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SEDIMENT REGIONAL MODELING (A CASE STUDY: TOROQ WATERSHED, KHORASANRAZAVI PROVINCE, IRAN)

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ABSTRACT

To determine the methods dealing with soil erosion and sediment control and performance of protective plans, estimation of annual sediment yield in a watershed is needed in addition to selection of the exact location of reservoir dams and calculation of their useful life. Although there are various imported models to estimate the amount of erosion and sediment, considering the specific climatic conditions of Iran as well as the conducted researches, a regional model has been given in the present study which is compatible to the dominant conditions of some watersheds of Iran, especially Khorasan Razavi Province. In order to obtain the model, firstly the factors affecting sediment yield of Toroq Watershed including physiographic, meteorological, hydrologic, land use and geomorphological factors were obtained. Then, the amount of annual suspended sediment produced in the watershed using sediment rating curve. After statistical analyses using SPSS software and Kolmogorov- Smirnov test, Pearson correlation and PCA analysis, the variables that had the highest effect on the sediment of watershed were determined among 50 variables. According to the results of correlation matrix, it was found that, the

variables of area, equivalent rectangular length, runoff volume, erosion surface and the northern slope have a correlation higher than 0.5. Finally, the equation of sediment estimation was determined using multi variable regression. Stepwise regressive equation with four variables including area, equivalent rectangular length, area percentage of surface erosion and slope direction was selected as the best model according to the results of relative error RMSE and efficiency coefficient with explanation coefficient by 0.85.

Keywords: Regional model, erosion, sediment rating curve, linear multi variable regression

INTRODUCTION

The issue of erosion in arid and semi-arid regions of the world is a huge barrier for economic development of the societies. In fact, sediment is the final product of erosion in a watershed. Sediment production occurs during a long-term period correlated to the mean erosion in the same period; since, the sediments reserved temporarily in various parts of the watershed in the rivers' bed, they will move again and arrive to the end of the watershed; while, a part of deposited sediments remain permanently and do not move again. Suspended sediment is the greatest non-point source pollutant and the main factor degrading the surface water quality. Destructive activities on the ground such as degradation of rangelands and forests, mining and development of agricultural activities cause this problem.In fact, sediment is the final product of erosion in a watershed. Sediment production occurs during a long-term period correlated to the mean erosion in the same period; since, the

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M.López-Vicente, J.Poesen (2011) predicted the relationship between runoff, sediment and soil erosion by water in different

scenarios of land use in Estanque de Arriba watershed, Spain. They predicted the hydrological relationship and soil erosion rate in four different scenarios of land use and barren lands in which 80 80 soil samples had been collected, using RMMF model.

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MATERIALS AND METHODS
Study area
Toroq Dam Watershed is located in Torqabeh Shandiz city which is 21 km away

from Torqabeh village located in the southwest of Mashhad, Iran. The area is

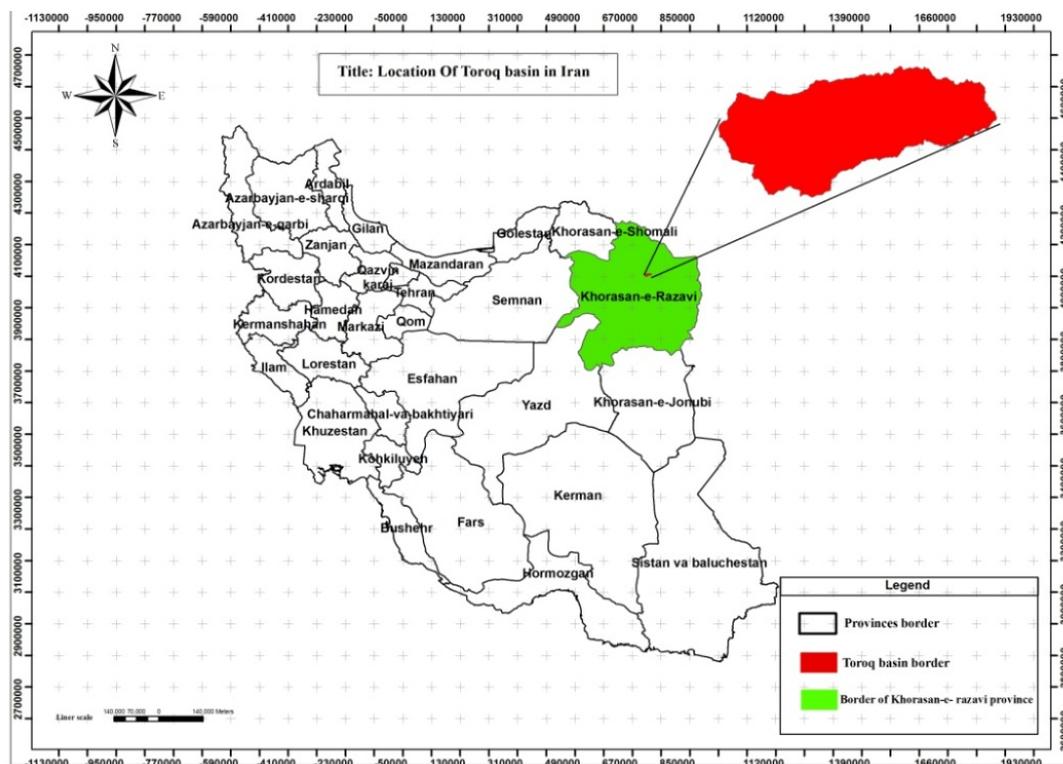163.12 km^2. The studied watershed has 30 sub-basins.

