Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 5, No. 3, p. 86-94, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

A Study of the impacts of different characteristics of geological formations in producing various erosion forms (Case Study: Watershed basin Hio and Shalamzar)

Mohammad Momeni*[1] Abolfazl Moeini[2] Hassan Ahmadi

[1]*Department of Watershed Management, College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran*

Article published on September 05, 2014

Key words: erosion, surface characteristics, geological formation, Hio and Shalamzar watershed.

Abstract

Soil erosion is highly regarded as a risk to human welfare and even its existence. Using the characterization of soil formations of a region originating from geological formations, the nature and circumstances of the occurrence of erosion can be found. In the present study, in order to evaluate the possible effects of various characteristics of geological formations of Elika, Shemshak and Late Quaternary for the occurrence of sheet, rill and gully erosion, aerial photo interpretation was attempted. On the aerial photos, dominant erosion forms were separated in order that the primary erosion map could be prepared. Then on any of the forms of erosion on each formation, two profiles were excavated. Thus a total of six profiles were constructed. Since sampling was performed at the 0-20 and 20-40 cm depths, a total of 36 samples were produced and then transported to the laboratory. Sodium adsorption ratio, electrical conductivity (EC), pH and organic matter were measured for each sample. For the analysis of data, Excell and SPSS software were used. The results showed that the aggregate stability depends on the organic matter content, electrical conductivity and absorption ratio. The higher goes the sodium adsorption ratio, the greater goes aggregate stability and the lower goes the erosion. At the same sodium adsorption ratio, soil with higher soil electrical conductivity is more resistant to erosion. Likewise, the soils with higher organic matter content, showed more resistance. Since soil acidity (pH) was not significantly different in the three types of erosion, it can be said in conclusion that this parameter has no significant effect on the rate of erosion.

***Corresponding Author:** Mohammad Momeni ✉ momenimohammad2014@gmail.com

Introduction

Erosion and sedimentation are two common important problems in the arena of watershed management in Iran. Soil erosion is a real threat to the environment, human health and welfare and ranks as the second global environmental challenge after population growth. If uncontrolled, soil erosion would extend up to a situation in which no fertility might be expected. Human being with such a severe utilization of natural resources wastes this God-given resource. Although soil erosion began since birth of the Earth, however, in the twentieth century with remarkable population growth and over-use of natural resources, erosion level has raised exponentially (Ahmadi, 1385). Abbasi & Abdi (1384) analyzed 29 samples of moraine of Ghezel Sofla and reach to the conclusion that high quantity of Na, Ca, Cl and gypsum could intensify erosion and lead to the expansion of rill, gully (in lower slopes) and bad lands (in higher slopes). Amiri (1387) by assessing the correlation of various characteristics and soil erosion forms showed that there is a significant relationship between soil acidity and erosion form. Pirvan *et al* (1388) analyzed moraine soils of Tehran and argued that high level of EC, in the range of 54.2 to 100 μmohs in the samples, has a significant correlation with soil erosion. Increased pH of moraine samples in the range of 7-7.8 could increase the level of the critical coagulation concentration (CFC) and prevent soil aggregate development. The latter will result in the mineral collapse and release of cations. Elliot *et al* (1989) studied 36 soil samples and showed that depending on the amount of clay, inter-rill erodability is influenced by the proportion soil aggregate finer than 0.25 mm, water-dispersible clay, magnesium and aluminum concentration and Soil Saturated EC. The authors also pointed that factors such as cation exchange capacity (CEC), sodium absorption ratio (SAR) and organic carbon percentage play role in shaping sensitivity to rill erosion. The shear strength of soil, which is important in the formation of rills, pertains to moisture content, the amount of calcium carbonate, sodium absorption ratio, specific surface area (particle size), water-dispersible clay and sand and clay percentage. Zhang *et al* (2006) suggested that human activities such as deforestation, dam construction and so forth make greater impact on discharge-water sediment load than annual runoff volume per se. Meanwhile, annual runoff volume is more likely to be controlled by climate change implications. Desantis and colleagues (2009) stated that PS, SAR, pH and TDS serve as the parameters for the identification of eroded and uneroded slopes. As an average, eroded surfaces show higher PS, SAR and pH compared with uneroded surfaces. The EPS level of eroded slopes is slightly higher than that of the uneroded ones. Zhang *et al* (2003) in a study showed that the intensity of particle dispatch in unaffected soils is one to twenty-three folds of that of the affected natural soils. They believe that with increase in flux intensity, particle dispatch ratio also increase linearly which is an exponential function of flux intensity and slope gradient. Ghadiri *et al* (2004) studied the effects of soil salinity and alkality and showed that increased alkality escalate soil erodability. This is research is dedicated to illustrate the role of geological formations on erosion processes in the study area. Therefore; we have determined the formations and soil characteristics and then erosion forms are investigated. Also in this study, probability of future forms of erosion have addressed. According to results, strategies and preventive recommendations have revealed toward decreasing erosion in this watershed

