Water Quality Modeling System in IRWMS

16 November 2005
Dr. Joonwoo Noh

Contents

- Background
- Water Quality Management in Geum River Basin
- Water Quality Modeling System in IRWMS
  - Steady State Water Quality Model
  - Unsteady Water Quality model
- Application Examples
- Further Development
"Protect the environment adequately but economically"

- Desirable water use:
  - Municipal
  - Industrial
  - Agricultural
  - Recreational
- Loadings W:
  - Point sources
  - Nonpoint sources
- Aquatic Environments:
  - River, Reservoir, Estuary
- Water quality models
  - Concentration, C
  - Desired concentration, Cgoal
  - C < Cgoal
  - Yes
  - No
- Environmental Control:
  - Treatment
  - Prevention

Desirable water uses:
- Drinking water source
- Industrial uses
- Fishing

Waste Load Allocation:
- Pollutant load
- Resulting water quality vs standard
- Waste load allocation
- Projected water quality
Water Quality Management in the Geum River Basin

Water Quality Issues in the Geum River Basin

1. Water Quality Problems in Rivers
   - Degradation of W.Q. during low flow season
   - High level of COD, T-N, T-P (BOD has been controlled)
   - Significant level of NH3-N during winter
   - Eutrophication
   - Accidental spills

2. Water Quality Problems in Daechung Dam Reservoir
   - Eutrophication (Algae bloom after summer storms)
   - Turbidity currents during flood season
   - DO depletion in hypolimnion
Geum River Basin

- TMDL is set up from 2005
- Identifying Regional Population, Industrial, and Irrigational Waste Load
- Waste Reductions & Allocation
- For Water Quantity & Quality Control
  Basin Water Resources Management is Important

Objectives of Water Quality Models

- Development of steady state river water quality model
  - For normal river & reservoir operation -
  
  To support monthly river & reservoir operation scheduling by providing projected river water quality based on forecasted river flow conditions

- Development of Dynamic river water quality model
  - For emergency operation during chemical spill -
  
  To support a real-time reservoir operation (daily or hourly) by providing projected river water quality based on scheduled reservoir discharge plan upon accidental water quality degradation (travel time and dilution effect)

- Development of reservoir water quality model
  - To assess an adequate reservoir water quality management plan (BMP)
  - To support a real-time control of turbidity current during flood season for minimizing the impact of turbidity current on reservoir water quality
Conventional Reservoir Operations vs. WQ

Water Quality Monitoring Sites
Annual Water Quality Variation

Water Quality Modeling System in IRWMS
Basin Water Resources Management

- IRWMS is Developed to Support
  - Rainfall-runoff for Reservoir and Watershed Inflow Estimation
  - Reservoir Operational Planning
  - Water Quality Evaluations

- Rainfall Runoff (RRFS)
- Reservoir Operation (SSDP, Comom, Korsim)
- Qual2E-Plus (Integrated)

Basin Reservoirs System Operation for Water Quantity & Quality!

Computational Element

- 16 reaches
- 131 elements
- 10 tributaries
- Water intakes, Pumping
- Water Elevation Stages
Hydraulic Data

Initial Conditions
Head Water & Point Load

Output Results
Water Quality Modeling System

QUAL2E-Plus
- Steady State WQ Model
- Long Term Projection
- Integrated in IRWMS

KORIV1- WIN
- Unsteady WQ Model
- Pollutant Spill
- Off-line Operation

Decision Support for Dam Operation

Steady State Water Quality Model
Qual2E-Plus Model

- **Improve Qual2E**
  - Most widely used river water quality model
  - 15 Water quality parameters are simulated
  - Reach, Element, Sources & Sinks
  - Steady state model
  - Flat-file data format
  - Embedded in watershed model (BASIN)
  - Does not support windows environment

---

Qual2E-Plus Kinetics
Dynamic Water Quality Model

KORiv1 Model

- Unsteady WQ model
  - Independent Model Run
  - Determine flushing discharge for contaminant spills

- Based on CE-Qual-Riv1

- Hydraulic module
  - Full dynamic equation (St. Venant eqns)
  - Continuity & momentum equation
  - 4-point implicit Preissman scheme

- Water quality module
  - Holly-Preissman for convection term
  - Similar kinetics to QUAL2E
  - Modeling of 12 WQ parameters (DO, CBOD, N groups, P groups, Mn, Fe, Algae, etc)
**Water Quality Kinetics**

