DEVELOPMENT OF A COMPUTER-AIDED SYSTEM TO SUPPORT THE BASIN-WIDE MANAGEMENT OF WATER QUALITY IN LAKES AND RIVERS

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ABSTRACT

A personal computer based easy of access software to help water authorities for setting basin-wide comprehensive management program on water quality control was developed. Users are requested to input geological and administrative mapping of pollution sources and related socioeconomic information supported by advisory system. Then the system enables them to estimate pollution loads from the basin including both point and non-point sources and to predict quality of the water bodies based on the present load and expected loads after alternative management plans are implemented. The C-language was used for system development except for the advisory subsystem where the Prolog was also used. Lake Sagamiko and its tributary, Katsura River, was used as a model basin for system development and validation.

KEYWORDS

personal computer, basin-wide management, pollution load, eutrophication management software

INTRODUCTION

The basic policy in Japan to construct treatment plants for domestic and industrial wastewaters was found not to be enough to restore polluted water bodies. Controls of non-point sources of pollution and small-scale wastewaters are now regarded to be evenly or more important and basin-wide management is urgently necessary. Except for large and very important water bodies, however, the lack of experts on water pollution control and related sciences makes it difficult for water authorities to set and implement basin–wide management programs.

Although various kinds of mathematical models for river and lake water quality management have been developed, the application of these models to a specific water body is not always easy because most of them presuppose basic understandings on model structure and biological, physical and chemical processes in the water. Also, pollution loads must be summed up beforehand taking all the complicated socioeconomic activities into consideration.

The purpose of this study is to present easy of access software to help water authorities for setting basin–wide comprehensive management program on water quality control(1). The system developed enables them to estimate pollution loads from the basin including both point and non–point sources and to predict quality of the water bodies based on the present load and expected loads after alternative management plans are implemented.

The C–language was used for system development except for the advisory subsystem where the Prolog was also used. A small polluted river basin in Japan, Lake Sagamiko and its tributary, Katsura River, was used as a model basin for system development and validation.

FUNCTIONS OF THE SYSTEM

A schematic diagram of the system configuration and relationships between major functions is shown in Fig. 1. The major functions incorporated into the system to fulfill the system performance are as follows:

(1)Definition of geological and administrative mapping of pollution sources

Numbers and names of river basins and administrative districts are requested to be input to define geological mapping of pollution sources. Five spreading sheets are generated automatically based on this information to support inputs of socioeconomic information necessary to estimate pollutant loads from each administrative district and tributary for each parameter (total phosphorus, total nitrogen and chemical oxygen demand).

The five spreading sheets are pollutant load per unit activity/area of pollution sources, scale of activity or area, generated pollutant loads, percent of discharge, discharged loads of pollutant into the water body. Fig. 2 shows an example of spreading sheet. These sheets are overlapped on a monitor and can be selected instantaneously by choosing appropriate function key (multiple windows, full screen editor).

