

Water exploitation of Karoon River for fish culturing through monitoring and simulation systems

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Abstract

Heavy metal pollution dispersion simulation in rivers and predicting spatial and temporal variations of pollutants can be used to determine the precise place and to schedule water withdrawal time for drinking, agriculture, aquaculture and ecosystem studies. To study the movement of heavy metal pollution through Karoon flow model, MIKE 11 was employed for simulation of the flow model of Karoon River as well as heavy metal moving. The model was run for lead along the 214 km of Karoon River from Ahwaz to Darkhvein. The input data used for this model were river morphology parameters, statistical data of water flow and water contamination. The output of the model conformed to real data collected from different locations along the River. It was concluded that Karoon River water exploitation for fish culturing (e.g., salmon culture) should be at least 40 km far from Ahwaz (close to Bayoz City) from July to December and 20 km for the rest of the year.

Keywords: Pollution, heavy metals, fish, lead, Karoon River, Iran

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Introduction

The surface waters are one of the best resources of water for aquaculture industry, however, development in technology and population increase have caused heavy contamination in these valuable resources which prevents to use them now or in near future (Karamooz, 2005; International standards for drinking water, 1971). Karoon River, one of the most important hydraulic flows of Iran, affected by intense physical, chemical and biological revolution after entering to Khuzestan Province. This river is vital for drinking, industrials and agricultures necessities (Diagomanolin *et al.*, 2004). On the other hand, a large amount of agricultural and industrial waste waters enter the river. These swages contain pollution agents, such as heavy metals and chemical complexes which in turn result into significant decrease in water quality of the river (Afkhami, 2002; Kabi *et al.*, 2002).

There are twenty three factories such as piping factory and metal beam, next to the Karoon River and most of them are near Ahwaz. They release their sewages, containing toxic heavy metals, directly into Karoon. Therefore, this river receives a large amount of lead containing wastewater (Esmaili Sari Imandel, 2000; Rauret *et al.*, 2000; Poorghaemi & Rostami, 2005;). Lead is known as one of the most toxic heavy metals on earth. 30 µg/dL lead can cause nervous system disorder while 30-100 µg/dL will result to sever problems in nervous system, kidneys, reproductive systems and anemia (Johnsen *et al.*, 2000). In aquatic environments, lead is

concentrated in bed sediment (Endo *et al.*, 2004). The solubility of lead depends on water pH and calcium and magnesium concentrations (increase of calcium and magnesium concentration will result to decrease in lead toxicity in water). In fish, lead mostly affects kidney, gill, liver and mussels. The gill epithelium and the fish death are the most common signs of high toxicity with lead due to interruption in oxygen exchange. The other signs of lead toxicity include sever damages of white and red blood cells and nervous system (Johansen *et al.*, 2000). Using simulation software (MIKE 11), Karoon River flows (Ahwaz-Darkhoein limitation) were studied in this paper. In this model, the decay and dispersion coefficients of lead were recorded after verification by experimental data. The heavy metals toxicity changes with water chemical and physical changes, such as saltness, dissolve oxygen, water hardness, temperature etc. The water hardness decreases the poisoning of heavy metals (Kashefipour *et al.*, 2006).

Materials and methods

In the present study, distribution of lead was simulated in Karoon River using MIKE 11 software and the rate of distribution was distinguished along the river. The data was collected from local laboratories. Data were entered as input time series (Kashefipour *et al.*, 2006). The advection diffusion and decay factor were determined according to pH and suspended solids of water (Abernathy *et al.*, 1984). These coefficients verified and calibrated with the real results from the laboratories. The lead simulated

during 2004-2005 and 2005-2006. Finally, the plan of water withdrawal time and place were proposed based on the results of the software.

Discharge of Karoon River during 2004-2005 was entered to software as a model boundary condition (Fig. 1).

