



Determining factors affecting production of suspended load and determining sediment yield homogenous regions (Case Study: Dez River)

Syedehnesaseyedolama^{1*}, Parisa Danyaei² and Atoosa Danyaei³

¹Faculty of Agricultural Sciences, University of Guilan Rasht

²Faculty of Agricultural Sciences, Islamic Azad University of Tehran

³Drshariaty Faculty, Technical & Vocational University, Tehran, Iran

ABSTRACT

Dez Dam as one of the largest dams of the Middle East has strategic role in development of Khuzestan Plain. Considering dry and semidry climate and subdesert climate of some cities of Khuzestan Province and also due to location of this dam in downstream of sub basins with relatively high sediment yield which caused loss of some useful capacity of tank in years following construction, importance of the present study increases. The present study has been conducted in upstream drainage basin of Dez Dam with area Gaging Stations for regional analysis of the suspended load and also determination of the sediment yield homogenous regions. In this study, base maps and physiographical, climatic and hydrological characteristics affecting production and carriage of sediment relating to each one of the subbasins were prepared with GIS techniques. Then, relationship between production of special daily suspended load and independent variables with statistical analyses, clustering and multivariate regression. Results showed that Vanaee, Afravandeh (Biatoon), Dokhaharan, Darehtakht, Drorood, Chamchit and Keshvar sub basins were included in the first homogenous group and SepidDasht, Tang Panj (Sesar), Tang Panj (Bakhtiari) and Telezang were included in the second homogenous group. Regression results showed the precipitation factor as the most important factor in production of suspended load of sub basins. To study priority of specific sediment yield for making decisions about prevention of water and soil, sub basins ending to Darehtakht, Dorood and Afravandeh stations had the highest sediment yield intensity in surface area.

Key words: suspended load, homogenous region, prioritization, Dez Drainage Basin

INTRODUCTION

Sediment in drainage basins is affected by different factors such as climate, ups and downs and human activities. Changes of sediment yield in drainage basins, time and space changes, size and granulation of sediment are of the most important sediment yield variables in drainage basins. Determination and estimation of sediment yield are one of the necessary watershed management and soil protection science [1] That used for identification of critical regions of a drainage basin [4]. One of the most important ways of preventing sediments into reservoirs is execution of watershed management operations. Since area of rivers is extensive and watershed management of the entire basin is not cost effective, it is important to determine critical sub basins in terms of sediment yield (prioritization of sub basins) [3].

Increasing trend of lands destruction and extensive human manipulations in different parts of nature particularly water and soil increase erosion rate and sediment rate and damages resulting from it. For this purpose, determination of the most effective factors in this process can allow access to optimal models and methods of controlling and reducing erosion and sediment yield.

Goal of this research is to identity and gain access to the most important factors affecting emergence and intensification of sediment, determination of sediment yield homogenous regions and also identification of critical regions in terms of production of sediment in Dez Dam drainage basin (Sesar River).

MATERIALS AND METHODS

Study area is a part of Dez river basin in upstream of Dez Dam as Dez Dam drainage basin which is known as drainage basin of Sesar River. Area of this basin is 16213 km² and is located between 10° and 48° and 21' and 50° as longitude and 31° and 34° and 7' and 34° as latitude. Annual mean precipitation in the studied area has been estimated from 150 mm per year in the plain lowlands to 1800 mm per year in highlands adjacent to Koohrang. Production of sediment in Dez Basin has been estimated between 300 and 3000 ton/km². In other words, averagely 1.5 mm of soil is eroded every year. In Dez Drainage Basin, there are 36 hydrometric stations and 11 Sediment Gaging Stations were selected in Drainage basin by referring to Iran Water Resources Research Organization and Regional Water Organization (Figure 1).



Figure. 1. Location of the studied stations in drainage basin area

To present suitable model for estimation of sediment production in sub basins, multivariate regression[4] was established with forward, backward, deletion, entrance of all variables and stepwise method between values of the specific daily suspended load as dependent variable and physiographical variables (length of the basin and area of the basin), climatic variables (average annual precipitation, average temperature, De Martonnearidity coefficient) and hydrological variables (average annual flow rate , minimum and maximum flow rates) as independent variables (Table 1).