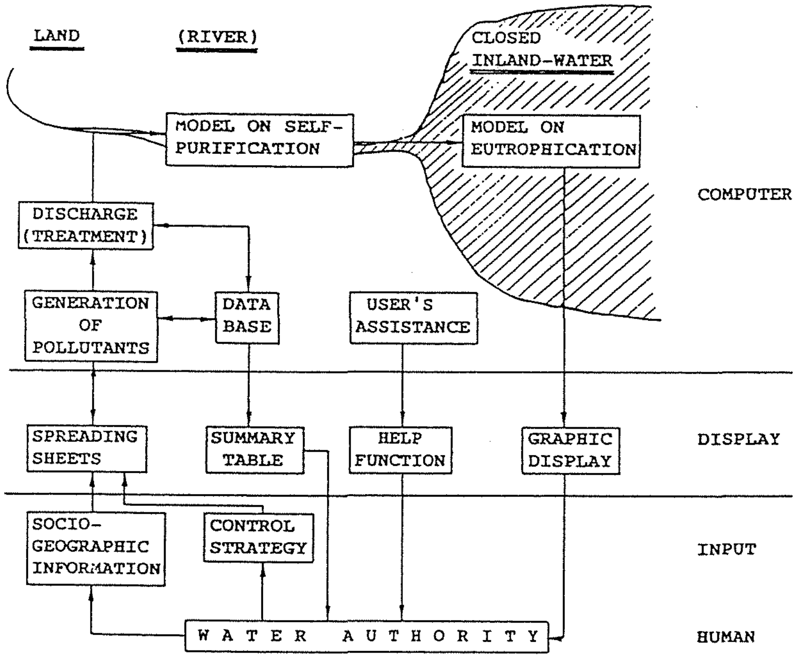

Fig. 1 Schematic diagram of system configuration and major functions

River Basin Management System   Memory Available: 260176
File name: katsura.rbm

Katsura R. Dischg	gray kg/yr	on-site kg/yr	live kg/yr	manu kg/yr	total kg/yr
Yamanakako	28.616	19.698	44.666		92.98
Oshino	39.712	18.894	0.95995		59.56595
Ashiwada	8.76	5.226	1.72791		15.71391
(S)B river	312.03	384.54	156.35	138.25	1324.87
SUM	320.79	389.766	158.0779	138.25	1340.584
Katsuyama	12.264	6.432			18.696
Kawaguchiko	92.272	63.516	1.92		181.3123
Fujiyoshida	322.952	63.516	29.51398	7.784	467.1928
Nishikatsura	23.944	11.658			35.602
Tsuru	188.048	27.738	56.67988	18.8416	314.3277
Otsuki	207.32	17.286	54.62531	19.8132	352.3416
Uenohara	147.752	42.612	14.61334		204.9773
total	1383.67	661.116	361.0564	184.6888	3067.58

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Number Initl. Genrt. D.Rate Dischg   Nitro. Phos. COD   COD

Fig. 2 Main data screen (sources of COD discharge)

It must be noted that the system was deigned to have an applicability to complicated river systems which has many tributaries as shown in Fig. 3. Spreading sheets are generated for each tributary as shown in Fig. 4. The data file (the sum of spreading sheets) for river D is introduced into the river file of river C. The files of river C and river B are introduced into the files (spreading sheets) of river A. Fig. 2 shows river B is flowing into river A at the district of Ashiwada.

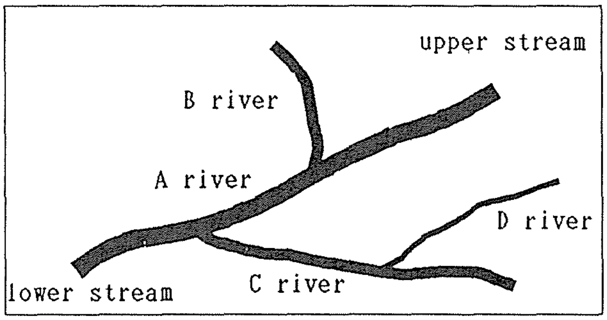

Fig. 3 A river with tributaries B, C and D.

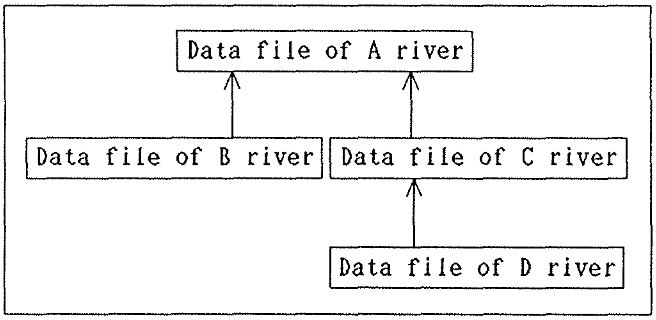

Fig. 4 Structure of data files for A river

(2)Inputs of socioeconomic information supported by an advisory system

Pollutant load per unit activity and the scale of activity/area are requested to be input into the spreading sheets. Fig. 5 shows an example of industrial COD loading from district of Tsuru (City of Tsuru).

Except for well studied basin, however, it is common that most of necessary information such as pollutant loads per unit activity and percent of discharge have not been fully surveyed in the specific basin to be managed and also, additional surveys are not always possible within a limit of budget and time.

This system provides an advisory system with uniformed database compiled

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Tsuru manu.	Number yen	UnitL. kg/yr/yen	Genrt kg/yr	D.Rate %	Dischg kg/yr
foods	3.06	2.11	6.4566	100	6.4566
textile	5.33	0.8	4.264	100	4.264
clothes	0.31	0.05	0.0155	100	0.0155
woods	2.51	0.85	2.1335	100	2.1335
furniture	0.41	0.04	0.0164	100	0.0164
china	1.13	0.23	0.2599	100	0.2599
not-iron	2.89	0.23	0.6647	100	0.6647
metal	3.5	0.3	1.05	100	1.05
machine	5.15	0.1	0.515	100	0.515
precision	17.33	0.2	3.466	100	3.466
total			18.8416		18.8416

Delete, Insert, Main data, Print, Quit

Number UnitL. Genrt D.Rate Dischg Nitro. Phos. COD COD

Fig. 5 Source data screen (industrial COD loading from City of Tsuru)

from published references of pollutant load per unit activity/area of each pollution source. The advisory system works in multi-windows to assist users to determine appropriate values of parameters for the specific basin.

