Global J. Environ. Sci. Manage. 5(3): 383-398, Summer 2019

Global Journal of Environmental Science and Management
(GJESM)

Homepage: https://www.gjesm.net/

CASE STUDY

Erodibility and sedimentation potential of marly formations at watershed scale

F. Rostami[1], S. Feiznia[2,*], M. Aleali[1], M. Hashmati[3], B. Yousefi yegane[4]

[1]Department of Geology, Sciences and Research Branch, Islamic Azad University, Tehran, Iran

[2]Department of Range and Watershed Management, Faculty of Natural Resources,

College of Agriculture and Natural Resources, University of Tehran, Karaj, Iran

[3]Soil Conservation and Watershed Management Research Department, Kermanshah Agricultural and Natural Resources Research and Education Center, Agricultural Research, Education and Extension Organization, Kermanshah, Iran

[4]Department of Geology, Faculty of Science, Lorestan, University, Khoram Abad, Iran

ARTICLE INFO

Article History:
Received 06 December 2018
Revised 20 February 2019
Accepted 11 March 2019

Keywords:
Erosion
Gurpi Formation
Kashkan Formation
Kermanshah
Merk Watershed

ABSTRACT

Grupi and Kashkan marl formations comprise a considerable part of Zagros region. These formations have a considerable erodibility and sedimentation potential because of their special geological and mineralogical characteristics. The objective of this study was to compare the erosion and sediment yield of Kashkan and Grupi formations in Merk watershed located in southeast Kermanshah, using the Modified Pacific Southwest Inter-Agency Committee model. This model is suitable for estimating erosion and sediment intensity within each geomorphologic unit comprising nine effective environmental factors as geological, pedological, climate, runoff, topography, landcover, land use, surface and river erosion factors. The results indicated that Kashkan formation comprise siltstone, sandstone, shale and conglomerate, and Grupi formation contains shale, clay and limestone with a high erodibility potential. Field measurements and soil samples analysis for effective factors releaved that sediment yield for Merek watershed was 18080.6 m^3/ha/y. Fortermore, field measurement and soil sampls analysis for effective factors releaved that sediment yields for Kashkan and Gurpi were 7243.3 and 10837.5 m^3/ha/y, respectively. The reasons for erosion intensity and sedimentation in the two mentioned formations are slope, vegetation and land use in addition to the type of rocks in Kashkan and Gurpi formations which are predominantly marl and shale.

DOI: 10.22034/gjesm.2019.03.10

NUMBER OF REFERENCES
59

NUMBER OF FIGURES
5

NUMBER OF TABLES
7

*Corresponding Author:
Email: *sfeiz@ut.ac.ir*
Phone: +982632223044
Fax: +982632249313

Note: Discussion period for this manuscript open until October 1, 2019 on GJESM website at the “Show Article.

INTRODUCTION

The amount of erosion in rocky units and transportation of sediments by carriers to sedimentary basins are determinant factors of geomorphological features, aggregation allocations and/or repetitive replacements of sedimentary masses (Brown *et al.,* 2009; Sui *et al.,* 2009). Soil is one of the most important resources and erosion of its particles leads to reduction of productivity, debilitation of vegetation, destruction of natural ecosystems and intensification of desertification, especially in arid and semi-arid regions (Lewis *et al.,* 2009; Feng *et al.,* 2010). Erosion is a process in which soil particles are removed from their bed and transferred to another place with the help of a carrier like water, wind and glacier (Ouyang *et al.,* 2010). Land use change, weak vegetation and the formations sensitive to erosion (such as marl and shale which annually produce million tons of sediments) are among important factors involved in intensifying watershed erosion in Zagros mountain basins (Pirasteh *et al.,* 2008). These sediments are transferred due different factors and are deposited in plains and/or reservoir of dams. Soil erosion is affected by different factors like geology, morphology, petrology (minerology, texture and structure of rocks) and mutual impacts. One of the most important factors of soil collapse is water erosion which leads to impoverishment of soil, destruction of fertile soils, sedimentation and pollution of surface water (Altin, 2009; Karbassi and Pazoki, 2015; Aravind *et al.,* 2016). The role of geological and geomorphological studies in investigation of watershed is very significant. It is known that the behavior of geological formations are different against weathering factors and erosion from petrological and are also different in terms of resistance. Therefore, the forms produced by erosion are different from each other. As a result, formations can be prioritized based on sensitivity to erosion, sediment production and prepared erosion sensitivity maps. Different approaches for controlling or preventing from production and transfer of sediment to the main channel were presented using the prepared maps and combin of them (Jia *et al.,* 2011). The history of using mineralogy method on sediments for determining the amount of contribution of rocky units to sediment production dates back to 1998 when the method was used in Kardeh dam watershed in Mashhad and Cham sub-basin located in Zayandeh Rud watershed in Isfahan (Marani Barzani and Khairulmaini, 2013). In Kasilian watershed, sensitivity to erosion in geological units was estimated by sediment sampling and mineralogical and texture considerations. Then abundance of particles of different sediments was converted to sensitivity of petrological units and formations to erosion (Zia Abadi and Ahmadi, 2011). In Chahar Mahal and Bakhtiari watershed, three factors of geology, slope and climate were the most effective factors in erosion and sensitivity of geological formations. In this watershed, sedimentation was studied based on the three mentioned factors and combination of them, and sensitivity of geological formations prior to quaternary was studied by Selby method (Masoumi *et al.,* 2014). Study of Cachoyeh watershed in Shiraz by mineralogical method determined that sensitive units to erosion are mainly located in the east and southeast areas and most of the watershed area is covered by the units with higher resistance to erosion (Zarei and Amiri, 2017). Main and secondary elements in tropical sediments of Terengganu lake watershed in Malaysia were considered using the geochemical method. Among the considered elements, molybdenum density and iron showed five times increase along upstream to downstream of lake (Sultan and Shazili, 2011). Estimation of the amount of sedimentation and preparation of the precipitation potential maps were executed by different methods. The amount of sedimentation is determined by mutual effect of erosivity power of erosive factor, erodibility limit of geological materials, land slope and land use. Among the factors affecting erosion, geological materials have different erosion intensities and their amount of erodibility depends on petrological features and geological structures such as folding (Santis *et al.,* 2010). In arid and semi-arid conditions and in abcence of hydrometer stations in most of the states, the Modified Pacific Southwest Inter-Agency Committee (MPSIAC) modified model can be used as an experimental model with relatively suitable accuracy in evaluating the erosion of basins which have no information (Abedian *et al.,* 2017). This model comprises erodibility and erosivity factors including topography, climate, run-off, lithology, soil (K factor from USEL), vegetation, land use, upland erosion, and gully erosion. MPSIAC is calculated by summation of all its factors for fairly accurate and reliable estimation at the catchment scale in the semi-arid regions (Vente and Poesen, 2005). The model validated in Zagros Mountain (near the study area) by Safamanesh *et al.*

(2006) and the obtained results showed its significant correlation with the actual field records (sediment yield) and suitablity for estimation of erosion intensity and sediment yield at the catchment scale. Furthermore, this model was validated based on suspended sediment and discharge during a period of 22 years. Sedimentation of petrological units of zones and geological periods in Salt Lake watershed show that maximum sediments are related to tertiary period. In this period, the maximum development of marl categories is observed (Khalilian and Shahvari, 2018). Marl formations of Ghasre Shirin and Somar are geologically studied, and the relation among the erosion forms with mineralogical features of marls were presented (Feiznia *et al.,* 2007). The obtained results indicated that the type of formation had the highest impact on appearance of different shapes of erosion, especially clay percent and its salts. Physical and mechanical characteristics of clay marl rocks were investigated by Asghari Saraskanrouda *et al.* (2017). This study showed that by increase of carbonate in clay marl rocks, their physical and mechanical characteristics are improved. Physicochemical features of marls and shapes of the occurred erosion show that sheet erosion in non-pervasive marls and rill and also gully erosions are widespread in different types of pervasive soils (Sokouti and Razagi, 2015). Soil erosion and sedimentation of Toroq watershed were estimated by the MPSIAC model, and they were classified to three classes of low, average and high based on erosive classes and precipitation intensity (Mansouri Daneshvar and Bagherzadeh, 2012). Estimation of erosion and sediment by satellite data and geographical information system revealed that major part of Zyarat watershed falls within the average class based on the qualitative classification of the MPSIAC model (Abdolahzadeh *et al.,* 2017). Results from estimating the amount of erosion and production rate of sediment by the MPSIAC method in watershed of Shurijeh dam demonstrated that about 37.64 m^3 sediment was produced per 1 km^2 annually (Tajgardan *et al.,* 2008). In Aydugmush watershed, soil and sediment erosion was presented using the MPSIAC model and RS and GIS technologies. Results showed that 251,000,000 kg soil was removed from the basin because of water erosion. In other words, in Aydugmush watershed, 475 tons of soil was destroyed per 1 Km^2 annually (Daneshfaraz *et al.,* 2017). The objective of this study was to compare the erodibility and sedimentation potential of two marly formations (Kashkan and Gurpi). This study was carried out in Merek catchment, Zagros region in 2018.