Material and methods

Study area

The study area, based on the administrative classification of Iran's basin by the Jamab org., falls in the Salk Lake basin to the south of the Alborz between 35 59 to 36 07 eastern longitude and 50 36 to 50 43 latitude, 34 kilometers west of Karaj, Alborz Prov., southwest of Savojbolagh township (Fig. 1). This watershed is limited to the north by Taleghan (Zidasht) and Abyak (Ebrahimabad –Samghabad) watershed, to the south by the Tehran-Karaj highway, to the east by Khour & Sefidarak watershed and to the west by Maskoul and Siman Abyak watershed. The total area of Hio and Shalamzar watersheds equals 5858.5 hectare. The longest river of the watershed is 17.2 Km, having a north-south direction. Hio and Shalamzar villages are located in this watershed. The elevation of the area ranges between 1265 through 2744 m a.s.l. the watershed is mainly mountainous with hills and plains dominated by good, average and bad rangelands, agricultural fields and riparian orchards. Four major land-uses can be recognized as urban and rural, orchards and agricultural fields. The average annual precipitation measures 445 mm. climate of the area, based on the Amberje Classification, is mountainous climate. Fig 1 shows the location of the suited area.

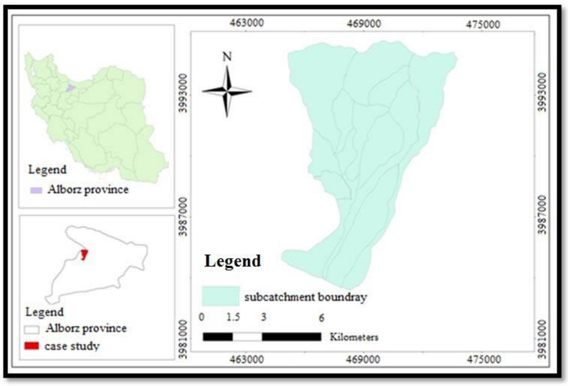

Fig. 1. Location of the study area.

The watershed, geologically speaking, is formed by different formations which are briefly overviewed as follow:

Elika Formation

In Hio - Shalamzar watershed, Elika Formation lays cataclinal on the Ruteh formation with an unconformity with laterite horizon protrusions. This formation has a uniform status of facies and is quite similar to other outcrops of this formation in the Alborz. About 109.15 hectares, ie 1.86% of the watershed area, is characterized by this formation.

Shemshak Formation

Lithology of this formation, bottom up, includes relatively thick, grey to creamy sand stones, mudstones and shale with interlayers of carbonaceous shale which contains frequent plant fossils. Towards the top, alterations of fine-grain sandstone, mudstone and shale together with shallow thin carbon layer is found. Shemshak formation covers 416.71 hectare, i.e. 7.1% of the total area of the watershed.

Late Quaternary Formation

This deposition dates back to Pleistocene epoch which mainly contains gravels and old landslides' deposition. The area coverage of this formation is about 1419 hectare or 24.2% of the total area of the watershed.

Methodology

The methods used in this study, depending on the nature and type of study and practicality, were selected such a way that include library researches and field studies based on the available data. In order to select the most important parameters in determining soil erosion of the area, a major step is aerial photo interpretation and identification of dominant erosion form. This will produce the primary erosion map of the area. By superimposing geo-morphological unit map and road map, GPS field control points were selected to be able to later identify and interpret polygons characteristics in GIS. Here, during the field reconnaissance, using GPS, the control points were identified and checked. Based on the geo-morphological unit map and road map, control points were traced using GPS. Field data including sheet, rill and gully erosions' status were recorded. Sampling was augmented with photographing the control points for further interpretation and reference.