(3)Calculation and summation of pollutant loads

Generated and discharged pollutant loads are calculated automatically. These pollution loads are automatically summed up for each administrative district and category of pollution sources such as industrial, municipal, forest, agriculture and etc. to show major pollution sources in the whole basin. Automatic recalculation for correction or modification of input values helps complicated tasks of pollution load estimation for various alternative plans proposed.

(4)Water quality in rivers and tributaries

Fate of pollutants discharged into a river from various points (administrative districts) along the flow is estimated by a simulation model on self-purification in river system. The model accounts for sedimentation, biodegradation and/or uptake both in flowing water and bottom sediments. Average width, depth and velocity of flow at intervals between adjacent districts along the river, and distance between these districts are parameters taken into consideration to specify rivers and their

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Katsura R.	Depth [m]	Width [m]	rate [m/s]	length [km]	N-Dischg [kg/yr]
Yamanakako	0.3	2	0.8	3.8	35.237
Oshino	0.4	4.1	0.8	5.1	23.12425
Ashiwada	0.4	6.5	0.8	0.1	6.89765
Katsuyama	0.5	6.7	0.7	0.1	7.52
Kawaguchiko	0.5	8.3	0.6	0.1	94.1451
Fujiyoshida	0.6	12.5	0.6	4.9	160.5615
Nishikatsura	0.7	18.3	0.6	7.2	13.865
Tsuru	0.8	22	0.6	10.4	97.6663
Otsuki	0.9	30	0.4	9.7	123.3049
Uenohara	1.4	60	0.5	5	66.5001

Delete, Insert, Main data, New data, Option, Print, Quit, Transfer

Number Unit L. Genrt D.Rate Dischg Nitro. Phos. COD

Fig. 6 River data screen (Katsura River)

capacity of self– purification. Fig. 6 shows an example of input information to specify Katsura River. The water quality and flow rate at the inlet into a lake is summed up to give pollution loads into a lake.

(5)Water quality in lakes and reservoirs

Annual average and seasonal variation of water quality in a lake are estimated for a given pollution loads summed up through the above mentioned procedure. The system has a simple ecological model and a load–response model. The lake is specified by surface area, average depth, hydraulic retention time, and depth of thermocline. State variables in the model are biomass of phytoplankton and pollutants both in epilimnion and hypolimnion. An example of simulation on lake water quality is shown in Fig. 7.

(6)Supporting functions for check and correction

All the values to specify socioeconomic activities such as pollution load per unit activity and scale of activities, do not have the same reliability. Reliability of each values are important information to know the reliability of the estimation of pollution loads and subsequent simulation of water quality. Also the reliability helps correction of input values during calibration and validation of the system. Degree of reliability is specified by user and expressed also in the spreading sheets

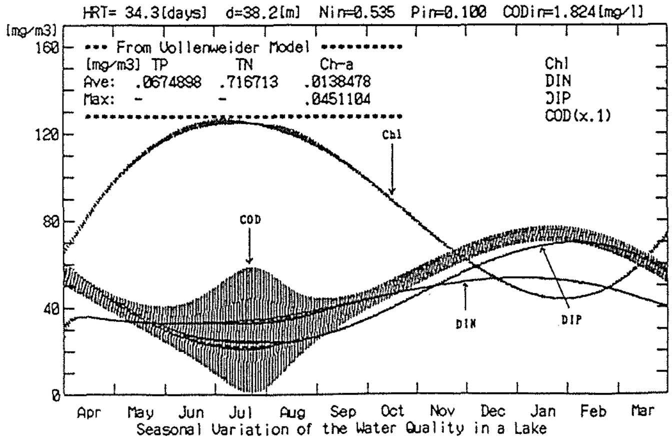

Fig. 7 Simulation of water quality in Lake Sagami

by five colors. Help functions are also introduced into this system to help input works and operation.

SYSTEM VALIDATION

Pollution loads from the river basin were estimated easily and the simulated water quality in the lake was in good agreement with observed data. Several countermeasures on water pollution control in the water bodies are assessed by the system to demonstrate the function of recalculation of pollutant loads and subsequent estimation of water quality. The system developed proved the effectiveness of the concept of system development and will be applied to other lake and/or river basins. It was also certified that the system developed by NEC PC-9801 personal computer can be transferred with small modification into IBM or compatible personal computers.

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