Study area

The study area is located in 35 km southeast of Kermanshah, Iran. Merk watershed, with an area of 1466.15 km^2, lies between latitudes 34° 35′ and 34° 41′ N and longitudes 46° 30′ and 47° 25′ E. This watershed is one of the most important sub-watersheds of Qarasoo and Karkheh rivers which joins Gharasoo River from western and northern parts. Merk watershed is located in a relatively mountainous region as 37.9% of its land is mountains and hills. The area has provided a good climate owing to an average altitude of 1,524 m above sea level. The highest and lowest altitudes of this basin are 2,820 m (Sefidkooh) and 1,440 m (watershed output in the Merk River) above sea level, respectively. Also, the geological diversity of its formations, including marl formations, due to its mineralogical characteristics, slip and gully erosion, have made it a good candidate for inappropriate use such as deforestation, grazing and agricultural activities (Fig. 1).

MATERIALS AND METHODS

In this study, the basic map of the studied basin was prepared based on topography and geological maps of Kermanshah with scales of 1:100000 and 1:250000. Slope, cover, land use and field control were used as data layers needed for determining the limit of marl and shale formations.

Filed visit

Early field control of border of Gurpi and Kashkan formations and region measurement (from top to down of formation) were executed to determine sampling points by GPS. Filed observations include particle size, texture, structure, color and sequence etc. Obsevations were done in outcrop region of each formation and sedimentary facies codes in formations were determined and labeled based on the classification in Miall, (1996) method.

Sampling

Sampling from formation layers was executed on roadside (depth of 3-4 m of road trench) and deep waterways. In this phase, removing surface soil from the formation layers, in which texture and color changes were obvious, was performed. In case of

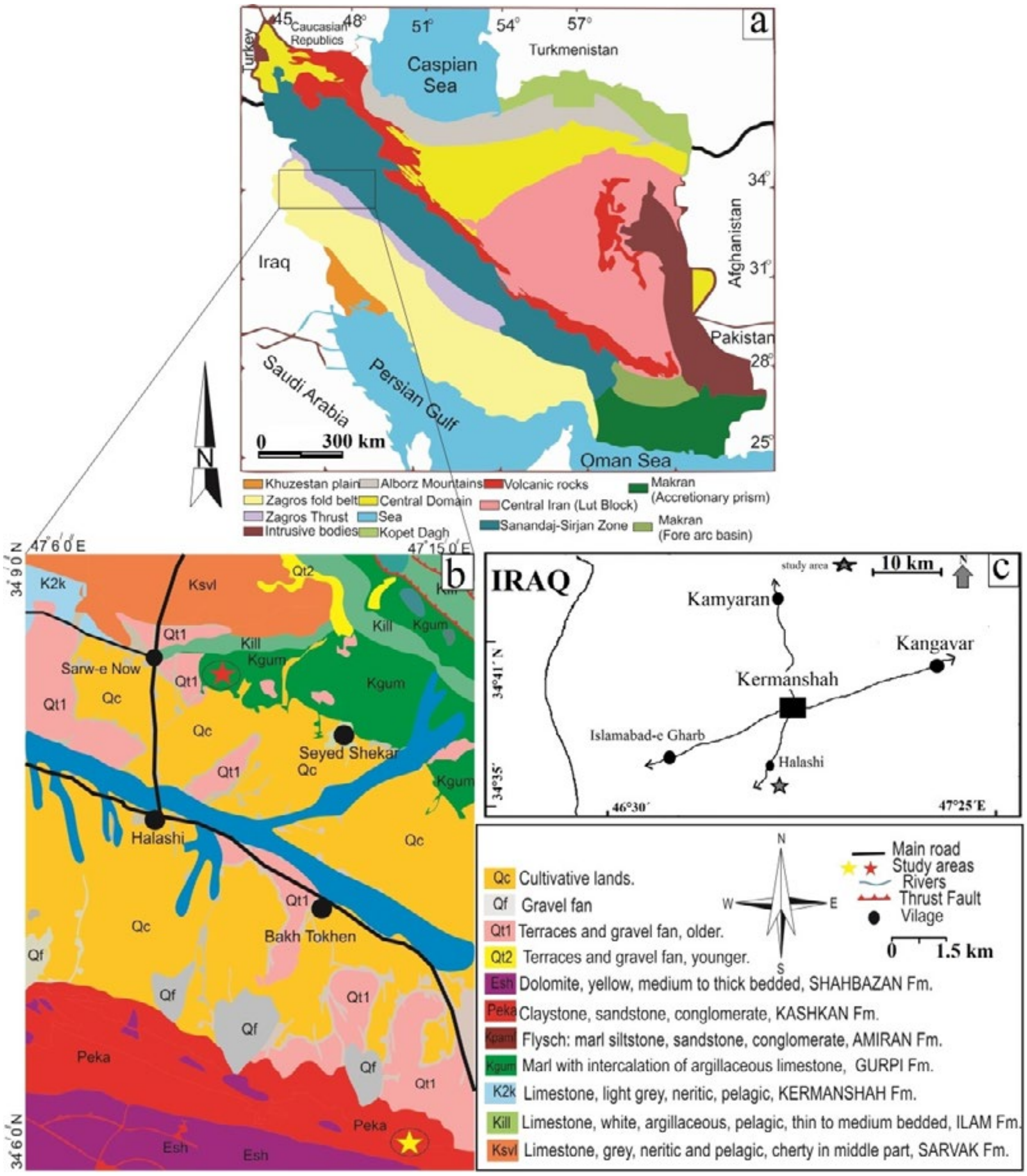

Fig. 1. Geological location of the study area and sampling locations in Merek catchment, Zagros region, Iran, adapted from the map of 1.100000 of Kermanshah (Karimi Bavandpoor and Haj Hoseini, 1999)

monotony, the samples were removed separately in each meter. Soil sampling was performed in depth of 0 to 20 cm of geomorphological facies for soil erodibility experiments (K factor) by the MPSIAC model. It included soil texture, fine gravel percent, organic and structure carbon and followed by experiments in pedology lab as well as consideration of geomorphological facies and sensitivity of rocky units of Grupi and Kashkan formations in the study area. Coordinates of the sampling area was determined by GPS and each sample was codified.

Experiment method

Samples were tested for sieve analysis and mineralogical tests. Sieve analysis was executed using pedological standard sieves (wet grading) and a hydrometer (Gee and Bouder, 1986). Moreover, mineralogy was performed by x-ray diffraction. Results fom sieve analysis and hydrometer were analyzed by Gradistat software and the needed data were obtained. Values of lime, plaster, electrical guide and organic materials were determined and calculation of total of chemical and destructive parts of each sample was done (Carter and Gregorich, 2008).

Sediment and erosion estimation method

Erosion intensity of geomorphological facies was estimated by Johnson and Gebhardt's (1982) modified PSIAC method. In this method, using basic map and other data, current maps and situation control of facies were prepared by GPS device in nature, and also the scores of nine effective factors, including geological, pedological, climate, runoff, topography, land cover, land use, surface and river erosion factors, in all facies were determined. Then, precipitation degree in all facies was achieved based on their area ration in the whole basin. Finally, sediment amount was calculated by placing the obtained amount in respective relation.