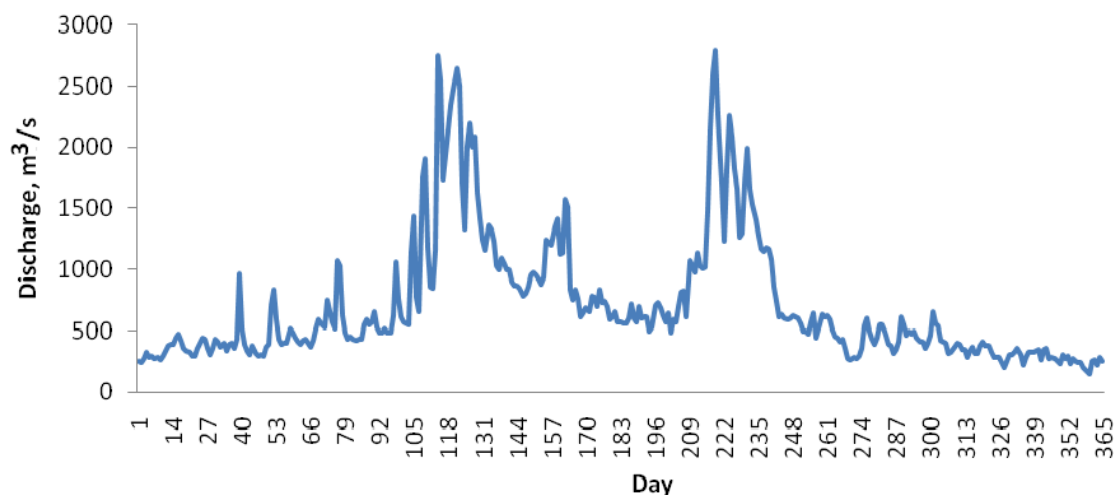


Figure 1: Karoon River discharge in Molasani station in the present study

As there are several metal factories in upstream of the river, a high amount of heavy metal contaminants enter to the river. In order to determine the effect of boundary condition, the pollution statistics were

accumulated from initial point, i.e. Three different heavy metal changes have been demonstrated during 2003 to 2007 (Fig. 2) (Kabi *et al.*, 2002; Diagonanolin *et al.*, 2004).

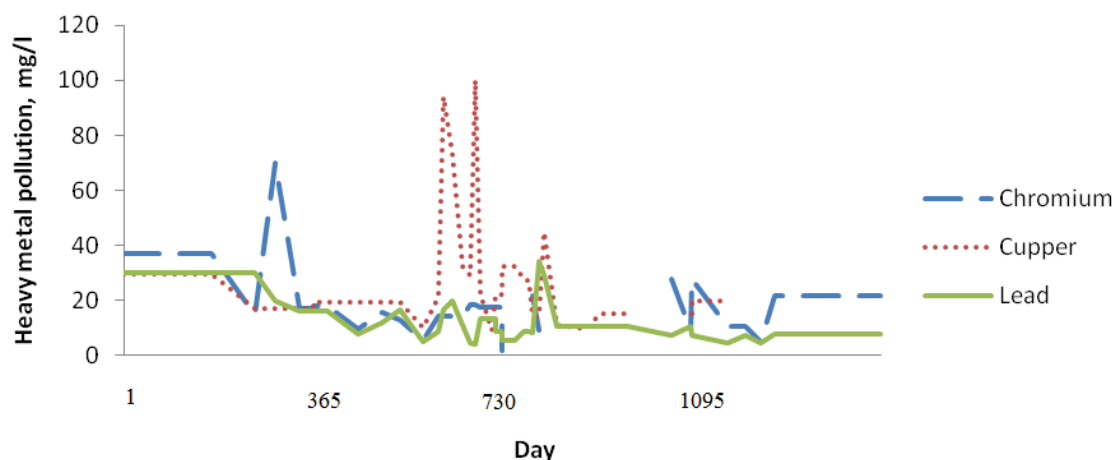


Figure 2: Heavy metal variation from 2003 up to 2007 in Molasani station

Coefficients of simulation model

Given the presence of high pollution in Karoon River (e.g., salts, heavy metals, sediments and other contaminants) and the adverse impact of these pollutant (e.g.,

diffusion, dispersion and decays), a hydrodynamic advection dispersion unsteady model were used.

