Simulation of Thermal Stratification and Dissolved Oxygen Concentrations Using Ce-Qual-W2 Model (Case Study: Shahid Rajaee Dam)

Pages 171-181

Pooneh Saeidi, Nasser Mehrdadi, Mojtaba Ardestani, Akbar Baghvand

Introduction: Due to shortage of fresh water resources, the quality of impounded water behind the dams become more important than how it was previously as a source of fresh water resource. Thermal regime and dissolved oxygen concentration are factors that affect the quality of water reservoirs. Many lakes show vertical stratification of their water masses, at least for some extended time periods. The atmosphere imposes a temperature signal on the lake surface. As a result, thermal stratification can be established during the warm season as a lake is sufficiently deep. On the contrary, during the cold period, surface coolingfo rces vertical circulation of water masses and removal of gradients in water properties. However, the gradients of dissolved substances like dissolved oxygen may be sustained for periods much longer than one annual cycle. In order to understand the annual cycle of temperature and dissolved oxygen in Shahid Rajaee Reservoir, Ce-Qual-W2 model was used. Study area Shahid Rajaee Reservoir Dam located over the Tajan River almost 40 km south of Sari, Mazandaran, Iran. Construction purposes of this dam is including water supply and regulation of for agricultural activities in Tajan lowland, potable water supply for the population within the plan area, industrial water supply, power generation, flood control, and prevention of the damage by flooding. The dam type is double curvature concrete arch dam and its height is about 133.5 m. reservoir volume is about 165 MCM and was constructed from 1987 until 1997.
Discussions: Shahid Rajaee reservoir dam is simulated using a two-dimensional, laterally averaged, hydrodynamic and water-quality model, CE-QUAL-W2. Hydrodynamics, temperature, and dissolved oxygen are simulated and then calibrated with observed data to verify accuracy. The input data used in this model are the best available and are assumed to be accurate representations of meteorology, flow, and water quality parameters. Meteorological data for the model include air and dew point temperature, wind speed, wind direction, and cloud cover observations and daily mean flow rates. These data are collected for a period from 2001 to 2011. Data for water quality parameters are taken from Mazandaran Water Company for the years from 2010 to 2011. When data are not available, statistical relationships was applied to supplement the water quality data. The hydrodynamic model built and calibrated for the years from 2001 to 2011. Then the model was used to simulate the thermal regime and dissolved oxygen concentrations for the period with two assumptions. The first assumption is continuation of current situation and the second is a 50% increase in water requirements. The bathymetric grid was generated using topographic maps in scale 1:100000. The water body was divided into 95 segments, and 45 layers. The segments have 50 meters length and all layers are 2 meters thick. The accuracy of the bathymetry data was checked using storage-capacity curves. The curves show reservoir storage at different reservoir elevations. The com parison of the model volume to the actual storage capacity is made to verify the accuracy of the model grid. Calibration data include temperature and DO concentrations measured at several monitoring sites taken at depth intervals of 1 to 15 meters from the water surface to the reservoir bottom.
Conclusions: The results indicate the thermal stratification in summer and vertical mixing in winter. This regime is predicted for the years from 2010 to 2014 in Fig. 1. Based on These results Shahid Rajaee Reservoir is in branch of warm Monomictic lake. Warm Monomictic lakes are lakes that never freeze, and are thermally stratified throughout much of the year. The density difference between the warm surface water (the epilimnion) and the colder bottom water (the hypolimnion) prevents these lakes from mixing in summer. During winter the surface water cool to a temperature equal to the bottom water. Lacking significant thermal stratification, these lakes mix thoroughly each winter from top to bottom. Dissolved oxygen modelling results showed that its concentration at reservoir bottom is zero when thermal stratification dominates. Dissolved oxygen concentration will be homogeneous at winter when thermal vertical mixing dominates. Winter Anaerobic conditions in the bottom of the reservoir are fading and the

reservoir is homogeneous in the vertical direction. Change in dissolved oxygen concentration is also predicted for the years from 2010 to 2014 in Fig. 2. The 50% increase in water requirement caused a decrease in water levels and water retention time in the reservoir. Besides this issue, 50% increase in duration of water requirement occurred in summer and the presence of anaerobic conditions decreased in the bottom of the reservoir.

CE, QUAL, W2 model, dissolved oxygen, Shahid Rajaee Reservoir Dam, temperature regime, twodimensional simulations