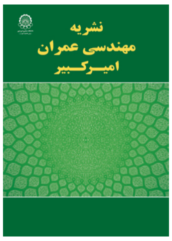

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Evaluation of Karun River Water Salinity Reduction Strategies Using Management Scenarios

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ABSTRACT: Karun River poses the largest and longest river of Iran that its water Salinity has been decreased in recent years owing to pollutant sources loading. The aim of this study is evaluating management practices to reduce river salinity in form of removal and reduction scenarios of point contaminant sources ranging from Mollasani to Farsiat (most critical range of population, industrial and agricultural density) using MIKE11 model. Reduction scenario results showed that the scenario of reducing from upstream boundary at the end of study area is influential on river salinity with the average reduction of 35.10 and 26.10% in wet and dry seasons, respectively. Results related to the simulation of combined options implied that the 52% reduction scenario from upstream boundary together with decreased point sources by 30% in both wet and dry seasons, respectively, with an average salinity of 60 and 46% outperform other options to reduce the river salinity. Comparing the results of premier scenarios with standard water salinity limits showed that in both wet and dry seasons, standard limit conditions connected with drinking and agricultural water could be met. The outcomes of this research demonstrate that rivers water quality can be increased by employing contaminant sources management strategies.

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1- Introduction

Increasing human population and the need to more food production has led to more pressure on water resources, especially rivers in the last century. So that, some rivers cannot play both roles of water supply and self-purification. Increased loading of contaminant sources to rivers through the development of agricultural, industrial and municipal activities have changed rivers water quality parameters. Salinity is one of the primary parameters for measuring water quality in rivers that shows concentration of the dissolved salts in water and its value increases through loading of point and non-point sources of pollution [1]. Management of river pollution is an important task in the planning and operation of water resources. Water quality management is an effort for protection and proper utilization of threatened and polluted water bodies [2-4]. River water quality simulation under different management scenarios facilitates reaching the river water quality to necessary standards, in addition to help in taking operational decisions and salinity control projects [5]. Thus, management practices should be simulated in the form of management scenarios before implementation and its performance should be evaluated, too [3].

Karun River salinity has increased in recent years due to the different pollutant sources loading, so that the salinity of the river has become an environmental problem. Literature reviews carried out in the field of simulation and management of pollutant sources loading indicated that depending on the circumstances of each rive, different management strategies are available to improve water quality. The aim of this research is evaluating management practices to reduce Karun River salinity under different removal and reduction scenarios of point contaminant sources within Mollasani to Farsiat using MIKE11 model.

2- Materials and Methods

2- 1- Study Area

Karun River is the most watery and the longest river of Iran with a length of about 900 km that is located in the south west of Iran [6]. Agricultural, municipal and industrial effluents entering the river have increased water salinity [7]. The study area is 105 km of this river, between Mollasani and Farsiat stations and major cities such as Mollasani, Weiss, Shiban and Ahvaz are located in its vicinity and the location of water withdrawal from hundreds of hectares of agricultural land and sugarcane industries are located at its end. The average of 10-

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year discharge of the river (2005-2014) in Ahvaz hydrometric station during wet seasons (Dec-May) is 543 m^3/s and in contrast average discharge of the river decreases during dry seasons (Jun-Nov) and is 330 m^3/s.

2- 2- Numerical model

MIKE11, which is developed by the Danish Hydraulic Institute (DHI), is a tool one-dimensional for modeling conditions in rivers, lakes, reservoirs, irrigation canals and other inland water system [8]. In order to investigate the variations in salinity distribution along the river, hydrodynamic module (HD) coupled with advection–dispersion module (AD) has been applied in this study.

The HD, based on the dynamic wave description, solves the vertically integrated equations of conservation of continuity and momentum (Saint-Venant Equation), as defined in Eqsuations 1 and 2. HD module solves continuity and momentum equations based on dynamic wave and in the form of implicit finite difference.

$$\frac{\partial q}{\partial x}+\frac{\partial A}{\partial t}=q \qquad (1)$$

$$\frac{\partial Q}{\partial fi}+\frac{\partial\left(a'\frac{Q^2}{A}\right)}{\partial x}+gA\frac{\partial h}{\partial x}+gAI_f=\frac{f}{w} \qquad (2)$$

Where Q is the river discharge rate, A is the cross-sectional area, q is lateral inflow, h denotes water level, If represents the flow resistance term, “f” is the momentum forcing, “pw” is the density of homogeneous water, “g” is the acceleration due to gravity and “a” is the momentum distribution coefficient [8]. The AD applies the integrated equation of mass conservation of a dissolved or suspended material. The equation is defined as follows;

$$\frac{\partial AC}{\partial t}+\frac{\partial QC}{\partial x}-\frac{\partial}{\partial x}\left(AD\frac{\partial C}{\partial x}\right)=-AKC+C_2q \qquad (3)$$

In which “C” is the salinity/suspended material concentration, “D” is the dispersion coefficient, “K” is the linear decay coefficient, “C2” represents source/sink concentration of the substance. Equation 3 assumes that the considered substance is completely mixed over the cross-sections and reflects two transport mechanisms: (1) advective transport is with the mean flow; and (2) dispersive transport is due to concentration gradients [8].