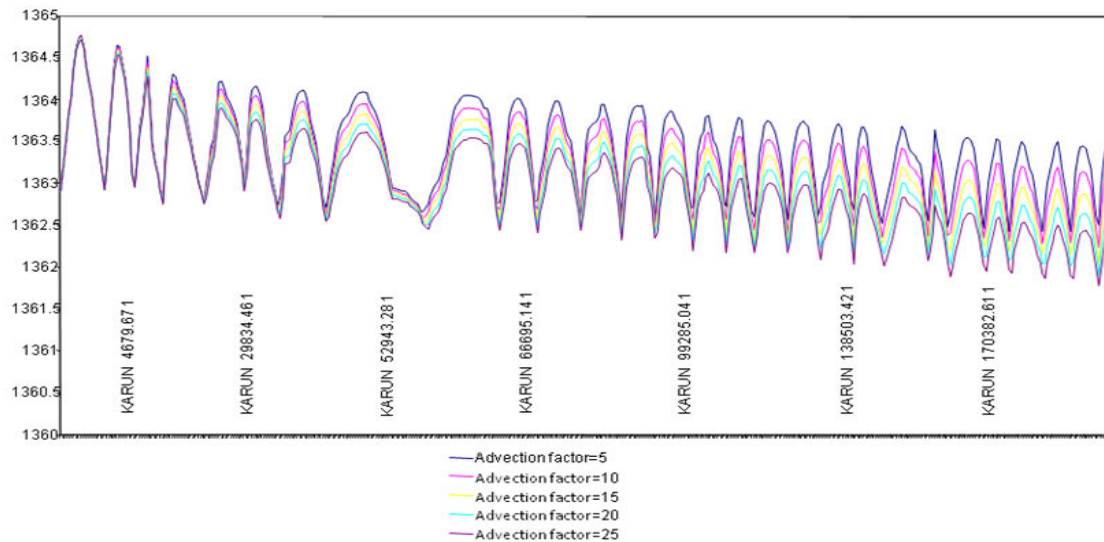


Figure 3: Comparison between different advections coefficient during a year along the Karoon River

In this research five decay factors were chosen, including:

- 1- Zero decay coefficient (permanent material)
- 2- Constant decay coefficient
- 3- Unsteady decay coefficient depends on PH
- 4- Unsteady decay coefficient depends on EC

- 5- Unsteady decay coefficient depends on PH & EC

To determine the correct decay coefficient for lead heavy metal, the model was run for all five decay coefficients (Roshanfekar, 2000). the results proposed in the following chart:

Table 1: Different decay coefficients for lead

Kind of Decay factor	Decay factor equation
Zero decay factor (permanent material)Conservative	$\kappa=0$ or $S_i^d=0$
Constant decay factor	$\kappa=Const.$
Unsteady decay factor depends on PH	$\kappa=-0.1646 \times pH + 1.4934$
Unsteady decay factor depends on EC	$\kappa=-0.00023 \times EC + 0.581$
Unsteady decay factor depends on PH & EC	$\kappa=0.160 \times pH - 0.000402 \times EC - 0.401$

In this table pH and EC are the rates of water acidity and electric conductivity in river water in Molasani station, respectively. By water pollution modeling in small distance, the internal and external pollution sources which are under the control and comparison between the entrance and extranets static's, will be available. According to the pH and suspected materials of Karoon (such as salt), it seems the last formula

($k = f(pH, EC)$) is the best one, based on which the range of this coefficient for lead is 0.11 to 0.44 (Roshanfekar, 2000). As shown in Fig. 2, when the decay coefficient is defined to 0.23, lead changes simulation in 10 kilometer down from source point is the same as experimental results and the model and experimental results has a good cover with each other. So this verified decay coefficient ($k=0.23$) can be used in lead dispersion modeling in Karoon River.