RESULTS AND DISCUTION

Gurpi and Kashkan formations

The study area is placed in two structural limits of fold-thrust Zagros zone (Fig.1). For this reason, formations of the region are diverse. Based on the geological map of the region and field observations, Kashkan watershed has outcrop with south side,

Table 1. Specifications of Kashkan and Gurpi formations in the study area

Era	Age	Formation	Area		Min litology properties
			ha	%	
Cenozoic	Eocene	Kashkan	2807.13	12.15	Claystone, siltstone and sandstone with middle layer of conglomerate
Mesozoic	Upercretaceous	Gurpi	2835.40	12.30	Shale, marlstone with middle layer of argillaceous and finelimestone

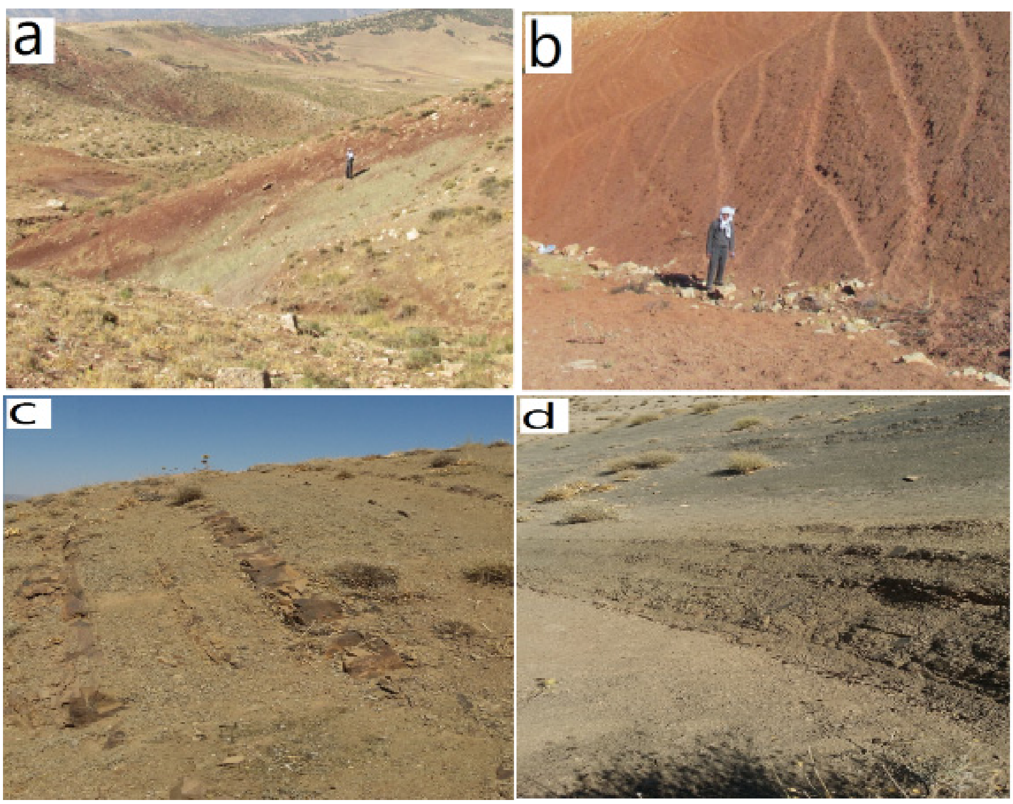

Fig. 2. Green and red siltstone units of Kashkan formation (a, b), shale and marl units of Gurpi Formation (c, d).

jungle use and dry-faming with isoclinic shape in Merk watershed. Field considerations show that deposits of the formation have alluvial terrace shape with moderate slope and agricultural use. Grupi formation is also parallel with Kashkan formation and its domains include agricultural lands. The percentages of the two formations is 12.15 and 12.30, respectively (Table 1 and Fig. 2).

Sedimentary facies in Gurpi and Kashkan formations

In this study, 5 rocky facies Gm, Sm, Fm, Fl, P were identified in Kashkan formation. The sediments in classification (Folk, 1974) were sandy silt, silt, sandy loam, and silty sand. In Gurpi formation, facies were alternatively identified from shale and marl with interlayers of lime. According to naming by Pettijohn *et al.* (1975), the three categories from maximum to minimum were chemical sediment with destructive materials (50%), marl (27.27%) and small destructive sediment with chemical salts (22.72%). Based on grading results, most of the two formations consisted of marl and granule shale (Table 2).

Geomorphological facies

Based on geomorphological maps, Kashkan and Gurpi formations have 5 and 8 facies in the study area, respectively. Nine factors involved in erosion of the formations were evaluated separately. Type of erosion in the regions where agriculture is performed was gully and rill. Types of erosion in rangelands of Kashkan formation was sliding and soil piping and in Gurpi formation was sheet. In forest region of Kashkan formation, type of erosion was piping and sliding (Table 3).

Mineralogical charectistics

Current minerals in Gurpi and Kashkan formations are smectite, kaolinte, lignite, quartz, calcite and dolomite. Peak curves of x-ray were obtained as 14.80, 10.47, 7.28, 4.48, 2.28, and 1.80 (Fig. 3). The smectite is dominant clay mineral in most parts of Zagros region (Owliaie *et al,* 2006). The difference among smectite, mica and vermiculite can be clearly determioned by XRD analysis (Borchardt, 1989). The amount of smectite and lignite minerals was higher in Kashkan formation than in Gurpi formation. However, the amount of kaolin was higher in Gurpi formation than in Kashkan formation. Clay minerals, especially smectite group, have a significant role in development of erosion. This group of clay minerals

Table 2. Sedimentary facies of Kashkan formation in the study area.

Lithofacies	Code	Description
Gravel	Gm	Grain-supported conglomerate, without depositional structure
Sandstone	Sm	Gray sand with purple shale
	Fm	Gray shale, limonite stratas and purple and green siltstones
Mud	FL	Thin laminae of mud, green rocks
	p	Clacrete or old soils

Table 3. Geomorphologic facies of Kashkan and Gurpi formations in the study area.

Formation	Facies	Topographic				Feature	Area	
		Slope (%)	Aspect	Altitude (m)	Land use	Erosion	ha	%
Kashkan	A_1	10 - 20	N	1600 - 1800	Rainfed cereal	Gully	406.77	7.19
	R_1	20 - 40	N	1600- 1800	Grazing	Piping-Landslide	243.97	4.30
	R_2	10 - 20	N	1600- 1800	Grazing	landslide	536.74	9.47
	F_1	10 - 20	N	1500- 1600	Illegal grazing	Piping-Landslide	170.00	2.99
	F_2	10- 20	N	1600 - 1800	Illegal grazing	Piping-Landslide	556.02	9.81
Gurpi	A_2	10 – 20	S	1600 – 1800	Rainfed cereal	Rill erosion	1054.22	18.60
	A_3	5-10	P	1420 - 1600	Cereal	Gully	884.75	15.61
	A_4	10 – 20	S	1420 – 1600	Rainfed cereal	Gully	556.54	9.82
	A_5	10 -20	N	1600 - 1800	Irrigated crops	Inter-rill – gully	208.75	3.68
	R_3	10 - 20	S	1500 - 1600	Grazing	Rill - sheet	340.55	6
	R_4	> 40	W	2200 - 2400	Wild live	Snow	292.75	5.16
	R_5	> 40	S	2000 - 2200	Grazing	Sheet – inter-rill	249.83	4.40
	R_6	10 -20	S	1600- 1800	Grazing	Piping- landslide	166.00	2.92
	Total						5666.89	100

A = Agriculture, R = Rangeland, F = Forest, P = Plain, S = South, N = North, W = West

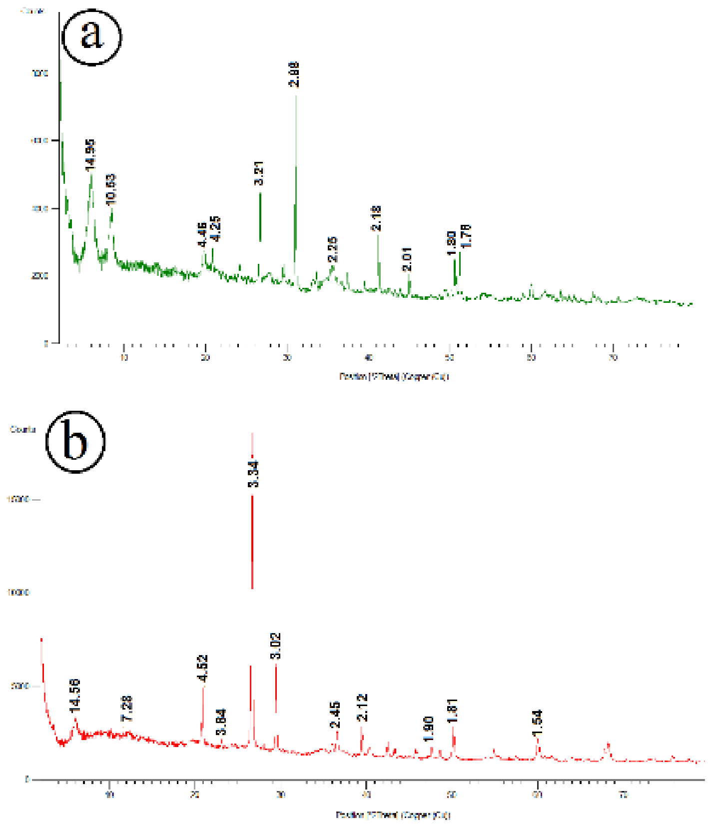

Fig. 3. Sample of X-ray diffractogram of Kashkan (a), Gurpi (b) formations

Table 4. Comparison of minerals in Kashkan and Gurpi formations in the study area