Selection and determination of variables have been based on criteria such as effectiveness of sediment yield and transfer, easy access, significance of variable in the studied region and use of the said variables in other conducted researches. Values of daily suspended load of each station was calculated with statistics of SedimentGagingStations and used as dependent parameter.

Area of each sub basin was determined with topographic maps and drawing of area under basins ending to the studied stations and with GIS software. Considering Table 1, the sub basins were divided in two groups in terms of sediment yield. The first group included sub basins with low sediment yield such as Vanaei, Afravandeh(Biaton), Dokhaharan, Darehtakht, Dorood, Chamchit, SepidDasht and Keshvar in which average suspended load rate is 258 tons per day. In the second group , sub basins such as Tang Panj(Sezar), Tang Panj(Bakhtiari) and Telehzang are located and have high sediment yield rate so that production rate of daily suspended load is 9765 tons per day which is 38 times as much as sediment load rate of the first group. One of the reason is large area of sub basins ending to the second group stations. On the other hand, only attention to total sediment yield cannot indicate critical or ordinary conditions of erosion and sediment production. Therefore, it is necessary to determine sediment yield rate in surface area to make acceptable comparison in terms of erosion intensity in all basins. On this basis, sub basins have been mentioned in terms of specific sediment load in the following Table.

To determine homogenous sediment yield regions in the studied region, cluster analysis[5] was done with different methods, average intergroup relationship, the nearest neighbor, full relationship (the furthest Neighbor), center of gravity , median method and ward method using SPSS software. Then, the best method was selected considering tree diagrams obtained from different methods and also specifications of the sub basins.

RESULTS AND DISCUSSION

The variables which affect output sediment yield in a drainage basin are various and abundant, therefore, use of multivariate regression method seems useful for access to the equation which indicates suitable relationship between sediment and each one of these factors. Considering final regression equations which were selected as final models for each sub basin, the most important factors affecting daily sediment yield were determined and on this basis, suitable executive and managerial decisions were made considering the mentioned factor or factors. Among the performed regression equations, the stepwise method was superior over other performed methods due to high coefficient of determination; lower estimation error and limited number of independent parameters[9]. Therefore, inclusion of powerful factor of precipitation in the regression equation obtained from this method (Equation 1) for production of specific daily suspended load in the study area indicates clear and full relationship between precipitations on the one hand and sediment yield on the other hand.

$$\text{SEDSP} = 0.002 * \text{PREC} \quad (1)$$

In the mentioned Equation:

SEDSP: specific daily suspended load ton/day/km²) and PREC: annual average precipitation (mm). In the studies conducted by [6] and [2] , importance of precipitation in sediment yield of the basin has been emphasized. Since quantity and quality of this parameter are not accessible to human, it is not possible to manage its time and place and all attentions are directed to water and soil protection and also plant vegetation. To determine sediment yield regions, cluster analysis was done for each sub basin and considering the tree diagrams presented in clustering method and based on specifications of sub basins, the ward method was selected as the best method. On this basis, the studied sub basins were divided into two homogenous groups (Table 2) by passing through separator of euclidean distance in approximate distance of 7 from the origin.

Table 1- Condition of Independent and dependent parameters in sediment gaging stations: prioritization of suspended load production in the studied sub basins of Dez Dam

