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Investigation of Seasonal Self-purification Variations of Karun River, Iran

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ABSTRACT: Evaluation of a river self-purification capacity provides required information for a sustainable management of the river receiving pollutants. The main target of this paper is to study and predict the seasonal variation of self-purification capacity of Karun River, IRAN. Dissolved oxygen (DO), BOD, nitrate and pathogens were the main quality parameters, which were considered in this paper. To achieve this aim, a length of 113 km of the river was simulated using QUAL2Kw model and calibrated and verified using field measured data in 2010. The above mentioned datasets were used also to determine the critical periods of self-purification phenomenon, involving the model for BOD, nitrate and pathogen parameters. Furthermore, three scenarios were supposed and considered, including, 30% reduction in the waste waters flow, increasing the river monthly flow by 30% and finally decrement of the waste waters concentrations by 30%. The above mentioned scenarios were assumed in order to enhance the water quality of the river, during the months with no standard limits. Results indicated that, the decrease of nitrate in January and February and the decrease of BOD for all month except October up to 30 %, have had the most positive effects on river water quality. The 30% decrease of waste waters flow rate containing pathogens had the most positive effects on the river water quality.

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1- Introduction

Different rivers' sustainable pollutant charge limit differs by temporal and local factors as well as type and intensity of pollutions inside river. Complicated relations between pollution charges and water quality can be defined well by using mathematical models. This study aims to investigate the qualitative parameters like DO, [1]BOD, nitrate, pathogen and seasonal changes of these parameters and critical periods of DO, BOD, nitrate and pathogen self-purification at first and secondly investigate quality of in use water by means of simulation results and aims to present some possible expected scenarios for improving river water quality in situations where water usage standards are not satisfied.

2- Materials and Methods

2- 1- Case Study

Figure. 1 shows the studied area. In the present research the sub-basin water quality is studied through the river network and four hydrometric stations. In Karun River's main branch from Shatit River till Ahvaz after join of two sub-branches in forty first kilometer of the river, point pollutions load have increased pollution of the river and decreased DO.

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1 Biochemical oxygen demand

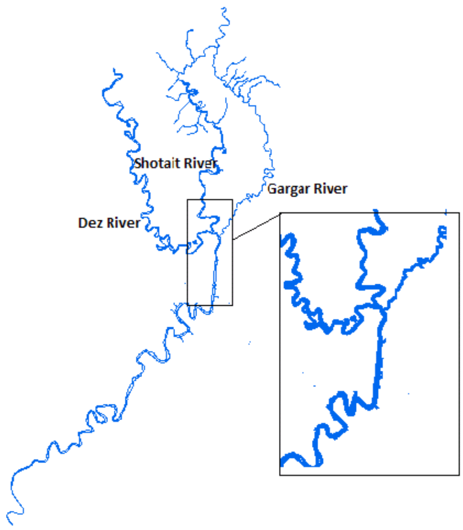

Figure 1. Case study location

2- 2- Modelling Tools

QUAL2K is capable of simulating 15 water quality parameters and solving advection-dispersion relationship in river with the means of numerical method [1-3]

2- 3- Research Method

According to existing hydrometric stations, Karun River's area was divided into four regions and each region's cross section properties was given to the model and Euler method was used for numerical solution and Newton-Raphson method was used for pH modelling and simulation. 12 months data during 2010-2011 was gathered by Khuzestan power and water corporation and Iran Water Resources Corporation and model was run for each month. The water quality parameters (2010-2011) for Karun River are shown in details in Table 1 before simulation.

Table 1. Statistical properties of water quality in 2010-2011 for Karun River (data collected by Khuzestan Power and Water Corporation).