Minerals	Abundance	
Formation	Kashkan	Gurpi
Smectite	24.70	15.94
Ilite	43.11	10.09
Kaolinite	10.71	12.87
Quartz	19.47	28.42
Feldspar	5.42	8.18
Calcit	16.77	22.23
Dolomit	15.28	22.32

is responsible for dispersion of fine-grained soils, reduction of permeability, especially in presence of sodium ion, and finally intensified erosion (Piccarreta *et al.,* 2006). Water absorption and loss in smectite leads to divergence phenomena as early phase of creep and slip phenomenon and rill and piping erosion in which the resulted seam leads to attraction of surface flows and facilitates their penetation into underneath layers (Liu *et al.,* 2008) (Table 4).

Estimating the erodibility and sedimentation using the MPSIAC model

The PSIAC modified method (MPSIAC) was employed for estimating erosion and sedimentation in all facies of Kashkan and Gurpi formations and nine indexes were obtained based on scoring.

Surface geological or petrological factors

According to the geological studies in the region and the MPSIAC model, different rocks were scored based on sensitivity to erosion. Kashkan formation includes siltstone and shale and Gurpi formation consists of shale and marl, both of which are the rocks with high erodibility. Average geological factors in Kashakn and Gurpi formations are 8 and in 7.25 respectively (Table 6). Basins with marl lithology have a higher sedimentary load compared to the basins schist, limestone and sandstone lithology (Sokouti and Razagi, 2015). Zarei and Amiri (2017) calculated the suspended load in some watersheds in Iran (Minab, Sefidrud, Shahrud, Sorkhab, Hablerud and Daryan Chai) and found that basins with high suspended sediment load have a marl-sensitive lithology. They included that sensitive formations are responsible for high sedimentation especially in marl lands.

Soil factor

To score this factor, first, the intensity of soil erodibility in region K was calculated depending on 5 criteria of percentage of gravel and silt, percentage of organic material, permeability percentage and soil structure. Based on the field studies and pedological experiments, the factors related to K were determined. Accordingly, silt was found as the prevailing part of the soil in the study area. In forest region, silt amount is low and sand amount is high. The main reason for sedimentation in marl units is high abundance of silt compared to sand and clay. Erosion increases with the increase of silt in soil because of lack of viscosity in silt (Maquaire, 2003). Generally, silt is broken because of dampening grained soils and the removed and transferred silt particles produce more sediment. While sand particles are resistant to transfer because of greater size, small particles of clay are resistant to removal because of continuity and

Table 5. Soil factor in Kashkan and Gurpi formations in the study area

Formation	Facies	%Coarse sand (0.1-2.0 mm)	Silt	Fine sand	Silt + fine sand	%Organic matter	Structure	Permeability		K factor (from RUSLE)
								mm/h	class	
Kashka	A_1	7.1	48.5	7.9	56.4	1.50	Medium angular	2.5 - 5	5	0.28
	R_1	5.4	44.6	8.0	52.6	2.10	Fine angular	2.5 - 5	5	0.27
	R_2	5.5	40.3	6.7	47.0	3.10	very fine angular	2.5 - 5	5	0.27
	F_1	8.3	35.6	8.1	43.7	4.50	very fine granular	<2.5	6	0.19
	F_2	10.7	37.6	9.0	46.6	3.72	very fine granular	<2.5	6	0.23
Average		7.4	41.3	7.9	49.2	2.98	-	-	-	-
Gurpi	A_2	9.7	40.1	9.5	47.3	2.61	Fine angular	2.5 - 5	5	0.27
	A_3	8.7	40.0	6.3	46.3	2.24	Massive	<2.5	6	0.27
	A_4	6.4	52.0	7.1	59.1	2.34	Massive	5 – 10	4	0.27
	A_5	4.1	71.0	3.9	74.9	3.40	Massive	5 – 10	4	0.27
	R_3	13.3	40.2	10.4	50.6	2.61	Fine blocky	10 - 20	3	0.27
	R_4	6.7	41.0	6.3	47.3	1.90	Coarse angular	2.5 - 5	5	0.27
	R_5	8.5	43.3	7.5	50.7	1.98	Coarse angular	2.5 - 5	5	0.27
	R_6	16.0	34.0	12.5	46.5	1.55	Coarse angular	10 - 20	3	0.27
Average		9.17	45.2	7.9	52.8	2.32				

A= Agriculture, R= Rangeland, F = Forest

Table 6. Comparison of the 9 factors involved in erosion and precipitation of different facies of Kashkan and Gurpi formations in the study area

Formation	Land Unit	Scoring MSIAC factors									
		1	2	3	4	5	6	7	8	9	Total
Kashka	A_1	9	4.20	5.64	11.50	3.50	6.5	10.20	17.25	11.69	79.48
	R_1	6	3.36	5.64	9.20	9.90	3.4	10	15.30	3.36	66.16
	R_2	9	5.21	5.64	7.52	14.85	4.2	12	20.25	13.6	97.27
	F_1	9	3.17	5.64	7.19	3.20	4.7	9.50	16.58	11.68	70.66
	F_2	9	3.81	5.64	8.45	8.21	5.8	11.3	19.7	11.7	83.61
Average		8	3.95	5.64	8.77	7.93	4.92	10.6	17.81	10.40	79.43
Gurpi	A_2	8	4.48	5.64	10.20	3.60	4.5	13.6	15.25	10.2	75.47
	A_3	8	4.10	5.64	11.90	3.30	6.6	12.4	15.25	8.38	75.57
	A_4	8	4.50	5.64	9.80	3.40	6.4	10.2	15.25	8.32	71.51
	A_5	7	3.10	5.64	8.20	5.94	4	11.2	15.25	7.70	68.03
	R_3	7	4.85	5.64	9.50	6.90	6.1	10	19.25	6.68	76.02
	R_4	5	4.20	5.64	13.20	10.89	4.3	9.8	11.50	0	64.53
	R_5	6	3.70	5.64	8.50	8.91	4	12.5	15	3.5	67.75
	R_6	9	3.70	5.64	12.50	8.25	8	13	20.50	13.36	94.12
Average		7.25	4.07	5.64	10.47	6.39	5.48	11.58	15.90	6.64	74.12

A= Agriculture, R= Rangeland, F = Forest viscosity among particles (Canga *et al.,* 1999). Stronger vegetation in forest region led to further protection of organic material and moisture, increase of building stability and reduction of soil erosion compared to adjacent rangelands. In the rangelands with grazing, cattle-broken grained soils, ventilation of soil and acceleration of organic materials oxidation, soil has more vulnerability against erosion. In agricultural lands, cultivation reduces the soil organic carbon in a short period, but erosion and change in distribution of particles size occure in a long time. Geissen *et al.* (2009) reported lower clay and higher sand in rangelands compared to seasonal cultivation regions. Calculations indicated a lower K value in Kashkan formation than in Gurpi formation. This can be attributed to the existence of the forest facies with lowe-permeability soils as compared to agricultural and rangelands facies in terms of building and texture (Table 5).

Weather

Weather factor is achieved for relationship $Y_3=0.2X_3$, in which X_3 is the maximum rainfall in 6 h with return period of 2 years near the metrological station (synoptic station of Kermanshah). Weather factor of 5.64 for all facies shows the rainfall with average period and intensity (Sereda *et al.,* 2011). Studies show that by increase of degree, climatic variables are intensified in summer, arid and semi-arid regions become warmer and the volume and intensity of surface runoff are reducd (Booij, 2005).