Soil Analysis

In this study, five factors were measured, including soil sodium absorption ratio (SAR), electrical conductivity (EC), soil acidity (pH) and organic matter (OM). On each formation and each eroded surface two soil profiles were excavated which totally on each erosion (sheet, rill and gully) surface six profiles were prepared. Thirty-six soil samples from 18 profiles at the depths of 0-20 and 20-40 cm were taken for further analysis in the laboratory of

University Jihad, Department of Natural Resources of Tehran University.The samples were then air dried naturally. Then, pebbles, insect debris, pieces of dried branches were discarded from the samples and then the remaining materials were passed through 2 mm sieve. Finally the samples were prepared for the tests. The measurement procedure of each of the factors is as follows:

Organic matter

To measure organic matter, 1 gr of soft, sieved soil was poured into the flask and then 10 ml of one normal potassium Bicarbonate and 20 cc of concentrated sulfuric acid were added into the flask and the solution was mixed and shaken gently. After cooling, the contents of the flask was transferred to a flask of 250 ml and made up to the volume with distilled water.

About 50 ml of the solution was transferred to a flask and then 10 drops of Diphenyl amine and 20 mg of sodium fluoride powder were added. The content was then titrated using Ammonium iron (II) sulfate until green.

Measuring the amount of soil organic matter is through oxidizing organic matter. In order to determine soil organic carbon, soil organic matter content is calculated by the following equation (Jafari Haghighi, 1382). At this time, the initial volume is read. Instead of sodium fluoride and Diphenylamine, Ferro Ortho Phenylene reagent can be used.

The amount of soil organic matter is measured as a function of oxidizable organic matter. Hence, by measuring soil organic carbon percentages, soil organic matter content is calculated by the following equation (Jafari Haghighi, 1382).

$$\%OC = \frac{(A-B)\times N \times 0/39}{P}$$

Where A is the volume of Ammonium iron (II) sulfate consumed, B is the volume of Ammonium iron (II) sulfate consumed for the control sample, P is the weight of soil sample and N stands for normality.

Dried Organic matter%=Organic Carbon * 1.72(OM)

Acidity (pH)

Potentiometric method was used to determine soil acidity. After adjusting the pH meter electrodes in buffers pH 4 and 8, they were rinsed and put into the solution and the pH was read and recorded. For the second sample, the electrode was rinsed with distilled water to read the next sample (Jafari Haghighi, 1382)

Electrical conductivity (EC)

Soil salinity was measured as a function of soil electrical conductivity. Digital EC meter was used for measuring EC and electrical conductance is obtained in terms of (ds/m) (Jafari Haghighi, 1382).

Sodium adsorption ratio (SAR)

Exchangeable cations were extracted using ammonium acetate method. Next, titration method was used for measuring calcium and magnesium. Flame photometry method was used to measure sodium. Once exchangeable cations are obtained, by the following formula SAR parameter is estimated.

$$\mathrm{SAR} = \frac{\mathrm{Na}+}{\sqrt{0.5\,(\mathrm{Ca}^{2+} + \mathrm{Mg}^{2+})}}$$

Analysis of physical and chemical properties

In order to analyze data in a more appropriate way, results for each of the three types of erosion were ordered in different sheets of Excell 2010 software (e.g. data related to surface erosion in Elika, Shemshak and Late Quaternary were together examined). In continue, using the SPSS software, relationship between the five chemical parameters of the three Formations affected by three types of erosions were examined at the depths of 0-20 and 20-40 cm.

Results

Finally, after the study, different forms of erosion facies were illustrated on the map (Fig. 2). On each of the three types of surface, gully, rill erosion on each formation, two soil profiles were established. In total, 18 profiles with two depth intervals of 0-20 and 20-

40 cm were established. Fig. 2 locates geographic coordinates of each of the profiles on each formation and each erosion facies.

Considering that sampling was performed at two depths of 0-20 and 20-40 cm a total of 36 samples was taken to the laboratory to determine soil chemical properties (sodium absorption ratio, electrical conductivity, pH and soil organic matter).

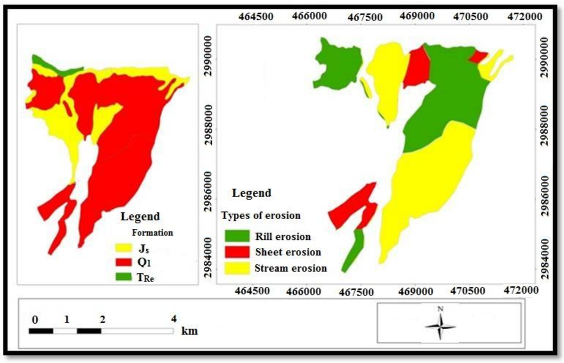

Fig. 2. Different erosion facies in the Shemshak formation.

