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EXTENDED ABSTRACT

Evaluation the Impacts of Causeway Remedial Actions on Urmia Lake Ecosystem Using Computational Fluid Dynamics and Spatial Analysis Method

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Causeway, Urmia Lake, Hydrodynamic modelling, Salinity distribution, Environmental impact assessment, Spatial analysis.

1. Introduction

Urmia Lake is the largest inland water body in Iran and the largest hyper-saline lake in the Middle East. In recent years, climate change, rainfall scarcity, increased cultivated areas in the related watershed, construction of dams and various other factors have all brought the lake's environment, hydraulic and water quality to critical condition (Zoljoodi and Didevarasl, 2014; Tourian et al., 2015; Fathian et al., 2016; Danesh-Yazdi and Ataie-Ashtiani, 2019). Moreover, the construction of the causeway has influenced the water flow in the lake, as a barrier to natural communication between the northern and southern parts. Changes in water flow conditions may affect water quality in two parts. Therefore, modeling of the lake water flow condition and its water level are crucial for identifying the problems. In the present study, the flow pattern and salinity distribution are simulated using a computational fluid dynamics model to investigate the hydrodynamic conditions and the impacts of causeway construction on Urmia Lake. Finally, to improve water exchange between the north and south parts, additional openings are proposed along the causeway. Then, the environmental impacts are evaluated for the preferred hydrodynamic modeling scenarios.

2. Methodology

2.1. Simulation of flow and salinity distribution in order to propose and evaluate the causeway remedial options

In this study, the MIKE3 Coupled model FM was used to perform simulations. A number of sensitivity analyses were performed to evaluate the effects of different modeling parameters on both hydrodynamic and salinity distribution results. The validity of the numerical model was assessed through comparing the results with previous measurements and studies done on the lake. Moreover, the effects of the causeway construction on temporal and spatial salinity distribution in the lake were investigated by performing one-year simulations.

2.2. Evaluation of flow regime in Urmia Lake with regard to remedial actions

Hydrodynamic modeling studies proved that water circulation patterns have been disturbed by the causeway construction. In this regard, additional openings are proposed along the causeway to improve flow circulation in the lake. The remedial alternatives are presented as openings of 500, 1000, 3000 and 4000 m

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and various combinations of them westward of the existing opening and flow regime is evaluated for each of the cases.

2.3. Environmental impact assessment of proposed remedial actions

In the present study, a spatial analysis method "map overlay" was used to evaluate possible improvements in the causeway that some remedial measures may provide. For this purpose, GIS maps of flow velocity and salinity distributions were generated using MIKE model outputs. Then, numerical outputs were converted to raster file and Digital Elevation Models (DEMs) were derived using ArcGIS software. Next, the raw DEMs were classified to compare options with a single scale. Finally, the model output was clipped to the boundary of the region and examined with the areas wildlife habitat sensitivity map. The target area was selected to evaluate the importance of high sensitivity areas and changes in flow velocity and salinity distribution were investigated in the area for the proposed remedial options.

3. Results and discussion

3.1. Evaluation of results related to simulation of the lake water salinity

In order to monitor the convergence of the advection-dispersion model, salinity simulations have been carried out for the 4-year period. Fig. 1 shows the comparison of lake water salinity at the end of the simulations for the two conditions, with and without the causeway. It is observed from the figure that the amount of water salinity has not changed significantly in the two conditions, and the exchange of water flow between the north and south parts has led to salinity exchange.

3.2. Environmental impact assessment using spatial analysis

The model outputs for evaluating changes in flow velocity and salinity distribution are visualized in Fig. 11. As seen in the figure, the proposed options do not have a significant effect on the salinity distribution in sensitive areas. On the other hand, the changes in the speed of water circulation occur more frequently at the openings. Since sensitive areas are far from the causeway, the increased velocity depreciates and does not continue to the areas. Therefore, the proposed additional openings in different scenarios will not differ much in terms of ecological impacts on the area.