Runoff

Runoff factor was achieved in facies of Kashkan and Gurpi formations using Merk watershed data. Facies of Kashkan Gurpi formations ranged 7-11.30 and 8.50-11.90 repectively. Average runoff factors for Kashkan and Gurpi formations were 8.77 and 10.47 repectively. It means that Gurpi formation has further runoff volume because of weak vegetation (Table 6). However, runoff volume has no significant relationship with erosion because erosion depends on

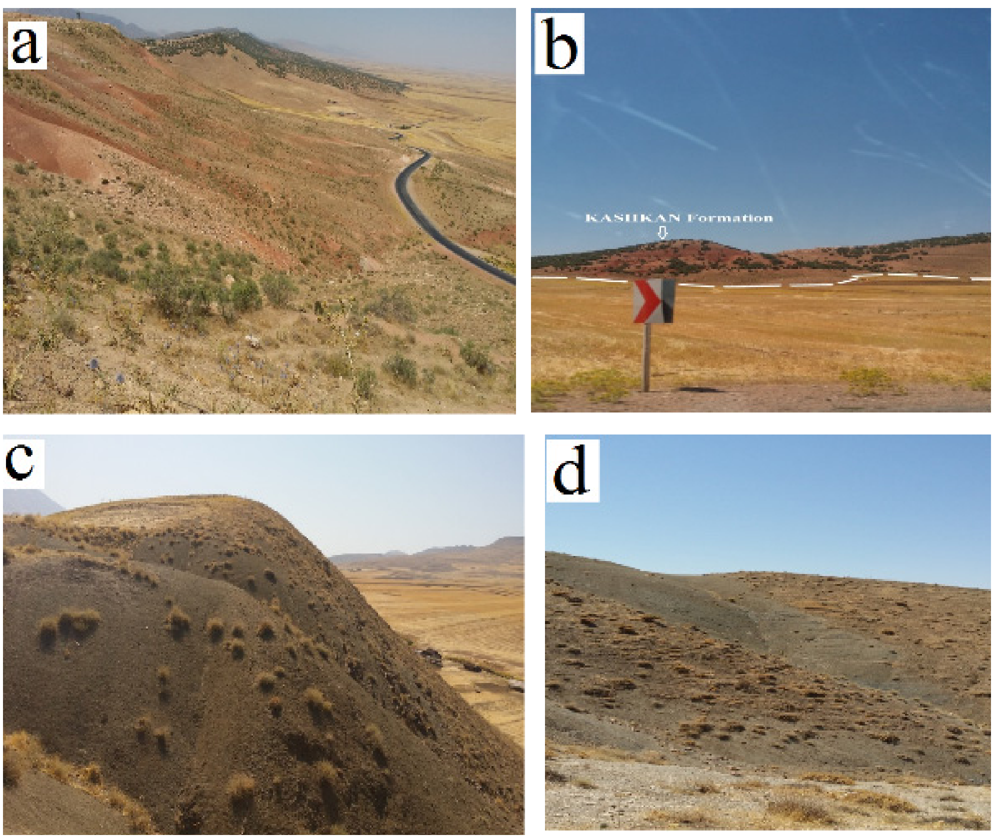

Fig. 4. Vegetation in Kashkan (a,b) and Gurpi (c,d) formations

other factors like soil texture (especially clay and silt), chemical characteristics, ground slope and climatic factors. Measuring runoff amount, removed soil and soil losses for different soils, Medinipur, West Bengal, India indicated found that runoff and sediment density were variable in different soils (Shit *et al.,* 2016). Levy *et al.* (1994) reported that higher or lower changes in runoff and sediment amounts has a linear relationship with annual rainfall. Niu *et al.* (2015) showed that slope, vegetation and soil type affect runoff and erosion significantly. Moreover, runoff has a positive correlation with soil waste, maximum runoff and erosion in terraces with steep slope. This can be attributed to different results because of difference in soil type and lack of vegetation. Cerda (2002) claimed that nature of parental materials has a basic role in hydrologic phenomena and erosion.

Topographical condition

In the study area, the obtained scores were 3.30-5.94 for slope of 10-18 in the agricultural lands, 6.90-18.45 for slope of 50-45 in the rangelands, and 8.21-3.20 for the slope of 9-24 in the forst regions. After final calculation, the average factors for Kashkan and Gurpi formations were obtained as 7.93 and 6.39, respectively (Table 6). Slope is one of features that has a high correlation with soil type and erosion (Karaş and Oğuz, 2017). Surface speed and erodibility power increase in very steep slopes. This can be attributed to reduction of permeability and increase of runoff volume in slopes (Ekwue and Harrilal, 2010). The effect of slope has been investigated and confirmed in different studies and resources (Metternich and Gonzales 2005; Toy *et al.,* 2002). Slope is one of the important factors, which affects the slot in domains. Rill erosion develops by the increase of degree and length of slope and consequently increases the speed, volume and discharge of runoff (Zhang *et al.,* 2008).

Land cover

Both formations are considered to be weak in terms of vegetation (Fig. 4). Maximum and minimum values were obtained in rangelands of Kashkan and Gurpi forrmations, respectively. The percentage of bare land is lower in Kashkan formation than in Gurpi formation. After calculations, values of the factors for Kashkan and Gurpi formations were obtained as 4.92 and 5.48, respectively (Table 6). Vegetation is a significant factor which controls intensity and abundance of surface flow and surface soil erosion (Garcia-Ruiz, 2010). Moreover, it is significant in reducing rill erosion, protects soil from rainfall and acts as a barrier against water flow. Root mass also keeps soil particles in their place. Usually when soil surface is covered with different barriers (such as pebbles, plant remainders, especially from different plant types), flow, early speed of flow and erosion are low (Giménez and Govers, 2008).

Land use

To determine the score of land use, two scores for agricultural region and cattle grazing are evaluated. The maximum percent of land use (13.6%) belongs to the agricultural region in Gurpi formation and the minimum percent (9.5%) belongs to the forest region in Kashkan fomation. Average scores of this factor for Kashkan and Gurpi formations are 10.6 and 11.58, respectively, indicating the topography of formations and a more expanded under-cultivation area in Gurpi formation compared to Kashkan formation (Table 6). Type of land use has a significant role in time, place, changes in features and soil quality (Zhao *et al.,* 2013). Bakker *et al.* (2004) reported that agricultural activities increase surface runoff and soil waste. On the other hand, cattle increases soil compression and destruction of soil structure and consequently reduces the diameter of grained soil weight average. The results obtained by Niu *et al.* (2015) are similar to the results achieved in the presnt study.

Erosion

First, seven factors presented in Bureau of Land Management (B.L.M) method were scored for all the facies using shape map, erosive facies and current data (Table 6). Then, the scores of current erosion in Kashkan and Gurpi formations were determined as 17.88 and 15.90, respectively. The rock type and topography in Kashkan formation had a geater impact compared to the Gurpi formation. Field observations showed different types of water erosion, especially surface, rill and gully, stream, wasting and bank erosion in basin surface. It was observed that the streams in domains with high slope and grazing connect to moats in downstream (Fig. 5). Gully erosion is one of the main reasons for soil waste in agricultural lands (Shit *et al.,* 2016). In addition to

