# Remediation Plans for Organic Pollution in Bosten Lake (Postprint)

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**Date:** 2020-04-26T00:00:00+00:00

## Abstract

The hydrological condition of Bosten Lake, where the inflow and outflow outlets are overly close, imposes constraints on organic matter concentration and its spatial distribution. A two-dimensional hydrodynamic-water quality numerical model was constructed using MIKE21 software to analyze the effectiveness of engineering schemes in improving organic pollution in Bosten Lake. According to simulation results and paired-sample 〖WTBX〗T〖WTBZ〗test analysis: under current conditions, implementing either the eastward relocation of the pumping station or diverting 3×108 m3·a-1 of water from the Kaidu River into the Huangshui Gully can significantly improve organic pollution in Bosten Lake, with annual average chemical oxygen demand (COD) concentration reductions of 13.4% and 8.91%, respectively; simultaneous implementation of both schemes produces more pronounced effects, reducing the annual average COD concentration by 20.2%; improving organic pollution in Bosten Lake through engineering measures is feasible. However, at the watershed scale, the engineering schemes only alter the organic matter balance without changing the total quantity, and the improvement in Bosten Lake's organic pollution originates from the transfer of pollutants to the downstream Kongque River.

## Full Text

## Preamble

### Study on the Project of Reducing Organic Pollutants in the Bosten Lake

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**Abstract:** The contiguous river estuary and outfall influence the discharge of organic pollutants, which limit the concentration and spatial distribution of the organic pollutants in the Bosten Lake. Various projects should be conducted to optimize the current hydrological conditions. The MIKE 21 software was applied to establish a two-dimensional numerical model and analyze the effects of different intervention projects. According to the simulation results and the paired sample T-test results, the annual chemical oxygen demand concentration in the Bosten Lake could be reduced by 13.4% by moving the outfall from the southwest to the southeast, 8.91% by diverting $3\times10$ $m^3 \cdot a^{1}$ of the runoff from the Kaidu River to the Huangshuigou River, and 20.2% by implementing both these projects. The results denote that it is feasible to reduce the organic pollutants in the Bosten Lake by optimizing the hydrological conditions. However, these projects only changed the proportion of the organic pollutants in the Bosten Lake; they did not reduce the quantity of organic pollutants in the basin. The organic pollutants were diverted into the Kongque River downstream.

**Keywords:** Bosten Lake; organic pollutants; MIKE 21; chemical oxygen demand; hydrological condition

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# 2 MIKE 21 Model Setup

## 2.1 Study Area and Data Collection

The Bosten Lake water system is located between 86°19 -87°28 E and 41°46 -42°08 N in Xinjiang, China [Figure 1: see original paper]. The lake has a surface elevation of 1047.00 m, a surface area of 1064.1 $km^2$, a storage capacity of $73.03\times10$ $m^3$, an average depth of 7.5 m, and a maximum depth of 16 m. The lake exhibits typical temperate continental climate characteristics.

Hydrological and water quality data from 2013–2016 were used for model calibration and validation. This period included hydrological data, water level data, and water quality monitoring data for Bosten Lake [Figure 2: see original paper]. The data comprised: (1) daily inflow and outflow rates from the Kaidu River, Huangshuigou River, and other tributaries; (2) monthly water quality monitoring data including COD, BOD , and nutrient concentrations; and (3) meteorological data including wind speed, direction, and temperature. The water quality standard for Bosten Lake follows the Class III surface water environmental quality standard of China, with BOD limited to 2 $mg \cdot L^{1}$.

## 2.2 Computational Grid and Model Configuration

The MIKE 21 hydrodynamic model was used to simulate water flow and pollutant transport in Bosten Lake. The computational grid was constructed with a horizontal resolution of 50 m, covering the entire lake area with structured rectangular cells [Figure 2: see original paper]. The grid consisted of approximately 3,000 active cells.

The hydrodynamic module solves the depth-averaged Navier-Stokes equations:

$$\frac{\partial h\bar{v}}{\partial t} = fv\bar{h} - gh\frac{\partial \eta}{\partial x} + \frac{\partial}{\partial x}(hT_{xx}) + \frac{\partial}{\partial y}(hT_{xy}) + hu^2 S_f$$

$$\frac{\partial h\bar{v}^2}{\partial t} = -f\bar{v}h - gh\frac{\partial \eta}{\partial y} + \frac{\partial}{\partial x}(hT_{xy}) + \frac{\partial}{\partial y}(hT_{yy}) + hv^2 S_f$$

where $t$ is time; $u$ and $v$ are depth-averaged velocities in the $x$ and $y$ directions; $g$ is gravitational acceleration; $\eta$ is water surface elevation; $h$ is water depth; $f$ is the Coriolis parameter; $\rho$ is water density; $S_f$ is the friction term; and $\tau_{sx}$, $\tau_{sy}$, $\tau_{bx}$, $\tau_{by}$ represent wind shear stress and bottom shear stress components.

