Dynamo water quality modelling for the Hsintien River, Taiwan

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Abstract

Considering mass balance in a river and using the principles of systems dynamics, a water quality model was formulated for the DO and BOD distributions in the Hsintien River in Taiwan. The simulated results were found to be acceptable regardless of simplified conditions on input data. A sensitivity analysis was also carried out and it revealed that flow rate, reoxygenation and deoxygenation coefficients had considerable influences on these distributions.

Notation

The following symbols are used in this paper.

A: river cross section area
ABDRB: auxiliary of BDRB
AODRB: auxiliary of ODRB
AODRF: auxiliary of ODRF
AOIR: auxiliary of OIR
AOIRD: auxiliary of OIRD
AOIRF: auxiliary of IORF
AOIRN: auxiliary of OIRN
ARWT: auxiliary of RWT
BDR: BOD decreasing rate
BDRB: BOD decreasing rate due to bacterial decomposition
BDRD: BOD decreasing rate due to dispersion
BDRF: BOD decreasing rate due to advective flow
BDRS: BOD decreasing rate due to settling out of BOD
BIR: BOD increasing rate
BIRC: BOD increasing rate by scouring
BIRD: BOD increasing rate by dispersion
BIRF: BOD increasing rate by advective flow
BIRR: BOD increasing fate by local runoff
BIRW: BOD increasing rate by waste discharge
BOD: Biochemical Oxygen Demand
BODN: initial condition of BOD
CD: coefficient of deoxygenation, i.e., Kl
CD20: value of CD at 20 °C
CR: coefficient of reaeration, i.e., K2
CR20: value of CR at 20 °C
CS: DO saturation concentration
CSET: coefficient of settling out of BOD, i.e., K3
DIS: distance (length) of the river section
DO: Dissolved Oxygen
DOO: DO concentration at the headwater
DOL: Dissolved Oxygen Level of the section
DON: initial condition of DO
DOW: DO concentration of wastewater
E: dispersion coefficient
Kl: coefficient of deoxygenation (i.e., CD)
K2: coefficient of reoxygenation (i.e., CR)
K3 coefficient of settling out of BOD (i.e., CSET)
K4 coefficient of areal demand of DO of bottom deposit
MAX: DYNAMO MAX function
ODR: oxygen decreasing rate
ODRB: oxygen decreasing rate due to carbonaceous bacterial oxidation
ODRD: oxygen decreasing rate due to dispersion
ODRE: oxygen decreasing rate due to bottom deposit
ODRF: oxygen decreasing rate due to advective flow
ODRN: oxygen decreasing rate due to nitrification
ODRR: oxygen decreasing rate due to respiration of plants
ODRW: oxygen decreasing rate by the input of waste loading
OIR: oxygen increasing rate
OIRD: oxygen increasing rate due to dispersion
OIRF: oxygen increasing rate due to advective flow
OIRN: oxygen increasing rate due to natural atmospheric reaeration
OIRP: oxygen increasing rate due to photosynthesis
Q: quantity of design flow of the river system
RBOD: BOD level in river
RBODO: river BOD concentration at the head water
RWT: river water temperature
STEP: DYNAMO STEP function
SWITCH: DYNAMO SWITCH function
T: step time of the wastewater discharge to the river
TM: time of water travelling
V: river flow velocity
VOL: volume of river water section
W: waste loadings
WQ: wastewater quantity

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Introduction

There is an increasing recognition that the health and well-being of man are becoming more dependent on the successful management of quality of the environment especially during the time of rapid growth of industrialization and urbanization. In order to manage this complex phenomenon, a system analysis approach to water quality management is needed to provide rational bases for making decisions on alternative courses of action. The optimum allocation of limited resources among competing activities by proper enforcement, and by reasoned analysis of the situation can significantly improve the water quality.

As defined by Gordon (1978), system simulation is a technique of solving problems by the observation of the performance over time, of a dynamic model of the system and the principal concern of a system dynamic study is to understand the forces