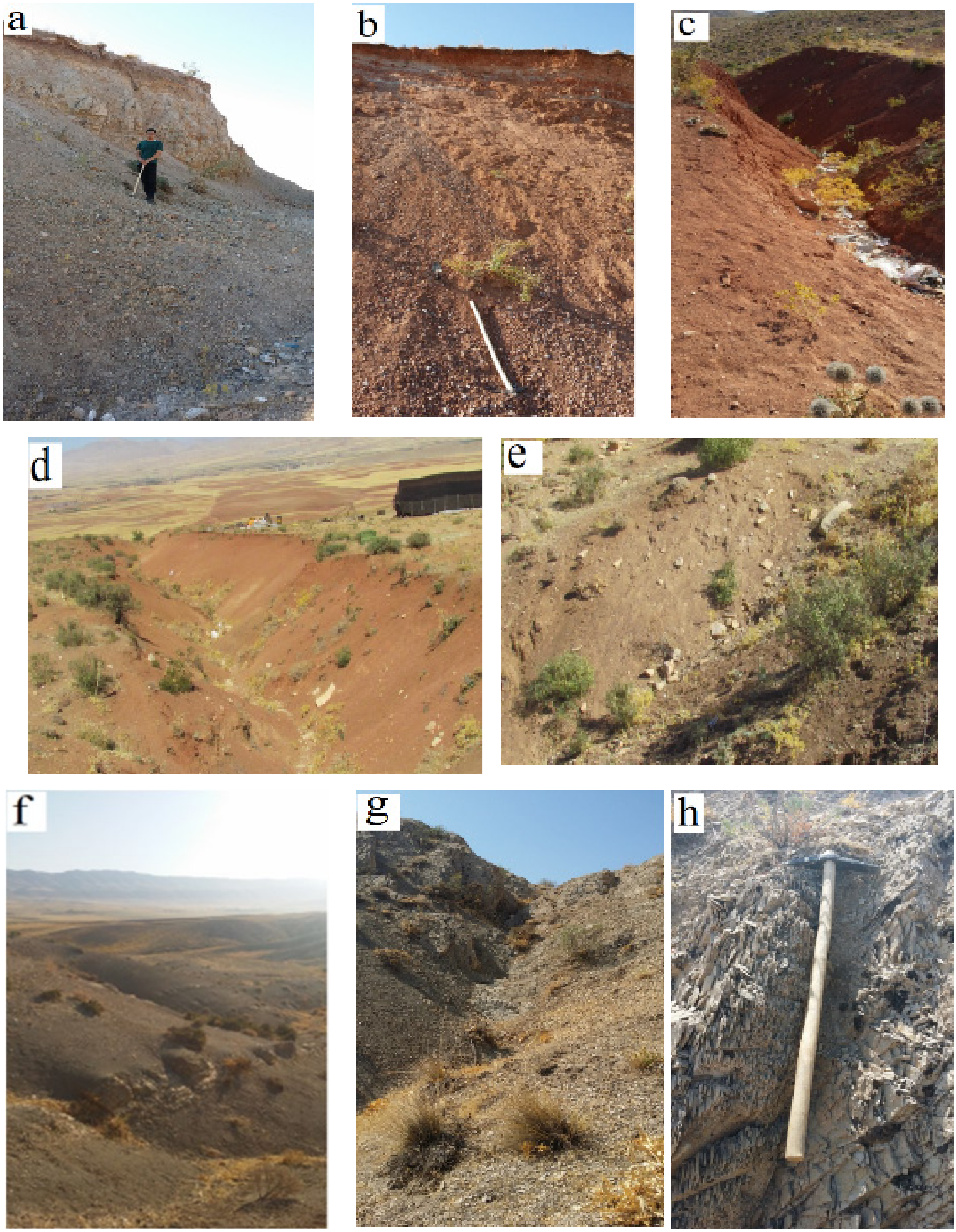

Fig. 5. Types of erosion in Kashkan formation. slip (a), rill and superficial (b), gully (c,d,e), and types of erosion in Gurpi formation. rill and superficial (f), rill (g), sheet (h).

Table 7. Depositional and erosion intensity in facies of Kashkan and Gurpi formations in the study area

F	Land-use	Area (ha)	Total Score	Erosion			Sediment yield degradation		
				$M^3/Km^2/Y$	intensity	class	$M^3/Km^2/Y$	intensity	Class
K	A_1	421	79.48	1510.1	High	IV	1135.6	High	IV
	R_1	250	66.15	1146.8	medium	III	420	medium	III
	R_2	550	93.27	1772.1	High	IV	1322.8	High	IV
	F_1	170	70.66	1224.8	medium	III	448.5	medium	III
	F_2	555.60	83.66	1589.5	High	IV	1195.8	High	IV
	Total	1946.6	78.64	7243.3	High	IV	4522.7	High	IV
G	A_2	1091.12	75.39	1434.4	High	IV	1077.3	High	IV
	A_3	915.70	75.57	1448.9	High	IV	1089.8	High	IV
	A_4	576	71.52	1239.7	medium	III	453	medium	III
	A_5	216.10	67.94	1177.6	medium	III	431.2	medium	III
	R_3	350	75.92	1457.3	High	IV	1084.9	High	IV
	R_4	300	64.44	1117	medium	III	409	medium	III
	R_5	256	67.75	1174.3	medium	III	430	medium	III
	R_6	170	94.12	1788.3	High	IV	1327.3	High	IV
	Total	3874.92	74.08	10837.5	High	IV	6302.5	High	IV

F= Formation, K= Kashkan, G= Gurpi, A= Agriculture, R= Rangeland, F = Forest

agricultural lands, Gully erosion was observed in other lands which were sensitive to erosion. Sensitive formations to erosion, high soil erodibility and weak vegetation provide a good condition for occurrence of central flows on domains, especially during rainfalls (Niu et al., 2015). According to the findings by Conforti *et al.* (2011), the amount of rill erosion is affected by many factors such as lithological combination, land use, torsion value, runoff power, length ratio, waterway slope and ground moisture. Moreover, Vandekerckhove *et al.* (2000) reported that the difference in the factors forming chasms in two regions is not only related to different lithological features and different topography but also stems from different climate conditions.

River erosion

Erosion of river bank and sediment transfer by floodwater were evaluated in this study. Considering the intensity of erosion in each facies and their scoring in Merk watershed, the values for this factor were determined. Results of calculations show that the maximum and minimum values for this factor are obtained in rangelands. The values of this factor in Kashkan and Gurpi formations were averagely 10.40 and 6.64, respectively (Table 6). Different erosive shapes in Kashkan formation, based on significance, include sliding erosion and gully erosion in rough hill lands and low slope deposits, respectively. Surface and rill erosion as well as sheet and sliding erosion are detected in Gurpi formation. Widespread type of erosion in both formations is surface erosion with low, average and high intensities. The most important factor in surface erosion is surface flow from rainfall and lack of sufficient vegetation. Since type of erosion is related to rock type, sliding erosion is common in Kashkan formation which consists sandstone, shale and siltstone. However, surface and rill erosions are common in Gurpi formation which is composed of marl and shale. Dute to lack of suitable vegetation and greate impact of cloudbursts, especially in arid months, intensity of erosions is high. The extent of gully erosion in Gurpi formation is low unlike Kashkan formation. Agricultural activities, excessive grazing and inappropriate irrigation system increase the intensity and depth of rill and stream erosions and consequently lead to moat formation (Fig. 5). Among nine factors in the MPSIAC model, erosion factor has a high impact on Kashkan formation. Bagherzadeh and Mansouri Daneshvar (2013), investigated sedimentation, soil erosion and priority of erosive factors and finally concluded that land use, geology and soil cover are the most important factors in estimating erosion in the MPSIAC model. Importance of the nine factors involved in erosion of Kashkan and Gurpi formations (current condition of erosion, geology, topography, weather, vegetation and soil) was investigated. Among them, six factors had a similar impact on erosion in terms of priority.

Kashkan and Gurpi formations cover 24.45% of whole Merk watershed. Caslculation of the nine factors for each facies demonstrated that erosion in Kashakn formation is higher than in Gurpi formation. After calculating the nine factors and the total scores for determining the amount of erosion and sedimentation in geomorphological basin and facies of Kashakn and Gurpi formations, the relation between degree of sedimentation and amount of sedimentation was used for calculating the amount of sedimentation degree (Table 7). The maximum amount of sedimentation in facies, agricultural land and rangeland was related to Kashakn formation. Both formations cover about 5812.52 hectares of the whole area. From this area, 5086.92 hectares (about 87.5%) and 725.6 hectares (about 12.48%) are placed in average level and high level of sediment production. Both formations produce an amount of 18080.6 m^3/ha/y sediments. The main reason for erosion is sensitivity of rocky units to erosion (marl and shale formation) because marls are highly sensitive to erosion and weathering and have a significant role in sedimentation of watershed. Marl formation in watersheds of Iran has been always a challenging issue and it is known as one of the important resources of sediment production. Different types of erosion, including surface, gully, rill and piping erosions, occur in these lands. Studies on sedimentation in watersheds show the basic role of marl formation in sediment production. Lack of vegetation in terms of lithological condition and slope are two important factors for basin erosion. Based on the results, degree or intensity of sedimentation in different facies varies from 1117 to1788.3 m^3/ha/y, with the maximum and minimum amounts occurring in rangeland facies of Kashkan and Gurpi formations respectively. It was found that Kashkan formation has more sedimentation (4522.7 m^3/ha/y) than Gurpi formation (1327.3 m^3/ha/y) (Table 7). Generally, different factors (such as geology, climate, slope, weathering and tectonic) affect erosion and sedimentation. Among them, geology, slope vegetation and land use are the most important factors involved in erosion of the study area. In watershed of Chahar Mahal and Bakhtiari province, geology was the most important factor in erosion (Masoumi *et al.*, 2014). Bagherzadeh and Mansouri Daneshvar (2013) also calculated the erosion in Golestan watershed using PSIAC and MPSIAC models and concluded that the values obtained by MPSIAC model were more close to reality.