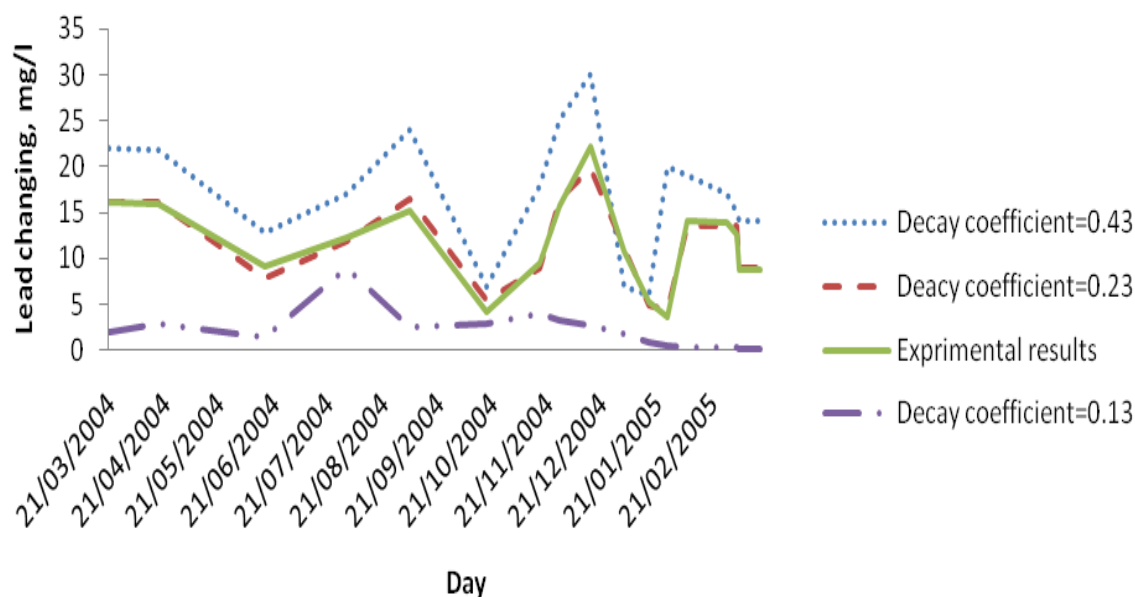


Figure 4: Comparison between different decay coefficients in a year with experimental data in 10 kilometer down from source

Running the model

Karoon hydrodynamic modeling between Ahwaz to Darkhoein was carried out with 307 points with specific geographical length and width and the hydrodynamic model has 200 vertical profiles that link on points (Rauret *et al.*, 2000). Solving model chooses as Hydrodynamic and advection diffusion model, the accessible files were introduced to software. These files were

known as river shape file (plane and vertical profiles), boundary condition files and initial condition files and at last advection and diffusion files.

Results

Based on the verification and calibration coefficients, the lead dispersion was simulated between 2004-2005 and 2005-2006 in limitation of Karoon River from

Ahwaz to Darkhoien. The internal data of this heavy metal in source was shown in Figs 5 to 8, and after running the model, the

specified heavy metal changes were shown in 10, 40 and 20 and 40 kilometers down from source (Figs 7 to 10, respectively).

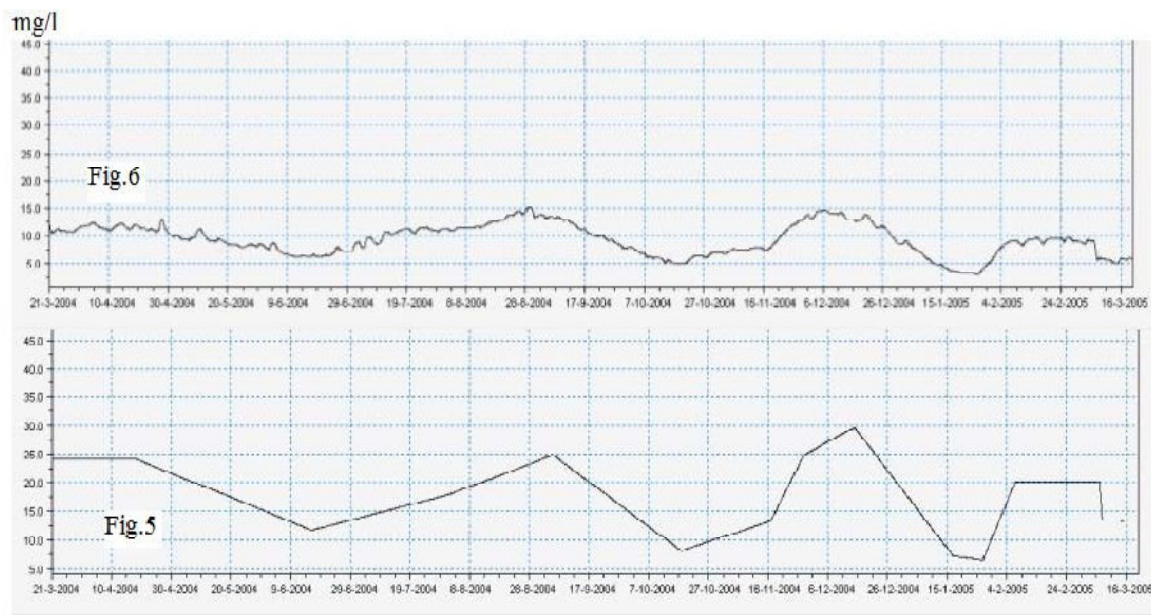


Figure 5: Lead value in source (experimental data)