Station	Daily suspended load ton/day	Specific daily suspended load ton/day/km ²	Area km ²	Length of basin km	annual average precipitation mm	Maximum flow ratem3/s	Minimum flow rate m3/s	Average flow rate m3/s
Vanaei	6.46	0.108	60	12	900	2.34	1.18	1.67
Afravandeh(Biaton)	9.71	0.081	120	24	380	0.96	0.14	0.42
Dokhaharan	86.80	0.089	973	46	425	13.71	1.27	4.73
Darehtakht	83.30	0.038	2185	55	630	2.3	0.85	1.46
Dorood	147.60	0.056	2655	83	550	30.56	3.83	10.47
Chamchit	99.80	0.289	345	32	650	14.67	4.06	7.31
SepidDasht	1193.40	0.166	7174	101	780	102.58	19.4	46.9
Keshvar	434.60	1.293	336	24	750	11.26	2.05	5.75
Tang Panj(Sezar)	6877	0.731	9410	151	900	243.11	25.74	104.15
Tang Panj(Bakhtiari)	9685	1.506	6432	144	1050	321.23	80.53	150.17
TelehZang	12733	0.785	16213	142	875	572.37	127.54	269.27

Table 2- Prioritization of suspended load production in the studied sub basins of Dez Dam

Necessity of actions for water and soil protection	membership in homogenous group	Rank of specific sediment production from low to high	Rank of total sediment production from low to high	Specific suspended load ton/day/km ²	Suspended load ton/day	Station
Ordinary	1	5	1	0.108	6.46	Vanaei
Ordinary	1	3	2	0.081	9.71	Afravandeh(Biaton)
Ordinary	1	4	4	0.089	80.86	Dokhaharan
Ordinary	1	1	3	0.038	83.30	Darehtakht
Ordinary	1	2	6	0.056	147.60	Dorood
Ordinary	1	7	5	0.289	99.80	Chamchit
Ordinary	2	6	8	0.166	1193.40	SepidDasht
Very necessary	1	10	7	1.293	434.60	Keshvar
Necessary	2	8	9	0.731	6877	Tang Panj(Sezar)
Very necessary	2	11	10	1.506	9685	Tang Panj(Bakhtiari)
Necessary	2	9	11	0.785	12733	TelehZang

Homogenous region is the region which has considerable similarities in terms of hydrological, geological, topographical characteristics and plant vegetation [7]. There are significant differences between two separating homogenous groups in terms of parameters such as area , length of basin , annual average flow rate and daily suspended load and this difference is clearly larger than difference of these factors between sub basins and inside the homogenous groups. Two types of prioritization have been done for the studied sub basins based on total sediment and specific sediment (Table 2) and one or both methods can be used dependent on goal, time and capital equipment, human force and other effective factors.

If control and reduction of the sediment to the dam or other reservoirs of hydraulic structures are considered in any form and material and human resources allow manager and planner to do so, it is more proper to prioritize use of suspended load production criterion. But in case operational preferences are considered for allocation of financial and human credits to control and reduce erosion and sediment yield in sub basins, specific sediment production should be used because this criterion shows the most critical conditions of sediment yield of sub basins separately from its volume and quantity. In this way, watershed management operations and other actions for reduction of erosion and sediment can be performed considering prioritization. Arab Khadari and Zargar(1995) in a study mentioned sediment yield rate of drainage basin as an accessible and acceptable criterion for gradation of sub basins. Najafi (2003) prioritized drainage sub basins of Isfahan and Sirjan considering annual sediment factor.

REFERENCES

[1]HAhmedi, Applied geomorphology(1st volume), 2nd,Tehran university publication , **1999**.
[2]M Alizadeh, practical hydrology, AstanQodseRazavi publication, Tehran, **2002**,634.
[3]MARab Khadari, A Zargar, *Research and Construction Journal*, **1995**, 29.
[4]A Brooshkeh,R Sokooti, M Arab Khadari, The first conference on Watershed management and Water and Soil Resources Management.University of Kerman,**2004**.
[5]A FotoohiArdakani, Textbook of SPSS 10,.,Shayegan Publication, **2002**, 448.
[6]M Mahdavi, practical hydrology (2nd volume), Tehran university publication, **1999**,401.
[7]M Mazin, M.S. thesis of Watershed management Department, TarbiatModarres University, **2003**, 81.
[8]D Najafi, M.S. thesis of watershed managementDepartment.TarbiatModarres University, **2003**, 75.
[9]M Vafakhah, M.S. thesis of watershed managementDepartment TarbiatModarres University, **1998**. 145.