood.

The information provision module creates links between products' chemical information created by the provided information processing module and the information related to the assessment results and processes the information for presentation to the general public. Presenting the assessment in terms of the chemicals used in familiar products makes the information accessible even to people who are not familiar with the chemicals themselves.

The publishing information database contains previously published information, stores and manages information relevant to the environmental effect assessment, and is the source of information processed by the provided information processing module. Finally, the processed information is sent to the information provision module.

The various interfaces include functions for providing public-oriented information over the Internet, transferring the publishing information selected by the back-office system over the Internet, and supporting the system administrator in various system administration tasks.

3. Conclusion

The River Basin Environmental Risk Assessment System can predict and assess river water quality and chemical concentrations from PRTR chemical effluent, industrial accounting, and weather data. In addition to long-term predictions and assessments such as yearly and monthly averages, the system can produce short-term ones in time-spans as short as one hour. We hope that by presenting the assessment results for river water chemical concentrations in easily understandable formats such as maps, this information will be useful in predicting and understanding the river environment situation and drafting measures for improving the river environment.

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