2- 3- Model calibrations

In this study, Manning’s n was used to represent the bed resistance. According to the previous studies, the river length was separated to three reaches (0-30, 30-70 and 70-105 km) for calibration of this coefficient and Manning’s n varied from 0.025 to 0.05 using 0.005 steps [9, 10]. Dispersion coefficient was calculated from empirical relations, and then was calibrated in the model using two values of 0 and 1 for b. Calibration results showed that the model presents better results when Manning’s coefficients of 0.032, 0.037 and 0.035 are used for reaches of 0-30, 30-70 and 70-105 km, respectively. Simulated and measured water surfaces were compared using Manning’s coefficients of 0.032, 0.037 and 0.035 at km 105 (Farsiat station) (Figure 1). Totally, simulated and measured water surfaces at Farsiat station were in good agreement (R^2=0.92). RMSE[1] and NRMSE[2] between simulated and measured water surface were obtained 0.16 m and 4.11%, respectively.

The results of dispersion coefficient calibration, based on simulation with the measured salinity concentration in 2011 at Farsiat station showed that Kashefipour and Falconer relationship [11] in the case of a=179.22 and b=1 with RMSE and NRMSE equals to 32.14 us/cm and 8.93%, respectively, carry out better simulation and also R^2 value of 0.93 was obtained for the agreement of average simulated and measured salinity.

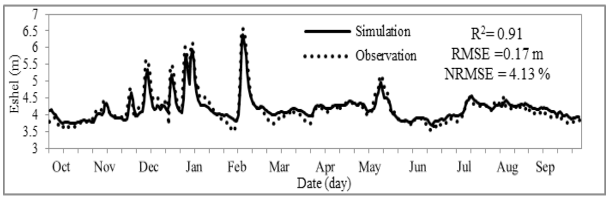

Figure 1. Comparison of the simulated and measured daily-averaged water levels at Farsiat Station

3- Results and Discussion

After simulation of each removal and reduction of point contaminant sources loading, results were evaluated in comparison to the existing condition (salinity in the year 2014) in the form of percent reduction of river salinity.

3- 1- Removal of pollutants

Percent reduction in river salinity due to the removal of pollutant sources is indicated in Table 1. Percent reduction of river water salinity due to the application of removal of all pollutant sources scenario, at 60 km (Ahvaz station) is 6.79% and 8.25% for both wet and dry seasons, respectively. While, at the end of the study area with increasing point sources of pollution for both wet and dry season will reach to 16.27 and 20.12 %, respectively. However, removal of all pollutant sources in the dry season is more effective in reducing river salinity than wet season. In the dry seasons, 1) river flow decreases and 2) loading of pollutant sources, especially water drainage from the farms increases. Thus, removing them will improve river water quality [12].

3- 2- Reduction of pollutant sources

Results of river salinity reduction due to each reduction options are presented in Table 2. Results showed that the effect of both options of reducing point source and reducing from upstream on river water salinity reduction is more in wet season relative to the dry season. So that, the maximum average of salinity reduction at Ahvaz station (km 60) in wet season will be 39.12%, while this value will reach to 28.70 % in the dry season.

In the reducing point sources of pollution scenario the same as removal scenario, effect of reducing point sources on river salinity reduction was low, while the effect of reduction scenario from upstream boundary with average reduction of 35.83 and 26.10 in the wet and dry season, respectively,

1 Root Mean Square Error (RMSE)
2 Normalized Root Mean Square Error (NRMSE)

at the end of study area (Farsiat station) was better. Thus, management of pollutant sources from upstream entrance boundary is more necessary. Such as management of salinity of Gotvand dam reservoir, effluent of irrigation networks and agro-industry.

Results related to the simulation of each combined options indicated that in both wet and dry seasons, DP1 and DU4 scenarios (60% reduction of upstream salinity +30% reduction of point sources) have better performance in reducing river salinity. So that, this scenario has caused river salinity to decrease more than 60% and 46% in wet and dry seasons, respectively Table 3. Results indicated that importance of pollutant sources management at upstream is considerable for reducing salinity in the study area.