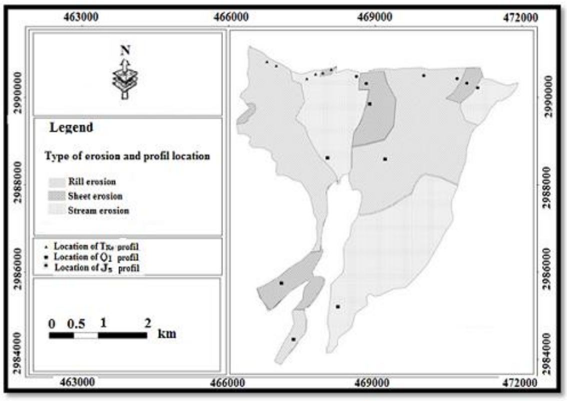

Fig. 3. Different erosion facies and location of excavated soil profiles in the region.

Result of Chemical analysis

Analyzing soil chemical properties of the three geological formation under sheet erosion facies. Table 1 provides the result of the ANOVA test for the three formations under sheet erosion at the depth of 0-20 cm.

Table 1. analysis of variance of soil chemical properties of the three formations under sheet erosion at the depth of 0-20 cm.

Parameters studied		Sum of Squares	df	Mean Square	F	Sig
EC	Formation	0.009	2	0.004	0.092	0.914
	Error	0.286	6	0.048		
	Total	0.295	8			
OM	Formation	0.06	2	0.02	1.5	0.296
	Error	0.12	6			
	Total	0.18	8			
pH	Formation	0.005	2	0.002	0.115	0.893
	Error	0.13	6	0.022		
	Total	0.135	8			
Oc	Formation	0.015	2	0.008	1.5	0.296
	Error	0.03	6	0.005		
	Total	0.045	8			
SAR	Formation	0.245	2	0.123	0.152	0.862
	Error	4.84	6	0.808		
	Total	5.09	8			

Table 2 provides the result of the ANOVA test for the three formations under sheet erosion at the depth of 20-40 cm.

Table 2. analysis of variance of soil chemical properties of the three formations under sheet erosion at the depth of 20-40 cm.

Parameters studied		Sum of Squares	df	Mean Square	F	Sig
EC	Formation	0.152	2	0.076	19.02	0.003
	Error	0.024	6	0.004		
	Total	0.176	8			
OM	Formation	0.105	2	0.053	1.35	0.328
	Error	0.234	6	0.039		
	Total	0.339	8			
pH	Formation	0.125	2	0.063	75	0
	Error	0.005	6	0.001		
	Total	0.13	8			
Oc	Formation	0.035	2	0.017	1	0.422
	Error	0.105	6	0.018		
	Total	0.14	8			
SAR	Formation	3.245	2	1.672	23.34	0.001
	Error	0.43	6	0.072		
	Total	3.77	8			

Analyzing soil chemical properties of the three geological formation under rill erosion facies.Table 3 provides the result of the ANOVA test for the three formations under rill erosion at the depth of 0-20 cm.

Table 3. analysis of variance of soil chemical properties of the three formations under rill erosion at the depth of 0-20 cm.

Parameters studied		Sum of Squares	df	Mean Square	F	Sig
EC	Formation	0.155	2	0.078	18.6	0.003
	Error	0.025	6	0.004		
	Total	0.18	8			
OM	Formation	0.095	2	0.048	2.71	0.145
	Error	0.105	6	0.017		
	Total	0.2	8			
pH	Formation	0.042	2	0.021	9.5	0.014
	Error	0.013	6	0.002		
	Total	0.056	8			
Oc	Formation	0.035	2	0.017	3.5	0.098
	Error	0.03	6	0.005		
	Total	0.065	8			
SAR	Formation	2.42	2	1.21	36.3	0
	Error	0.2	6	0.033		
	Total	2.62	8			

Table 4 provides the result of the ANOVA test for the three formations under rill erosion at the depth of 20-40 cm.

Table 4. analysis of variance of soil chemical properties of the three formations under rill erosion at the depth of 20-40 cm.