Figure 6: Lead value in 10 kilometer down rom source

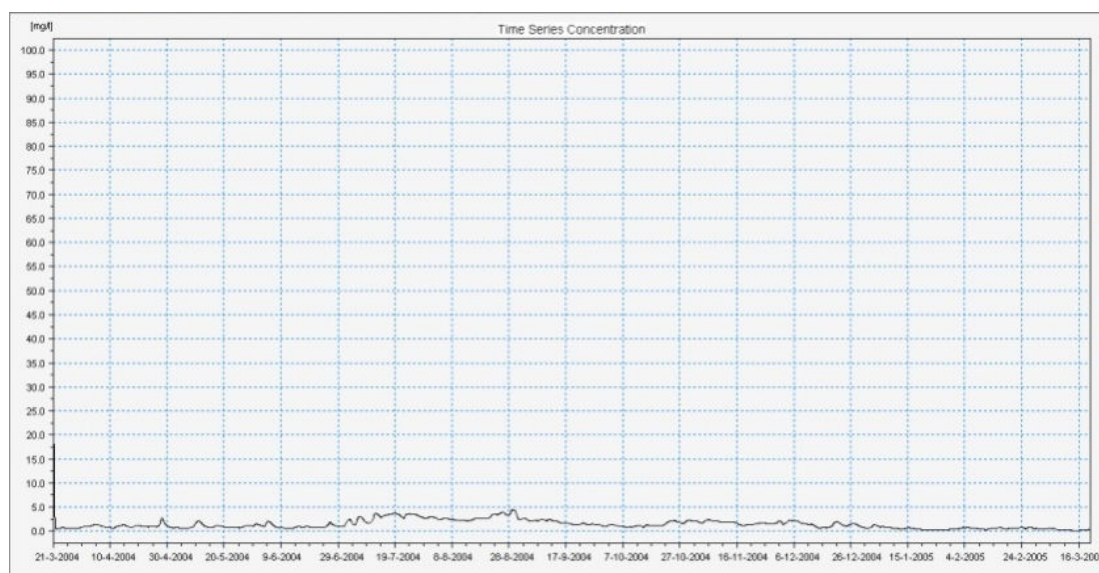


Figure 7: Lead value in 40 kilometer down from source

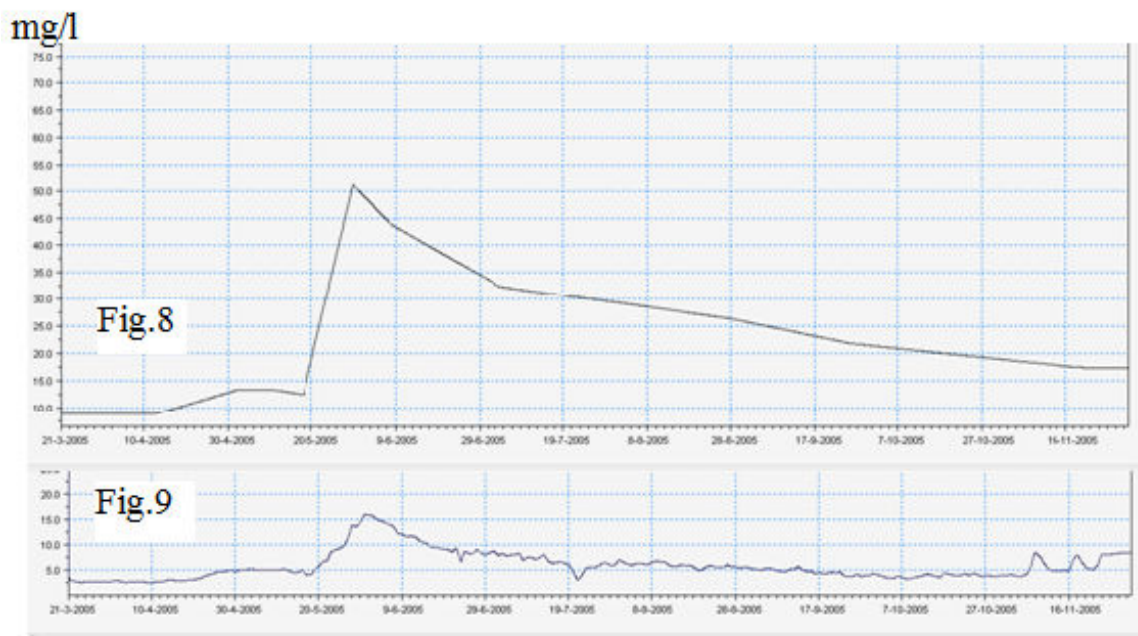


Figure 8: Lead value in source (experimental data)

Figure 9: Lead value in 20 kilometer down from source

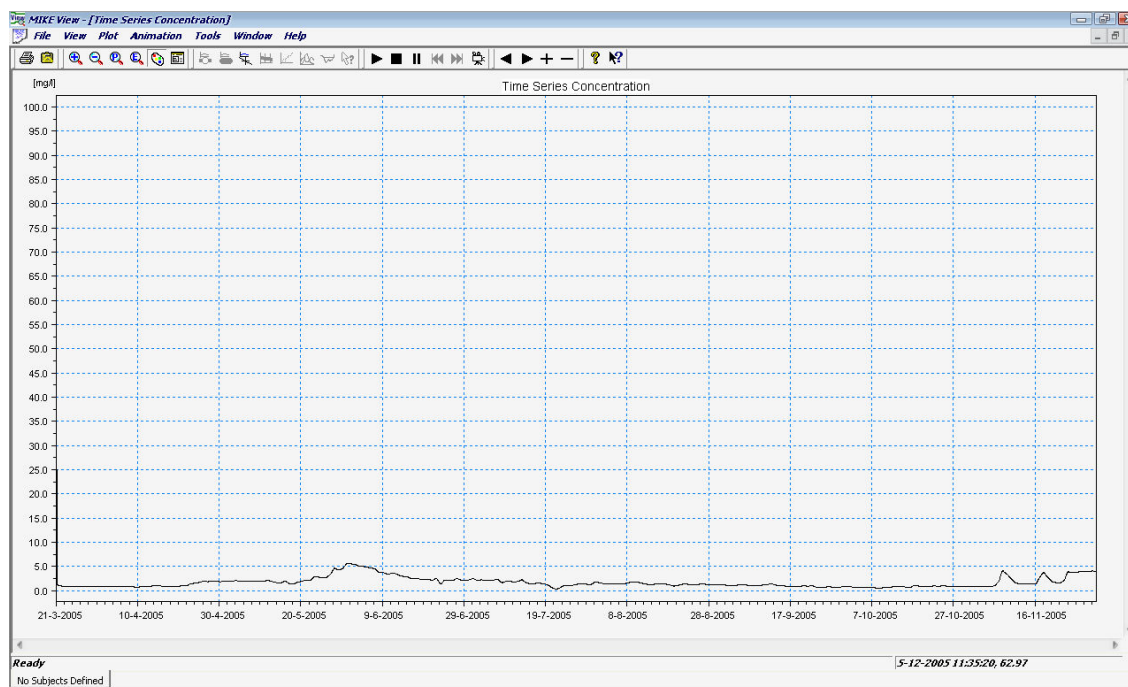


Figure 10: Lead value in 40 kilometer down from source

Discussion

In variation of heavy metal, toxicity along the Karoon River is affected by two basic parameters: the volume of water contaminants and the range of discharge variation during a year and also dispersion, advection and decay coefficients of river. The hydraulic dispersion simulator model with correction of coefficients and their interactions is a new simulator for Karoon River modeling and its pollutions. According to standards of organizations and health companies such as WHO and EPA, the permissible value of lead in drinking water must be less than 0.01 milligram per liter and the permissible value of lead for fish culture in warm water must be less than 10 milligram per liter (Roberts, 2001). Therefore, it seems water withdrawal of Karoon at least up to 40 kilometer down from Ahvaz (about Bayoz) for fish culture is possible during a year. This distance can be reduced by specific management and engineering methods applying such as withdrawal from wells. In addition, this recent model can work as intelligent alerting system. The model conducted for a year using experimental pollution and discharge data. This model can simulate the hydraulic situation (discharge and depth) of the longest Iranian river. This model also helps to define the rate of dissolve materials such as EC, TDS and all kinds of heavy metals such as: Aluminum, Iron, Nickel, Copper, Zinc, Arsenic, Cadmium, Chromium, Mercury and Lead in different times and places. According to the results of the present study, it could be possible to suggest a time and the place of water