![Diagram showing the processes involved in water quality kinetics]

**Schematic of Modeling**

1. **Data Preparation**
2. **Hydrodynamic Input file generation and model run**
3. **Check out the result of hydrodynamic module**
4. **Water quality file generation and model run**
5. **Check out the results of water quality model**

<table>
<thead>
<tr>
<th>Data Preparation</th>
<th>Run Hydrodynamics</th>
<th>Run Water Quality</th>
<th>Output Display</th>
</tr>
</thead>
</table>
| • Model grid and node  
  • Geometric data  
  • Hydro parameters  
  • Kinetic parameters  
  • Initial conditions  
  • Boundary conditions | • Hydro input  
  • Lateral flow  
  • LAQ  
  • Cross section  
  • XSF | • Water quality  
  • HINP  
  • Hydro output  
  • VWD  
  • Lateral load  
  • LAC  
  • Meteorological  
  • MET | • Water level  
  • Flow, velocity  
  • Concentration  
  • By node display  
  • By time display  
  • Graph & Table |
Diagram

- 1 main reach and
- 7 tributaries (8 segments)
- 2 nodes for each tributary
- Total 70 nodes

Data Preparation
2000.9.13 ~ 9.18 (Typhoon Saomi)

Discharge Increase for WQ Improvement
Bridge

EL Gauge

- Model Verification

- CBOD (mg/L) vs. Distance from Dam (Km)
- NH3-N (mg/L) vs. Distance from Dam (Km)
- NO3-N (mg/L) vs. Distance from Dam (Km)
- Org-P (mg/L) vs. Distance from Dam (Km)
Application Examples

- **Scenario Setup**
  - Maintenance of Water treatment plant in the Kap stream
  - Releasing BOD 100 ppm, 620,000 ton/day
  - Estimate discharge release to maintain BOD concentration below 3 ppm
  - Inform water intake system at Downstream

Application of Water quality accident
- Maximum Concentration Variation

![Graph](image)

**BOD (mg/L)**
- Distance from Dam (km)
- Maepo, Geumnam, Gongju, Gyuam, Gangkyung

**BOD5 (mg/l)**
- Distance from Dam (km)
- Observed

**NH3-N (mg/l)**
- Distance from Dam (km)
- Observed
- NH3-N Simulation
Flushing Effects
Release Pattern Change to Evaluate Downstream Water Quality

Flushing Scenario

NH3-N Concentration

Koriv1- Plus

- Updated Version of Koriv1
- Enhanced Visual Description
  - Channel Visualization
  - Cross Sectional Shapes, Depth
- Coloring Index of WQ Concentration
- Animated Result Output
Model Summary

- Qual2E-Plus & KORiv1 Model
  - Steady and unsteady water quality model
  - In the steady state, the results are very similar
  - Both are developed under window environment

- KORiv1
  - Useful for the accidental spill at downstream
  - Determine adequate discharge for flushing
  - Effect of water quality improvement
  - Compute channel maintenance flow

Further Development

- Integration with basin runoff system
  - RRFS System
  - Reservoir operation system

- Estimate channel flow maintenance discharge

- Environmental flow Estimation

- Use TMDL Support Tool

- Real-time turbidity current modeling in Reservoir & Downstream
Hydraulic Analysis (Riv1H)
Discharge Decision for Emergency case (Riv1Q)
Flushing effect / Travel Time
Monitoring & Assessment
Impact Analysis on Discharge Variation
Identify Watershed Pollutant source
Discharge to meet WQ Criteria
Projecting long term water Quality (Steady)

Long-Term WQ

Emergency Spill

KoRev1
Qual2E-PLUS

Integrated Water Quality & Environmental Flow Analysis System

PHASIM, RAP

Environmental Flow

Monitoring & Assessment
Impact Analysis on Discharge Variation

Reservoir Water Quality Model

RTMMS

Real-time Monitoring
Real-time Prediction

R T M M S

Turbidity, Temp, DO, pH, Conductivity
CDMA wireless Internet Network
Server
Temp & Turbidity Forecasting
Input Data Preparations
2D Simulations
Reservoir contaminant influx computation module

GIS based Basin water quality Temporal spatial DB

Realtime turbidity flux prediction system

River water quality evaluation system for reservoir operation

Thank you