Standard deviation	Average	Minimum	Maximum	Parameter
0.498	7.467	6.545 (Su)	8.236 (W)	DO (mg/l)
0.512	3.28	2.36 (A)	4.036 (Su)	BOD (mg/l)
1.304	8.016	7.175 (A)	12.07 (W)	NO_3 (mg/l)
0.424	0.509	0.015 (A)	1.1 (A)	Pathogens
5.393	23.05	13.75 (W)	31 (Su)	TEMP (degC)

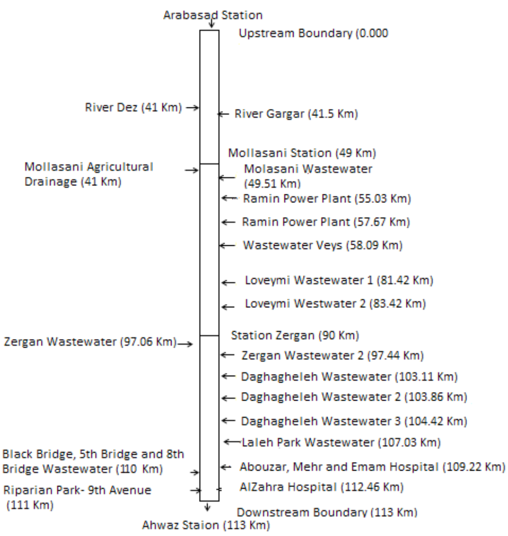

Figure 2. Intervals and entrance locations of Karun River

After collecting data, they will be divided into two subsets for calibration and validating in a way that a greater part of the data must be used for the first step. Then with comparing the results gained from modeled and measured data, model's validation for new circumstance can be investigated and model reliability will be determined. Data of two months of autumn in 2010 were used for the model. Then the gained results from QUAL2Kw model were compared with observed data using Root Mean Square Error (RMSE) and standard error. Relations between these standards are shown in equations 1 and 2.

$$NRMSE = \frac{\sqrt{\frac{\sum_{i=1}^{n}(Y_{si}-Y_{oi})^2}{N}}}{\bar{Y}} \quad (1)$$

$$SE = \sum_{i=1}^{n}\left[\frac{(Y_{ti}-Y_{mi})^2}{N}\right]^{0.5} \quad (2)$$

In these equations Y_{si} is parameter estimated by model on i^{th} day, Y_{oi} is observed parameter value on i^{th} day, N is number of measurements, Y_{ti} is i^{th} model prediction parameter and Y_{mi} is i^{th} measured parameter.

According to contemporary science, in rivers assimilative capacity, load capacity (LC) or total maximum daily load (TMDL) is the maximum tolerable pollutant charge in river if water quality standards are regarded well. Waste load allocation is a portion of total daily load which will be allocated to a present or incoming point polluting source. Point sources waste load allocation (WLA) and load allocation (LA) beside margin of safety (MOS) is equal to total maximum daily load. (Equation 3)

$$LC = TMDL = WLA + LA + MOS \quad (3)$$

3- Results and Discussion

Table 2 illustrates a comparison of QUAL2Kw simulation results and observed data. According to the results, all of the qualitative parameters have the minimum relative error and root mean square error.

BOD, pathogen and nitrate alterations have been investigated to determine the effects of pollution discharge toward river on river's water quality. River self-purification effects on BOD, pathogen and nitrate were calculated for 2010-2011 and results are shown in Figure 3. According to Figure 3, on average, river's self-purification capacity for BOD and nitrate is higher in spring and winter since river discharge is much more. River's self-purification is more effective on pathogen in January and March because of water speed and high discharge of river; also it is considerable in warm months, because of pathogen decomposition as a result of exposure to sunlight. The results showed that transmission is more effective than reaction to remove coliform which is similar to Azimi 2010 Qual2kw simulations results in Sefied Roud River.

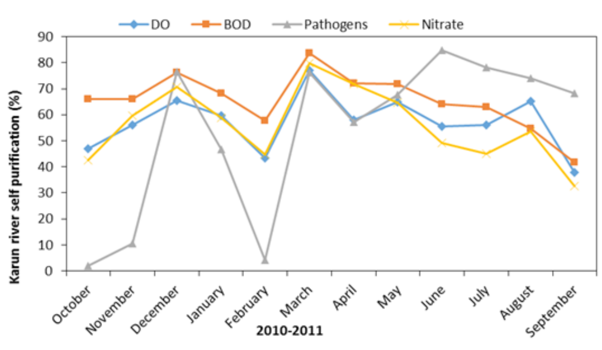

Figure 3: Karun River self-purification potential for qualitative parameters

Table 2. Statistical parameters of QUAL2Kw simulated data compared to observed data