Figure 1: location of study area in Iran

In study of surface waters if instantaneous and periodic sampling methods are used to monitor water quality, determination of sampling stations and qualitative measurement of water will be necessary. After field visits and investigating the topography of study area, 9 sampling stations were determined.

Sampling time and the number of samples

Sampling was carried out in autumn and winter in Dez River. In order to increase accuracy in statistical calculations, three samples were taken from each station during

the sampling time, and the taken samples were used to measure following parameters:

1. The first sample for BOD$_5$ measurement

2. The second sample for COD measurement

3. The third sample for measuring other physic-chemical parameters

Temperature and DO were measured at the location. Ultimately, 30 samples were taken for each stage from study stations to measure concerned parameters, and then they were transported to the laboratory.

Preparation of sampling containers

Sampling containers were plastic polyethylene according to standard

guidelines. In order to prepare the containers, they firstly were washed by a kind of washing diluted liquid, then, they were pickled by sulfuric acid, and finally they were washed using distilled water without ions.

Stabilizing and transporting the samples to laboratory

Samples of physic-chemical experiments and BOD, were kept near ice under 4 ^{0}C. In order to stabilize COD samples and stop bacterial activities in the samples, 1 ml concentrated sulfuric acid was added for every 1 liter of sample. The name of station, sample and sampling date were written on all the containers. Also, the samples were prevented to be contacted with metal, rubber and galvanized tools during all sampling stages and their transportation to the laboratory.

Sampling and measurement devices

Temperature was measured by a mercury thermometer, and dissolved oxygen was measured by a portable DO meter named HANNA HI9142 made in Italy at sampling location. The other physic-chemical factors were measured in laboratory by related devices. With regard to the study subject, various tools and materials were needed to be used to achieve the study objectives. Used equipment in this research were classified

into three sections including field, laboratory and computer sections.

Field equipment

Nansen bottle, portable DO meter model HANNA HI9142, mercury thermometer, vehicle, GPS, icebox.

Laboratory equipment

Beakers in various sizes, 250 cc and 500 cc flask, test tubes, filter paper (Whatman 42), burette and its stand, Glass funnel, graduated cylinders in various sizes, 0.5, 1 and 2 L polyethilene containers, gas flame, plastic sucker, wash bottle.

Laboratory materials

Solution of potassium dichromate, solution of ferrous ammonium sulfate, silver sulfate, mercuric sulfate, concentrated sulfuric acid, concentrated ammonia solution, tin chloride (II), phenol, di-sulfuric acid solution, standard solution of phosphate, nitrate standard solution, Magnet tablets.

Computer equipment

In order to provide report, NSF WQI software was used. The following steps should be done to calculate NSFWQI qualitative index:

1. To provide qualitative data of parameters BOD5, TDS, PH, dissolved oxygen, nitrate, phosphate, turbidity, temperature, and fecal coliform

2. To calculate sub-index of each parameter from quality index curves

(Raw values of the parameters should be converted to sub-index and the sub-index of each parameter was calculated).

3. Determination of weight factor of each parameter considering the number of parameters which their qualitative data are available.