Table 1. Percent reduction of river salinity due to the removal of pollutant sources scenario

Management scenarios		Percent reduction relative to the (%) existing condition			
		Ahvaz Station		Farsiat Station	
		Wet season	Dry season	Wet season	Dry season
Removal of point sources	removal of all	6.79	8.25	16.27	20.13
	removal of agricultures	3.06	4.97	5.61	10.66
	removal of sewages	2.48	1.05	6.99	6.65
	removal of Industrials	3.79	1.60	3.72	1.64
	Average	4.04	3.97	8.15	9.77

Table 2. Percent reduction of river salinity due to the reduction of pollutant sources scenario

Management scenarios		Percent reduction relative to the (%) existing condition			
		Ahvaz Station		Farsiat Station	
		Wet season	Dry season	Wet season	Dry season
Reduce point source	30%	4.11	3.21	10.40	9.41
	50%	5.86	5.67	14.11	14.98
	Average	4.98	4.44	12.26	12.19
Reduction of upstream	8%	10.01	6.95	9.12	6.33
	25%	31.89	23.22	29.18	21.12
	43%	47.85	35.24	43.82	32.04
	60%	66.79	49.39	61.20	44.90
	Average	39.12	28.70	35.83	26.10

Table 3. Percent reduction of river salinity due to combined scenarios

Management scenarios		(%) Percent reduction relative to the existing condition			
		Ahvaz Station		Farsiat Station	
		Wet season	Dry season	Wet season	Dry season
Combined scenarios	DU3+DP2	51.49	39.35	54.97	41.98
	DU4+DP1	67.92	51.61	67.41	52.51
	Average	59.71	45.48	61.19	47.25

4- Conclusions

In this research, different management scenarios including removal of pollutant sources, reduction from upstream entrance boundary, reduction of point sources and combination of superior options were simulated using MIKE11. Simulation results of different management scenarios indicated that effect of different options of removal of pollutant sources on reducing river salinity is different during dry and wet seasons. Results related to the removal of all pollutant sources along the river showed that effect of this scenario is more during the dry season than the wet season.

Reduction scenario of pollutant sources from upstream boundary has the most effect on reducing river salinity between different scenarios, especially during wet season. Thus, management of pollutant sources from upstream in the form of reduction or lack of pollutant sources loading such as salinity of Gotvand dam reservoir, effluent of Gotvand and Aghili irrigation network, Shoaibeh and Karun agro-industry, effluent of Gotvand and Shooshtar cities is necessary.

Simulation results of combined scenario indicated that combination of salinity reduction from upstream with reduction of point sources of pollution has the best performance in reducing salinity along the river. Between combined scenarios, scenario of the 30% reduction of point sources with 60% reduction from upstream has the most effect in reducing river salinity. Comparison of the results of this scenario with allowable limits of salinity indicated that it has desirable standard limit condition for drinking and agricultural water, in both wet and dry seasons.

References

[1] N.W. Quinn, Adaptive implementation of information technology for real-time, basin-scale salinity management in the San Joaquin Basin, USA and Hunter River Basin, Australia, Agricultural water management, 98(6) (2011) 930-940.

[2] L. Somlyódy, M. Henze, L. Koncsos, W. Rauch, P. Reichert, P. Shanahan, P. Vanrolleghem, River Water Quality Modelling: III. Future of the Art, Water Science and Technology, 38(11) (1998) 253-260.

[3] Q.T. Doan, Y. C. Chen, P. K. Mishra, Numerical Modeling in Water Quality Management for Rivers Case Study of the Day/ Nhue River Sub-basin, Vietnam, Journal of Earth Sciences and Engineering, 6(5) (2013) 1111-1119.

[4] G.B. McBride, Calculating stream reaeration coefficients from oxygen profiles, Journal of Environmental Engineering, 128(4) (2002) 384-386.

[5] R. Prairie James, B. Rajagopalan, J. Fulp Terrance, A. Zagona Edith, Statistical Nonparametric Model for Natural Salt Estimation, Journal of Environmental Engineering, 131(1) (2005) 130-138.

[6] M. Afkhami, M. Shariat, N. Jafarzadeh, H. Ghadiri, R. Nabizadeh, Developing a water quality management model for Karun and Dez Rivers, Environmental Health Science and Engineering, 4(2) (2007) 99-106.

[7] H. Ghadiri, Salinization of Karun River in Iran by Shallow Groundwater and Seawater Encroachment, Advances in Hydro-Science and Engineering, 4 (2016) 1-9.

[8] Danish Hydraulic Institute (DHI), MIKE11 a modeling system for rivers and channels, Reference Manual, 2009

[9] A. Roshanfekr, S. Kashefipour, N. Jafarzadeh, Numerical modelling of heavy metals for riverine systems using a new approach to the source term in the ADE, Hydroinformatics, 10(3) (2008) 245- 255

[10] S. Mohammadi, S.M. Kashefipour, Numerical modeling of flow in riverine basins using an improved dynamic roughness coefficient, Water resources, 41(4) (2014) 412-420.

[11] S.M. Kashefipour, R.A. Falconer, Longitudinal dispersion coefficients in natural channels, Water Research, 36(6) (2002) 1596-1608.

[12] E. Farber, A. Vengosh, I. Gavrieli, A. Marie, T.D. Bullen, B. Mayer, R. Holtzman, M. Segal, U. Shavit, Management scenarios for the Jordan River salinity crisis, Applied Geochemistry, 20(11) (2005) 2138-2153.

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