RMSE				SE				2010
DO	BOD	NO_3	Pathogens	DO	BOD	NO_3	Pathogens	
0.0384	0.029	0.127	0.459	0.088	0.064	0.236	0.109	April
0.079	0.073	0.066	0.158	0.162	0.195	0.151	0.201	May
0.092	0.069	0.111	0.586	0.278	0.068	0.302	0.705	June
0.095	0.095	0.163	0.559	0.176	0.095	0.381	0.0817	July
0.087	0.079	0.217	0.379	0.18	0.139	0.52	0.34	August
0.133	0.061	0.068	0.294	0.262	0.183	0.117	0.734	September
0.87	0.216	0.897	0.441	0.208	0.129	0.0599	0.483	November
0.061	0.08	0.101	0.77	0.151	0.075	0.303	2.65	December

According to 2010-2011 results for Karun River qualitative variables, simulations in three conditions of decrement of the waste waters flow rate into the river by 30%, decreasing of the waste water concentration by 30%, increment of the river upstream flow by 30% and effects of reduction of incoming pollutants from Dez and Gargar sub branches on improving water usage quality in months in which using standards was not satisfied have been investigated.

Based on results, BOD exceeded the standard limit in all months except September. 30 percent decrement in entering pollution from Dez and Gargar to Karun improved self-purification effects on this variable (BOD) and in October, December, February, and March BOD had improved a lot and reached the standard level. In January 30% reduction of entering pollutants from Mollasani-Ahvaz interval had a special effect on improving the river self-purification capacity and reached the standard limits in 80 kilometre from upstream. In other months 30% reduction in waste water flow and reduction in entering pollution charge had a same effect on improving BOD levels.

Based on results in October, December, January and February background concentration had a substantial effect on river's water quality in a way that pathogen concentration in October, January and February was higher than user standard limits from 80 kilometre after Arab Asad station and was not appropriate for waste water entrance and in December despite of applied conditions for improving river's pathogen, amount of this qualitative variable exceeds the standard limit. 30% reduction of entering pollutants from Dez and Gar Gar to Karun and entering pollutants from Mollasani-Ahvaz had the best effects on improving pathogen level. In October, January and February 30% reduction of entering pollutants from Mollasani-Ahvaz and 30% increase of upstream flow had the best effects on pathogen levels.

Based on results, Nitrate concentration had increased in December along the river and in critical regions was near the using standards and in January was more than standard level. 30% reduction in pollutions coming from Dez and GarGar and entering pollutions from Mollasani-ahvaz interval had a great effect on nitrate reduction in a way that in January the amounts of this qualitative variable had reached user standard limits. In December 30% increase in flow in river's upstream has greater effects on improving nitrate amounts than 30% reduction of pollution concentration or reduction of entering pollutants. Bagherian Marzouni et al. (2014), Shamsaei et al. (2006) and Karamouze et al. (2004) have investigated Karun River water quality and reported the critical conditions of river. According to their study river had the highest self-purification capacity in winter and this capacity was lower in summer[4-6]. In this research investigation of qualitative variables like seasonal BOD, Nitrate and pathogen showed Karun River has a high self-purification capacity in winter for water quality variables and this capacity decreased in summer.

4- Conclusion

Simulation results for BOD, pathogen and nitrate shows that Karun River had the lowest self-purification capacity in winter because of using nitrate fertilizers for plant growth and entrance of this pollutants into the river and had the highest self-purification capacity in February for pathogen but totally in warm season pathogen destruction by sun light caused standard amounts of this variable.

30% reduction of entering pollutants from Dez and Gar Gar to Karun River and pollutants entering from Mollasani -Ahvaz interval in months that this qualitative variables were more than qualitative standard has the greatest effect on improving BOD, nitrate and pathogen amounts (in December). For improving pathogen in October, January and February 30% reduction of entering pollutions from Mollasani-Ahvaz interval has the greatest effect.

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