Table 1- The amount oftotalsedimentandspecialsedimentSub-basin

Sub-basin	Area (ha)	SDR	Totalsediment (tons per year)	Special sediment (Tons per hectare per year)
T1	1352/423	0/65	1931/9	1/4
T'2	834/4632	0/69	671/2	0/8
T'3	730/7638	0/71	2187/8	3/0
T4	432/3842	0/71	2565/9	5/9
T'5	64/36061	0/88	1015/9	15/8
T6	273/9624	0/72	773/0	2/8
T7	315/0832	0/72	1280/0	4/1
T8	636/2113	0/70	1385/3	2/2
T9	359/7225	0/72	1418/1	3/9
T10	502/6662	0/71	2583/9	5/1
T'11	675/1549	0/70	2441/8	3/6
T12	453/9834	0/71	2743/7	6/0
T'13	1643/095	0/62	3412/1	2/1
T14	1932/936	0/62	2926/9	1/5
T'15	1183/921	0/67	3347/9	2/8
T16	1057/68	0/66	850/1	0/8
T'17	764/3136	0/69	1882/9	2/5
T18	272/8082	0/72	832/3	3/1
T'19	152/3473	0/77	835/0	5/5
T20	464/5992	0/71	799/0	1/7
T21	762/54	0/69	926/0	1/2
T22	1445/983	0/63	1157/8	0/8
catchment	16311.1	0.52	36214/8	2.2

(According to the importance, each parameter has its specific weight in NSFWQI; so, each parameter was multiplied by suggested weight factor of NSFWQI in order to calculate final index. Weight factors of NSFWQI have been determined in Table (1.2).

4. Final index is calculated by the following equation:

$$NSFWQI = \sum_{i=1}^{n} W_i I_i$$

Where I_i is sub-index of each achieved parameter from base curves and W_i is weight factor of each parameter.

Table 2- Principal component analysis, PCA

| Variable	Component
area	0/943
Equivalent rectangle length	0/918
Surfaceerosion	0/899
The volume of runoff	0/953
TheNorth Slope	0/879

Fecal Coliform should be considered as index. Then, they graded water quality level from zero (the worst case) to 100 (the best case) based on raw data. After that, drawn curves were normalized to obtain weight curve for each parameter. Results of 9 parameters were compared to draw curve and Q-value. After calculating Q-value, the parameter is multiplied by a weight factor (based on the importance of in determination of water quality) based on the importance of the parameter in water quality. For instance,

DO has a high weight value (0.17) since, it has a higher importance in determination of water quality compared with other factors. Then, resulted numbers are summed to determine WQI (Water Quality Index).

- Comparison of the measured parameters based on the standards of WHO and EPA shows that, BOD and PH of all stations are standard. Turbidity of Dez, Abbasabad, Chanibieh and Aboltoyur is also standard and the rest of stations are higher than standard.

Table 3- Three stepwise regression models to estimate erosion, regressive and Inter

R	CE	RMSE	RE	Multivariatemodelssediment	No
0.78	0.31	805.3	16.40	S= 588.63 + 594.02(E)	1
0.81	0.33	777.4	16.41	S= 445.95 - 83.16(A)+1144.22(E)	2
0.83	0.35	749.4	16.40	S=437.85 -121.05(A) 1177.45 + (E)+36.23(N)	3
0.85	0.39	661.1	15.72	S= -253.97-285.16(A) 2713.75+ (E)-991.11(S.E)+710.5(N)	4
0.86	0.4	662.1	15.75	S= -233.8 -296.4(A) 2707.5+ (E)-994.22(S.E)+73.28(F.V) + 711.34(N)	5