The advection-dispersion module solves the transport equation:

$$\frac{\partial h\bar{u}C}{\partial t} + \frac{\partial h\bar{v}C}{\partial t} = hF_c - hk_p\bar{C} + hC_s S_t \quad (4)$$

where $F_c$ is the source/sink term; $\bar{C}$ is the depth-averaged concentration; $S_t$ is the settling velocity; $k_p$ is the decay coefficient; and $C_s$ is the sediment concentration.

Model validation was performed using water level and COD concentration data from 2012-2016. Statistical metrics including Root Mean Square Error (RMSE) and Nash-Sutcliffe Efficiency (NSE) coefficient were calculated to evaluate model performance [Figure 3: see original paper].

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## 3 Simulation Scenarios and Results

### 3.1 Model Validation

The calibrated model achieved satisfactory performance with RMSE values within acceptable ranges and NSE coefficients exceeding 0.65 for both water level and COD simulations, indicating good agreement between simulated and observed values [22–23].

### 3.2 Scenario Design

Three intervention projects were designed to optimize hydrological conditions and reduce organic pollutant concentrations in Bosten Lake :

**Project 1 (BCE Optimization):** Relocating the outfall from the southwest to the southeast region of the lake to improve water exchange and reduce pollutant retention.

**Project 2 (BCD Diversion):** Diverting $3\times10$ $\mathrm{m}^3\cdot\mathrm{a}^{1}$ of runoff from the Kaidu River to the Huangshuigou River to alter the flow path and dilution pattern.

**Project 3 (Combined):** Implementing both the outfall relocation and flow diversion simultaneously.

Project design specifications

| Project | Description | Flow Diversion ($10$ $\mathrm{m}^3\cdot\mathrm{a}^{1}$) | Outfall Location |
|---|---|---|---|
| BCE Optimization | Outfall relocation only | 0 | Southeast |
| BCD Diversion | Flow diversion only | 3 | Southwest (original) |
| Combined | Both interventions | 3 | Southeast |

### 3.3 Simulation Results

The model simulated COD concentrations under each scenario for the period 2013–2016. Results showed significant spatial and temporal variations in COD distribution . The average COD concentration under baseline conditions was $22.05\pm1.19$ $\mathrm{mg}\cdot\mathrm{L}^{1}$. Project 1 reduced the average COD to $19.15\pm1.46$ $\mathrm{mg}\cdot\mathrm{L}^{1}$, Project 2 reduced it to $20.32\pm0.97$ $\mathrm{mg}\cdot\mathrm{L}^{1}$, and the combined project achieved the greatest reduction to $17.59\pm1.07$ $\mathrm{mg}\cdot\mathrm{L}^{1}$.

[Figure 4: see original paper] illustrates the spatial distribution of COD concentration improvements under the combined scenario, showing particularly notable reductions in the western and central regions of the lake.

### 3.4 Statistical Analysis

Paired sample T-tests were conducted to assess the significance of differences between scenarios. Results indicated statistically significant differences ($P < 0.05$) between all project scenarios and baseline conditions .

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## 4 Discussion and Conclusions

The simulation results demonstrate that optimizing hydrological conditions can effectively reduce COD concentrations in Bosten Lake. The combined project achieved a 20.2% reduction in annual average COD concentration, while individual projects yielded reductions of 13.4% (outfall relocation) and 8.91% (flow diversion). These improvements are statistically significant as confirmed by T-test results .

However, it is important to note that these projects primarily redistribute existing pollutants rather than reduce the total pollutant load entering the basin. The diverted organic pollutants from the Kaidu River are ultimately discharged into the downstream Kongque River, which may create new environmental challenges in that system.

The study confirms that MIKE 21 modeling is an effective tool for evaluating water quality management strategies in large lakes. Future work should consider: (1) long-term monitoring to validate model predictions under implemented projects; (2) assessment of ecological impacts on the Kongque River downstream; and (3) integration of pollutant source control measures to achieve actual load reductions rather than mere redistribution.

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[22–23] Additional references on model validation and water quality standards.

*Note: Figure translations are in progress. See original paper for figures.*