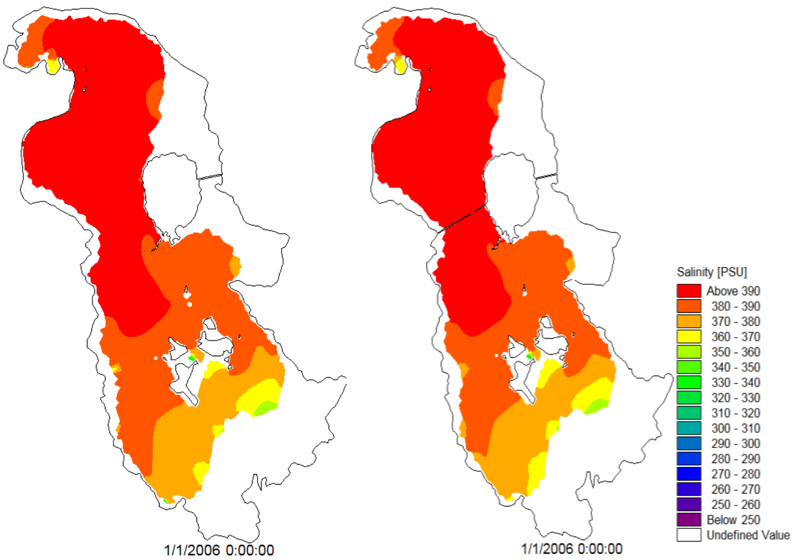

Fig. 1. Comparison of the lake water salinity at the end of simulations for two conditions, with and without the causeway

4. Conclusions

Simulation of flow and salinity distribution was performed in the lake for a one-year period. The results highlight that the water salinity of the lake does not change significantly in the two conditions and the temperature and salinity exchange occur between the north and south parts. Evaluation of time series of salinity variations in different parts of the lake during the simulation period indicated that the maximum salinity difference in both with and without the causeway is 3 PSU for the northern part and 10 PSU for the southern one. Assessment of model outputs for salinity patterns provided by the map overlay technique shows that the proposed options do not have a notable impact on the flow velocity and salinity distribution in sensitive areas.

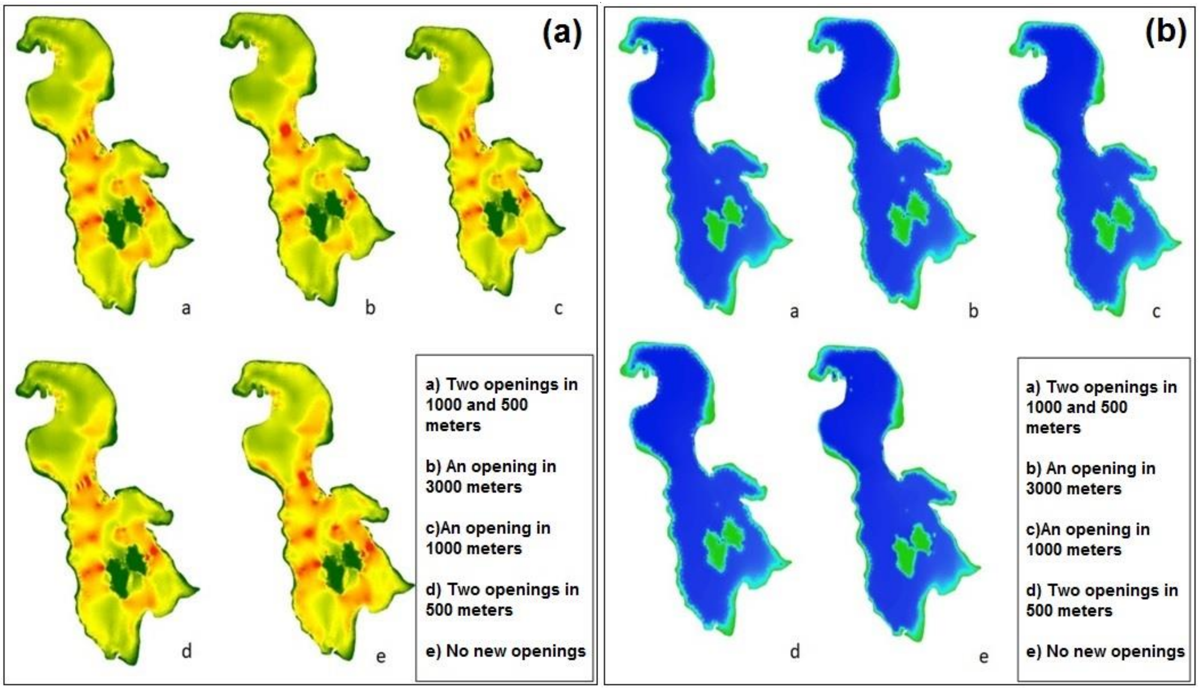

Fig. 2. Model of changes in: a) the speed of water circulation, b) salinity distribution in Urmia Lake as a result of additional openings construction (proposed options)

5. References

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