Tracing sediment sources in Royan Drainage basin, Iran

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ABSTRACT

For successful soil conservation measures, obtaining information about the relative importance of sediment source and their shares in sediment production is required. Tracing or source studies are emphasized in recent years due to their privileges. In this research, sediment sources were identified using tracing method. A small earth dam is constructed at the outlet of Royan Drainage Basin in 1993. In this study, sediments were sampled from dam reservoir, different sources were also sampled. Fifteen tracers were first selected for tracing which are: the amounts of N, Carbon, Cr, Co, Mg, K, Na, smectite, cholorite, illite, kaolinite, PH and two magnetic properties consisting of X_{LF} and X_{FD}. The samples were analyzed in the laboratory for these parameters and different statistical methods were applied to the data including Nonparametric Kruskal Walis Test, Stepwise Differentiation Function Analysis. The contribution of each sediment source in sediment yield was obtained by optimization of multivariate composite model which shows Karaj Formation (EV) contributes %32.86, Quaternary unit (Q) %30.92, gully erosion %26.77, Shemshak Formation (Js) %4.69, Upper Red Formation (M1) %2.35 and Lar Formation (Jl) %1.41 of sediment yield and have the highest contributions in sediment yield respectively. The results of this research can be used in soil conservation projects for execution of suitable management strategies.
Keyword: Sedimen, Soil conservation, Iran, Tracing, Source studies.

INTRODUCTION

Soil erosion is one of the most important environmental problems in developing countries including Iran which has destructive effect on all natural ecosystems being managed by human. Erosion not only causes land degradation and lowering of fertility, but by producing and accumulation of sediments, lowers reservoirs dam capacity. For decrease of soil erosion effects, soil conservation and sediment control measures are needed. For execution of these plans, information about the relative importance of sediment sources is required. Sediment sources may be geological rocks and formations, land uses, soils or different erosions. There are different methods for determining the relative importance of different sources, among which tracing or sediment source identification is emphasized in recent years due to advantage it has. In this method, physical, chemical and organic characteristics of sediments and sediment sources are determined. Here, by using suitable combination of the mentioned characteristics and multivariate models, the contribution of different sources is determined.

For determining source of sediments in Upper Torridge Catchment, United Kingdom, sediment yield data of hydrometric stations were used [1]. Then by using different statistical methods, he determined the potential of each tracer in differentiating sediment source and then by using composite multivariate model, he determined the share of each source. Among 19 parameters which were first chosen, the optimal composition of tracers were: N, P, Cs137, C, Cr, Fe, and Rd-226 which could completely differentiate sediment sources. According to composite multivariate model, the contribution of sediment from Woodland

Pasture topsoil was (%47), cultivated topsoil(%28), Channel banks (%23), and Woodland topsoil (%2). Similar studies have been performed [2,3,4].

The studied area is Amrovan Drainage Basin, located in Seman Province, Iran. A small earth dam is constructed in the outlet of the basin in 1993 for flood-control. In this research sediments accumulated in the reservoir of dam were sampled and analyzed for sediment source identification. Mean annual rainfall is 174.5 mm, mean elevation is 1845m, mean annual temperature is 17^0C. Rangeland is the main land use in the area, a part of drainage is under badland erosion.

MATERIALS AND METHODS

Sediments were sampled from reservoir dam. Primary field studies showed that there are four sources of sediments in the drainage basin: Quaternary unit, Upper Red Formation, Hezar-Dareh Formation and Badland erosion. These sources were also sampled. The samples were analyzed in the libratory for tracers consisting of : N, C, Ca, Cr, Co, Mg, K, Na, PH, smectite, cholorite, illite, kaolinite and two magnetic characteristics of X_{LF} and $X_{FD.}$ The potential of tracers in differentiating sources of sediments was analyzed statistically using two steps statistical method proposed [5]. To determine which tracers show meaningful differences between sources, non-parametric Kruskal-Wallis test was used. Then Stepwise differentiation function analysis was used for decreasing the number of parameters first used so that the parameters have the lowest amount of correlation and the highest amount of differentiation potential. For obtaining the optimum results for determining the share of sediment sources optimization methods were used [6]. By using Equation 1 and by using the method of minimizing the sum squares of remaining the optimal share of sediment sources was estimated.

$$R_{es} = \sum_{i=1}^{n} \left(\frac{C_{ssi} - \left(\sum_{s=1}^{m} c_{si} \cdot p_s \right)}{C_{ssi}} \right)^2 \qquad (1)$$

In which:

Cssi : The amount of tracer i in reservoir sediments

Csi : The amount of same tracer in sediment source S

Ps : The share of each S source in sediment production

S : The name of homogenous unit

n : The number of tracer parameters

Rse : Minimum of sum square of remaining

RESULTS

Figure 1 shows the geology formations map of Royan Drainage Basin. Table 1 shows the results of Kruskal-Wallis Test for determining the parameters that can differentiate sediment sources. These parameters are the one that are meaningful at %5 level. These parameters are shown in Table1 as *. According to this Table, all variables are meaningful at %5 level. In other words, the mean concentration of each parameter is different at least in one of sediment sources relative to other sources.
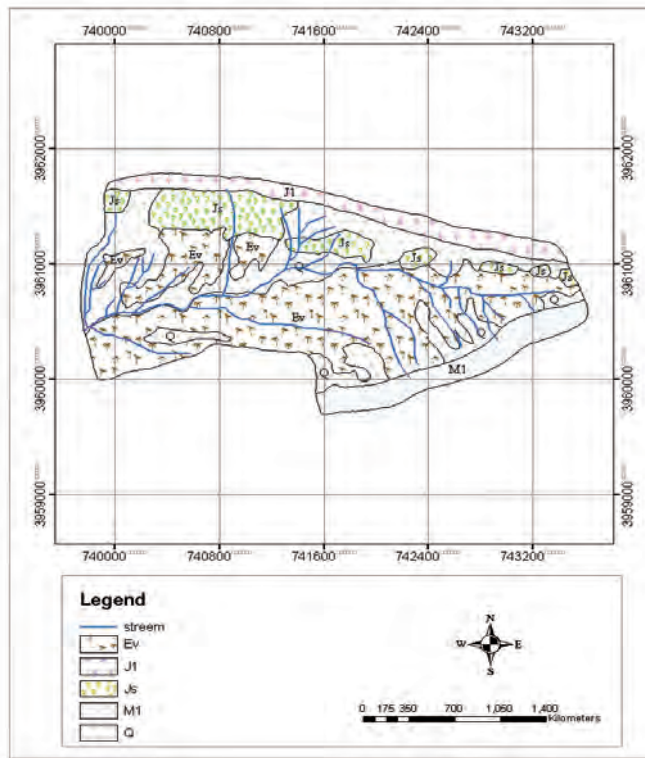
Figure 2. geology formations map of Royan Drainage Basin

Table 1. The results of Kruskal-Wallis Test for determining suitable tracer for differentiation of sediment sources

No.	Tracer parameter	P valu	No.	Tracer parameter	P valu
1	N	0.00*	9	Na	0.00*
2	PH	0.00*	10	smectite	0.00*
3	C	0.00*	11	Cholorite	0.00*
4	Ca	0.00*	12	Illite	0.00*
5	Cr	0.03*	13	Kaolinite	0.01*
6	Co	0.00*	14	X_{LF}	0.03*
7	Mg	0.00*	15	X_{FD}	0.00*
8	K	0.01*			

Table 2 shows the different steps in addition of tracer parameters in differentiation function by Stepwise method and its effect on differential power of sediment sources. Wilks Lambda is a criteria of the ratio of inttragroup differences to intergroup differences.

Table 2. Different steps of entering tracers to model and their effect on differentiation of sediment sources.

step	The characteristic tracer of entered	Willks Lambda	Cumulative percentage of correct classification of samples
1	Cholorite	0.097	57.1
2	X_{FD}	0.049	75
3	N	0.024	82.1
4	Oc	0.004	92.9

Table 3 shows the relative importance of sediment sources in Amrovan Drainage Basin. According to this Table, Karaj Formation (EV) contributes %32.86, Quaternary unit (Q) %30.92, gully erosion %26.77, Shemshak Formation (Js) %4.69, Upper Red Formation (M1) %2.35 and Lar Formation (JI) %1.41 of sediment yield and have the highest contributions in sediment yield respectively. The relative error of the multivariate model which is used for the estimation of the share of sediment sources for each sediment sample is from 2.2 to 11.34 and its mean is 7. The mean efficiency coefficient of the model is 0.99. The low relative error and the high efficiency coefficient represents accuracy and efficiency of the model.

Table 3. The relative importance of sediment sources in Royan Drainage Basin

Sediment sources	Total share (%)
Upper Red Formation	2.35
Karaj Formation	32.86
Lar Formation	1.41
Shemshak Formation	4.69
gully Erosion	26.77
Quaternary unit	30.92

DISCUSSION AND CONCLUSION

Results show that Karaj Formation, Quaternary unit and gully erosion are three more important sources. Karaj Formation covers the high areas of basin, so it is the main sediment source. Quaternary Unit is located downstream and along the main drainage and its sediments enter the drainage directly and are not trapped in the way, so has the high contribution [4]. Gully erosion deprived of vegetations and is under active erosion.

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