withdrawal from Karoon River for different aims such as: fish culture, drinking, agriculture and etc. Also, repetition of such a study may result to make a managing plan for monitoring the Karoon pollution. When solid materials enter to an aquatic system (one dimensional), it could be propagated in two ways: dispersion and advection. In a one dimensional system, the effects of pollution dispersion are resulted from the system forced to a problem (like the effects of water velocity). It means that the water movement in river may cause to moving of suspension materials along the river. On the other hand, molecular and internal interaction of water molecules and pollution molecules and also effects of saltiness, heat, turbulence and density variation, could resulted to materials advection in a system. These situations are intensively engaged with water status, suspected materials and river position (Rauret *et al.*, 2000). The effects of advection are remarkable in deep water or waters with high turbulence or static waters (water with less movement). So in a system like a Karoon River that water moves with high speed, the effects of advection are negligible which is shown in the figure 1. Regarding to sensitivity of analyses which runs on model and the effects of DHI recommendations, it seems better to contemplate the dispersion factor equal to 70. As shown in the Figs1-3, different advection coefficient did not have any significant impact on pollution propagation in Karoon River. The decay coefficient is the range of increase or decreases of specific pollution in the way of river that is one of the most important

parameters in advection-diffusion equation for heavy metal distribution modeling.

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References

- Abernathy, A. R., Larson, G.L. Mathews, R.C., 1984.** Heavy metal in the surface sediment of Fontana lake, North Carolina, waters, 18 (3) 351-354.
- Afkhami M, 2002.** Karoon river groundwater and surface water pollution relation at Ahvaz city, 2nd International Conference on water resources and environmental research, Dresden University, Germany. USA, pp 844.
- Diagomanolin, V., Farhang, M., Ghazi-Khansari, M., and Jafarzadeh, N., 2004.** Heavy metals (Ni, Cr, Cu) in the Karoon waterway river, Iran, Toxicology Letters, 151, 63-68.
- Endo, T.; Haraguchi, K. Cipriano, F. Simmonds, M.P. Hotta, Y. and Sakata M., 2004.** Contamination by mercury and cadmium in the cetacean products from Japanese market. Chemosphere. 54 (11): 1653-1662.
- Esmaili Sari, A. & Imandel, 2000.** Inspection of heavy metals in Persian Gulf, 4th conference of engineering chemical, Iran. International standard s for drinking water, 1971. World Health Organization, 3rd ed. Geneva.
- Johansen, P.; Pars, T. and Bjerregaard, P., 2000.** Lead, cadmium, mercury and selenium intake by Greenlanders from local marine food. Science of total Environment, 245: 187-94
- Kabi H., Rafizade M. and Jafarzade N., 2002.** Determining the self-refining of Karoon River for zinc and cadmium heavy metal, the 6th international river engineering seminar, Chamran university, Ahvaz, Iran. (In Persian)
- Karamooz, 2005.** [General patterns for water pollution decrease in Iran.] Water Resources Research, 1, 43-51. (In Persian)
- Kashefipour, S.M., Lin, B., and Falconer, R.A.,(2006).** Modeling the fate of facial indicators in a coastal basin. Journal of Water Research, 40: 1413-1425.
- Poorghaemi, Rostami, 2005.** Defining the rate of copper and lead in dirking water of Tehran, Environmental journal, 36, 27- 32.
- Rauret, G. Rub. V, R. Lopez-Sanches, J.F. 2000.** Determination and Speciation of Copper and Lead in sediment of Mediteranean Rive , river tons, Catalonia.
- Roberts, R.J, 2001.** Fish pathology (3 ed). W.B Sawnders. Harcornt publishers Co. LTD. London, England. 472P.