CONCLUSION

Marl formations of Kashkan and Gurpi cover a considerable part of Zagros region. Because of their special geological and mineralogical features, they have a high potential for erodibility and sedimentation. The aim of this study was to calculate the amount of erosion in the mentioned formations in Merk watershed, Kermanshah using the MPSIAC model. It was found that about 4053.42 and 1768.1 hectares of the study area were in high level and average level of sediment production, respectively. Agriculture facies of Kashkan and Gurpi formations had the maximum (79/48%) and the minimum (63.73%) erosions, respectively. Moreover, rangeland facies of Gurpi formation had the maximum (94.12%) and the minimum (64.44%) erosions. Forest facies of Kashkan formation showed the maximum erosion (83.66%). Both formations had a total of 18080.8 m3/ha/y erosion. The factors such as slope, vegetation and land use along with type of rocks were found to be effective in erosion intensity and sedimentation in Kashakn and Gurpi formations which are composed of marl and shale.

ACKNOWLEDGEMENTS

The authors would like to extend their gratitude to all who assisted in conducting this wok and supported it.

CONFLICT OF INTERESTS

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

%	Percentage
B.L.M	Bureau of land management
cm	centimeter
E	East
Fig.	Figure
GPS	Global positioning system
h	hour

Ha	Hectare
K	Soil erodibility from RUSLE
K factor	Soil erosion coefficient
kg	Kilograms
km^2	square kilometer
m	Meter
m^3	Cubic meter
MPSIAC	Modified Pacific Southwest Inter-Agency Committee
N	North
PSIAC	Pacific Southwest Inter-Agency Committee
Rs	Remote sensing
X_3	6-hour rainfall intensity
XRD	X-ray diffractometer
Y	Year
Y_3	Weather factor

REFERENCES

Abdolahzadeh, A.; Ownegh, M.; Sadoddin, A.; Mostafazadeh, R., (2017). Comparison of two landslide-prone area determination methods in Ziarat Watershed, Golestan Province. J. Emergency Manage. 5(1): 5-13 **(9 pages).**

Abedian, S.; Salman Mahiny, A.; Karbakhsh Ravori, H., (2017). Estimating of erosion and sediment yield of Gorganrud basin using erosin potential method. Nat. Environ. Change 3(1): 19-32 **(14 pages).**

Altin, T., (2009). Pleistocene and Holocene fluvial development of the Ecemis Valley. Central Anatolia, Turkey, Q. Int., 204(1-2): 76-83 **(8 pages).**

Aravind, J.; Kanmani, P.; Sudha, G.; Balan, R., (2016). Optimization of chromium(VI) biosorption using gooseberry seeds by response surface methodology. Global J. Environ. Sci. Manage., 2(1): 61-68 **(8 pages).**

Asghari Saraskanroud, S; Zeinali, B; Mohammadnejad, V., (2017). Analysis physical and chemical properties of soil and morphometric impacts on gully erosion. Desert 22-2: 157-166 **(9 pages).**

Bagherzadeh, A.; Mansouri Daneshvar, M.A., (2013). Evaluation of sediment yield and soil loss by the MPSIAC model using GIS at Golestan watershed, northeast of Iran. Arabian J. Geosci. 6, 3349-3362 **(13 pages).**

Bakker, M.M; Govers, G; Rounsevell, M.D., (2004). The crop productivity-erosion relationship: an analysis based on experimental work. Catena, 57: 55–76 **(22 pages).**

Borchardt, G., (1989). Smectites, in: Bighman, J.M.; Dixon, J.B.; Milford, M.H.; Roth, C.B.; Weed, S.B. (Eds.), Minerals in Soil Environments. Soil Sci. Soc. Am., Madison, Washington, 728-767 **(40 pages).**

Brown, A.G.; Carey, C.; Erkens, G.; Fuchs, M.; Hoffmann, T.; Macaire, J.J.; Moldenhauer, K.M.; Walling, D.E., (2009). From sedimentary records to sediment budgets: multiple approaches to catchment sediment flux. Geomorphology, 108 (1-2): 35-47 **(12 pages).**

Booij, M.J., (2005). Impact of climate change on river flooding assessed with different spatial model resolutions. J. Hydrol. 303: 176-198 **(20 pages).**

Canga, M.R., (1999). Effects of subsequent simulated rainfall on runoff and erosion. Turk. J. Agric. For. 23:659-665 **(6 pages).**

Carter, M.R.; Gregorich, E.G., (2008). Soil sampling and methods of analysis, CRC Press, Taylor and Francis Group (**198 pages**).

Cerda, A., (2002). The effect of season and parent material on water erosion on highly eroded soil in eastern Spain. J. Arid. Environ. 52: 319-337 **(19 pages).**

Conforti, M.; Aucelli, P.C.; Robustelli, G.; Scarciglia, F., (2011). Geomorphology and GIS analysis for mapping gully erosion susceptibility in Turbolo stream Cat chment. Northern Calabria, Italy, Nat. Hazards., 56: 881- 898 **(18 pages).**

Daneshfaraz, R.; Rahmati, M.; Akbari Moghanjiq, P., (2017). Soil erosion and sediment mapping in Aidoghmoush watershed appling MPSIAC model and GIS and RS technologies. Environ. Resour. Res. 5: 35-49 **(14 pages).**

Ekwu, E.I.; Harrilal, A., (2010). Effect of soil type, peat, slope, compaction effort and their interactions on infiltration, runoff and raindrop erosion of some Trinidadian soils. Biosyst. Eng. 105(1): 112-118 **(7 pages).**

Feiznia, S.; Heshmati, M.; Ahmadi, H.; Ghodousi, J., (2007). Study marl gully erosion Aghajari formation in Qasr-e Shirin. J. Constr. Res. 74: 33-40 **(7 pages).**

Feng, X.; Wang, Y.; Chen. L.; Fu, B; Bai, G., (2010). Modeling soil erosion and its response to land-use change in hilly catchments of the Chinese Loess Plateau. Geomorphology, 118: 239-248 **(10 pages).**

Folk, R.L., (1974). Petrology of sedimentary racks: Hemphill Publishing Company Austin, Texas (**182 pages).**

Garcia-Ruiz, J.M., (2010). The effects of land uses on soil erosion in Spain. A review, Catena 81: 1-11 **(11 pages).**

Gee, G.W.; Bauder, J.W., (1986) Particle size analysis. In: Klute, (Ed.) Methods of Soil Analysis. Part 1, 2nd ed. America Society of Agronomy, Madison- Wisconsin., 383-411 **(29 pages).**

Giménez, R.; Govers, G., (2008). Effects of freshly incorporated straw residue on rill erosion and hydraulics, Catena, 72: 214-223 **(10 pages).**

Geissen, V.; Sanchez, R.; Kampichler, C., (2009). Effect of land-use change on some properties of tropical soils, an example from Southeast Mexico. Geoderma 151: 87-97 **(11 pages).**

Jia, X.; Wang, H.; Xiao, J., (2011). Geochemical elements characteristics and sources of the riverbed sediment in the Yellow River Desert Channel. Environ. Earth Sci., 64(8): 2159-2173 **(15 pages).**

Johnson, C.W.; Gebhardt, K.A., (1982). Predicting sediment yield from sagebrush rangelands. Proceeding of Workshop on Estimating Erosion and Sediment Yield on Rangelands. Tucson, Arizona, March 1981. US Department of Agriculture, Agric. Rev. Manuals, Western Series, 26: 145-156 **(12 pages).**

Karimi Bavandpoor, A.R.; Haj Hoseini, A., (1999). Geological map of Kermanshah with the scale of 1:100000, Geological Survey of Iran.