Scatterplot
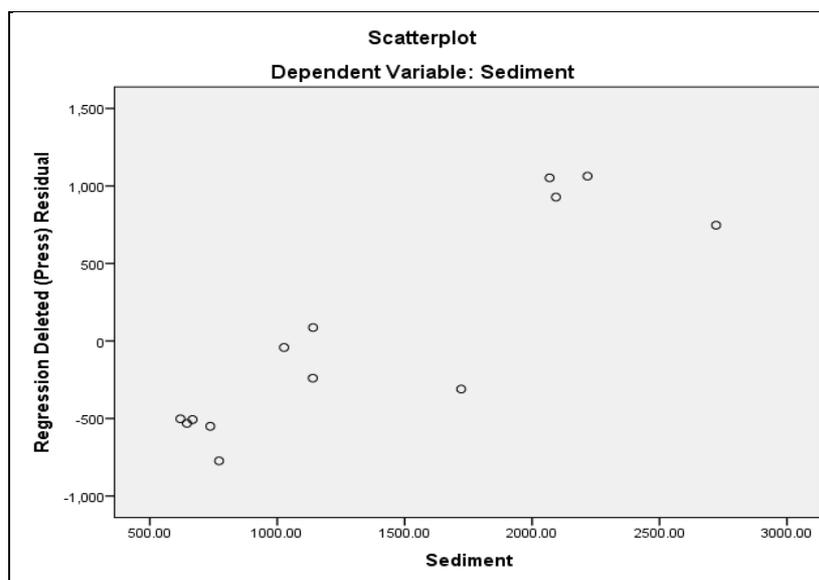Dependent Variable: Sediment
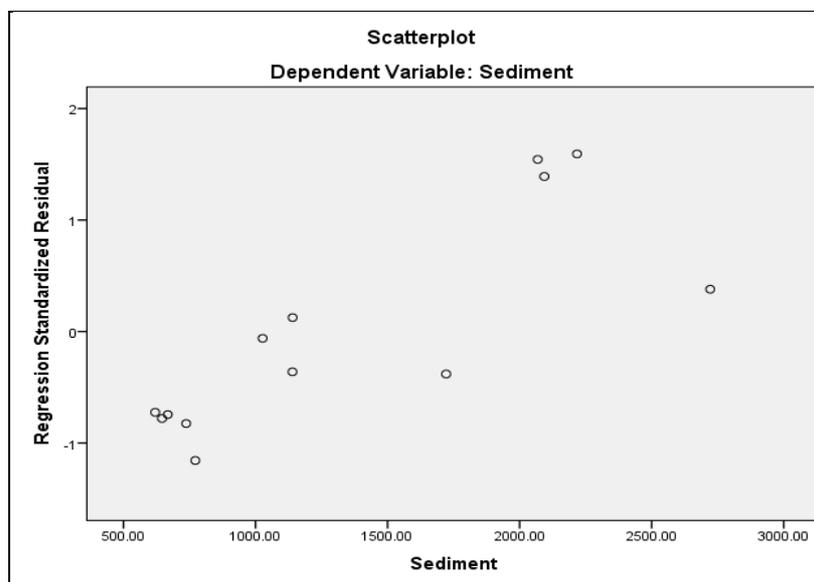
Figure 2, 3- The remaining sediment analysis charts for validation of the equation

- Comparison of parameter phosphate based on the standard of southwestern Asian countries shows a lower amount than the standard for all stations. Comparison of BOD based on standard of China and South Korea indicates that, BOD for all stations is standard but, this value is higher than permitted amount for stations Hafttapeh, Khamat village, Chanibieh and Aboltoyur based on standard of Thailand. This comparison based on the standards of India shows that, BOD is less than the standard in all studied stations.

CONCLUSION

- Comparison of biochemical oxygen based on the standard of England demonstrates that, all stations except Chanibieh and Aboltoyur are placed in clear class. Chanibieh and

Aboltoyur also are placed in relatively clear class.

By comparison of the results of this study with conducted similar studies on the other rivers in various countries inside and outside Iran, it can be concluded that, mean water quality of this river is less than the rivers of Malaysia and America. Also, comparison of water quality of this river with the rivers of I India showed that, water quality of Dez River is higher than some rivers of India and is almost same as some other rivers in this country. Also, comparison of water quality of this river with Tajan River in Iran showed that, mean water quality of Dez River is lower than Tajan River in Mazandaran province. In this study, water quality of Tajan River has been evaluated as suitable class

according to the classification of water quality index.

the river pathway and industrial effluent of these factories (Pars paper mill, farming and industry factories of Hafttapeh, Shoeybieh, and a part of effluent of Karoon farming and Industry) which enter the river, also, farm lands overflowing their drain water into the river, existence of various villages and counties along the river path and entrance of wastewaters resulted from these centers to the river. Considering these effective sources on the river water quality, the results of water quality index can be investigated. In this section, the results of calculating the water quality index are interpreted based on the mean of the data.

In upstream stations of the river (Dez dam reservoir, regulatory Dez dam, BisheAbbasabad, BisheHamidabad), water quality status was relatively suitable while, in downstream stations (Hafttapeh, Khamat village, Bamdezh, Chanibieh, Aboltoyur), water quality had been reduces due to the existence of various contaminants mentioned above. Comparison of seasonal index of water quality in the studied stations shows that, water has had its worst quality in the autumn but, it was the best in winter due to increase of precipitations and dilution of pollutants. Also, this graph demonstrates

that, the maximum amount of seasonal water quality index has been obtained in station of reservoir Dez dam in upstream and the minimum amount index was found in Bamdezh station due to the entrance of various pollutants and especially effluent of farming and industry of Karoon. According to the results of comparisons of water quality index between the stations and autumn and winter, Dez River can be divided into two parts. The first part includes Dez dam reservoir, Dez regulatory dam, Bishe Abbasabad and Bishe Hamidabad in upstream of the river and before entrance of the pollutants, and the second part includes Hafttapeh, Khamat village, Bamdezh, Chanibieh and Aboltoyur in downstream of the river and after entrance of the pollutants which have an almost similar situation in terms of water seasonal index of water quality.

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