Karaş, E.; Oğuz, İ., (2017). Evaluation of Soil Erosion and Sustainable Land Use Management in the Sarısu Basin. Turk. J. Agric. Food Sci. Technol., 5(8): 864-872 **(8 pages).**

Karbassi, A.R.; Pazoki, M., (2015). Environmental qualitative assessment of rivers sediments. Global J. Environ. Sci. Manage., 1(2): 109-116 **(8 pages).**

Khalilian, S.; Shahvari, N., (2018). A SWAT Evaluation of the Effects of Climate Change on Renewable Water Resources in Salt Lake Sub-Basin, Iran. Agri. Eng., 1, 44–57 **(14 pages).**

Levy, G.J.; Levin, J.; Shainberg, I., (1994). Seal formation and interrill erosion, Soil Sci. Soc. Am. J., 58: 203-209 **(7 pages).**

Lewis, C.J.; McDonald, E.V.; Sancho, C.; Pena, J.L.; Rhodes, E.J., (2009). Climatic implications of correlated Upper Pleistocene glacial and fluvial deposits on the Cinca and Gallego Rivers (NE Spain) based on OSL dating and soil stratigraphy, Global Planet Change., 67: 141-152 **(12 pages).**

Liu, C.; Sui, J.; Zhao-Yin, W., (2008). Sediment load reduction in Chinese rivers, Int. J. Sediment Res. 23, Elsevier, 44-55 **(12 pages).**

Mansouri Daneshvar, M.; Bagherzadeh, A., (2012). Evaluation of sediment yield in PSIAC and MPSIAC models by using GIS at Toroq Watershed, Northeast of Iran. Front. Earth Sci. 6(1): 83–94 **(12 pages).**

Maquaire, O; Malet, J.P; Remaitre, A; Locat, J; Koltz, S; Guillon, J., (2003). Instability conditions of Marly hillslopes: towards landsliding or gullying? The case of the Barcelonnette Basin, South East France, Bull. Eng. Geol. Environ. 70: 109-130 **(22 pages).**

Marani Barzani, M.; Khairulmaini, O.S., (2013). Desertification risk mapping of the Zayandeh Rood Basin in Iran. J. Earth Syst. Sci. 5(122): 1269–1282 **(14 pages).**

Masoumi, H; Jamali, AA; Khabazi, M., (2014). Investigation of Role of Slope, Aspect and Geological Formations of Landslide Occurrence Using Statistical Methods and GIS in Some Watersheds in Chahar Mahal and Bakhtiari Province. J. Appl. Environ. Biol. Sci., 4(9)121-129 **(9 pages).**

Metternich, G.; Gonzales, S., (2005). FUERO: Foundations of a fuzzy exploratory model for soil erosion hazard prediction. Environ. Modell. Software, 20: 715- 728 **(14 pages).**

Miall, A.D., (1996). The geology of fluvial deposits, sedimentary facies, basin analysis and petroleum geology. Springer- Verlag, Berlin, New York (**582 pages).**

Niu, C.Y.; Musa, A.; Liu, Y., (2015). Analysis of soil moisture condition under different land uses in the arid region of Horqin sandy land, northern China. Solid Earth., 6: 1157–1167 **(11 pages).**

Owliaie, H.R.; Abtahi, A.; Heckr, R.J., (2006). Pedogenesis and clay mineralogical investigation of soils formed on gypsiferous and calcareous materials, on a transect, southwestern Iran. Geoderma, 134 (1-2): 62-81 **(20 pages).**

Ouyang, W.; Skidmore, A.K.; Hao, F.; Wang, T., (2010). Soil erosion dynamics response to landscape pattern. Sci. Total Environ. 408: 1358-1366 **(9 pages).**

Pettijohn, F.J.; Potter, P.E.; Sieve, R., (1975). Sedimentary Rocks Harper and Row. New York (**628 pages).**

Pirasteh, S.; Kumar Tripathi, N.; Mahmoodzadeh, A.; Ziaee, H.R., (2008). Integrated remote sensing and GIS based watershed erosion study in Zagros Fold Belt, Iran. Geoinformatics Int., 3 (4): 1-12 **(12 pages).**

Piccarreta, M.; Faulkner, H.; Bentivenga, M.; Capolongo, D., (2006). The influence of physico-chemical material properties on erosion processes in the badlands of Basilicata, Southern Italy. Geomorphology., 81: 235-251 **(17 pages).**

Safamanesh, R.; Azmin-Sulaiman, W.N.; Ramli, F.M., (2006). Erosion risk assessment using an empirical model of pacific south west inter-agency committee method for Zargeh watershed, Iran. J. Spatial Hydrol., 1: 105-120 **(16 pages).**

Santis, F.D.; Giannossi, M.L.; Medici, L.; Summa, V.; Tateo, F., (2010). Impact of physico-chemical soil properties on erosion features in the Aliano area (Southern Italy). Catena, 81; 172-181 **(10 pages).**

Sereda, J.; Bogard, M.; Hudson, J.; Helps, D.; Dessouki, T., (2011). Climate warming and the onset of salinization: Rapid changes in the limnology of two northern Plains lakes. Limnologica 41: 1-9 **(9 pages).**

Shit, K.P.; Bhunia, G.S.; Maiti, R., (2016). An experimental investigation of rill erosion processes in lateritic upland region: A pilot study. Eur. J. Soil Sci. 2016, 5 (2) 121 – 131 **(11 pages).**

Sokouti, R.; Razagi, S., (2015). Erodibility and loss of marly drived soils. Eurasian J. Soil Sci. 2015, 4 (4): 279 – 286 **(8 pages).**

Sui, J.; He, Y.; Liu, C., (2009). Changes in sediment transport in Kuye River in the Loess Plateau in China. Int. J. Sediment Res. 24 (2): 201-213 **(13 pages).**

Sultan, K.; Shazili, N., (2011). Geochemical base lines of major and trace elements in the tropical sediments of the Terengganа River Basin, Malaysia, Int. J. Sediment Res. 25: 340-354 **(14 pages).**

Tajgardan, T.; Aubi, S.A.; Joybary, Sh., (2008). Estimation of erosion and sediment by using satellite data and GIS by using the mode (case study: Zyarat watershed), Sazandegi and Pajuhesh magazine 79: 38-45 **(8 pages).**

Toy, T.J.; Foster, G.R.; Renard, K.G., (2002). Soil erosion process prediction measurement and control, John wiley and sons, Inc, New York (**338 pages).**

Vandekerckhove, L.; poesen, J.; Oostwaud Wijdenes, D.; Gyssels, G.; Beuselinck, L.; DeLuna, T., (2000). Characterisitsc and controlling factors of bank gullies in two semi-arid Mediterranean environments. J. Geomorphol., 33: 37-58 **(22 pages).**

Vente, D.J.; Poesen, J., (2005). Predicting soil erosion and sediment yield at the basin scale: Scale issues and semi-quantitative models. Earth Sci. Rev., 71: 95-125 **(31 pages).**

Zarei, A.R.; Amiri, M.J., (2017). Evaluation of soil losses and sediment yield using modified PSIAC model. Iran Agric. Res. 36(1) 111-116 **(6 pages).**

Zhao, G.; Mu, X.; Wen, Z.; Wang, F.; Gao, P., (2013). Soil erosion, conservation, and Ecoenvironment changes in the Loess Plateau of China. Land Degrad. Dev. 24: 499-510 **(12 pages).**

Zhang, Q.; Lei, T.; Jun, Z., (2008). Estimation of the detachment rate in eroding rills in flume experiments using an REE tracing method. Geoderma, 147: 8-15 **(8 pages).**

Zia Abadi, L.; Ahmadi, H., (2011). Comparison of EPM and geomorphology methods for erosion and sediment yield assessment in Kasilian Watershed, Mazandaran Province, Iran. J. Earth Syst. Sci., 1269- 1282 **(14 pages).**

AUTHOR (S) BIOSKETCHES

Rostami, F.; Ph.D. Candidate, Department of Geology, Sciences and Research Branch, Islamic Azad University, Tehran, Iran. Email: *fereshtehrostami867@yahoo.com*

Feiznia, S., Ph.D., Professor, Department of Range and Watershed Management, Faculty of Natural Resources, College of Agriculture and Natural Resources, University of Tehran, Karaj, Iran. Email: *sfeiz@ut.ac.ir*

Aleali, M., Ph.D., Assistant Professor, Department of Geology, Sciences and Research Branch, Islamic Azad University, Tehran, Iran. Email: aleali.mohsen@gmail.com

Hashmati, M., Ph.D., Associate Professor, Soil Conservation and Watershed Management Research Department, Kermanshah Agricultural and Natural Resources Research and Education Center, Agricultural Research, Education and Extension Organization (AREEO), Kermanshah, Iran. Email: *heshmati46@gmail.com*

Yousefi yegane, B., Ph.D., Assistant Professor, Department of Geology, Faculty of Science, Lorestan, University, Khoram Abad, Iran. Email: *bizhan.yegane@gmail.com*

HOW TO CITE THIS ARTICLE

Rostami, F.; Feiznia, S.; Aleali, M.; Hashmati, M.; Yousefi yegane, B., (2019). Erodibility and sedimentation potential of marly formations at watershed scale. Global J. Environ. Sci. Manage., 5(3): 383-398.

DOI: 10.22034/gjesm.2019.03.10

url: https://www.gjesm.net/article_34766.html