Parameters studied		Sum of Squares	df	Mean Square	F	Sig
EC	Formation	0.034	2	0.017	2.214	0.19
	Error	0.046	6	0.008		
	Total	0.08	8			
OM	Formation	0.105	2	0.052	4.846	0.056
	Error	0.065	6	0.011		
	Total	0.17	8			
pH	Formation	0.009	2	0.004	0.093	0.912
	Error	0.287	6	0.048		
	Total	0.296	8			
Oc	Formation	0.045	2	0.023	5.4	0.046
	Error	0.025	6	0.004		
	Total	0.07	8			
SAR	Formation	0.56	2	0.28	2.8	0.138
	Error	0.6	6	0.1		
	Total	1.16	8			

Analyzing soil chemical properties of the three geological formation under gully erosion facies. Table 5 provides the result of the ANOVA test for the three formations under gully erosion at the depth of 0-20 cm.

Table 5. analysis of variance of soil chemical properties of the three formations under gully erosion at the depth of 0-20 cm.

Parameters studied		Sum of Squares	df	Mean Square	F	Sig
EC	Formation	1.095	2	0.548	3.6	0.093
	Error	0.91	6	0.152		
	Total	2.005	8			
OM	Formation	0.105	2	0.052	1.5	0.296
	Error	0.21	6	0.035		
	Total	0.315	8			
pH	Formation	0.215	2	0.107	4.96	0.054
	Error	0.13	6	0.022		
	Total	0.345	8			
Oc	Formation	0.035	2	0.017	1.5	0.296
	Error	0.07	6	0.012		
	Total	0.105	8			
SAR	Formation	7.95	2	3.97	3.6	0.94
	Error	6.63	6	1.105		
	Total	14.58	8			

Table 6 provides the result of the ANOVA test for the three formations under gully erosion at the depth of 20-40 cm.

Table 6. analysis of variance of soil chemical properties of the three formations under gully erosion at the depth of 20-40 cm.

Parameters studied		Sum of Squares	df	Mean Square	F	Sig
EC	Formation	0.015	2	0.007	1.8	0.244
	Error	0.025	6	0.004		
	Total	0.04	8			
OM	Formation	0.289	2	0.144	1.65	0.268
	Error	0.525	6	0.087		
	Total	0.814	8			
pH	Formation	0.06	2	0.03	9	0.087
	Error	0.02	6	0.003		
	Total	0.08	8			
Oc	Formation	0.155	2	0.078	18.6	0.06
	Error	0.025	6	0.004		
	Total	0.18	8			
SAR	Formation	2.18	2	1.09	1.75	0.252
	Error	3.74	6	0.623		
	Total	5.92	8			

Discussion

Study of the physicochemical properties of the soils of a given region originating from different geological formations, facilitates the interpretation of nature and manner of soil erosion. To this end, five parameters namely EC, pH, OC, Organic matter and SAR were measured. One of the features widely meeting the eye in Hio-Shalamzar watershed is erosion facies. Based on the field study, the main driving force of erosion in the area is water. Erosion forms include sheet, rill, gully erosion as well as landslides and mechanical abrasion. As a result, the three dominant erosion forms of the area were studied and interpreted for different geological formations. As for the EC and its impact on erosion, it was found that soils of higher levels of EC are more resistant to erosion which corroborates the findings of Rahimi *et al* (2000). Soil pH parameter showed no meaningful difference for the three erosion forms. Thus, pH may not be an important factor in studying erosion forms which agrees with Zangane (1391). Given that organic matter is a function of soil organic carbon, hence, relative changes of each will mimic the same pattern. From the organic matter perspective, it could be deduced that the Elika formation is more prone to rill erosion while sheet erosion is more pronounced in the Shemshak formation and sheet and rill erosion both are dominant in the Late Quaternary formation. Increased levels of SAR lessen the soil aggregate stability which leads to vulnerability to erosion agents. Dwelling on the findings, it could be concluded that soil aggregate stability depends on organic matter, EC and SAR in such a way that higher SAR decrease aggregate stability and intensify erosion. At the same level of SAR, soils of higher levels of EC show more resistance. Likewise, do soils with higher organic matter content.

Acknowledgement

The authors would like to heartily appreciate the Natural Resources and Watershed Management Office of Alborz Province for generously providing useful information to do this research

Citations

Ahmadi H. 2006. Applied geo-morphology. Vol.1 (Water Erosion). Tehran University Press. 688 pages.

Amiri M, Amini S. 2008. Lithology and petrology and minerals of Almoghlagh (Northern Asad Abad). M.Sc thesis, Tarbiat-e-Moalem Univ. Tehran.

Abasi N, Abdi P. 2005. A study of the relationship between moraine chemical properties with its environmental behaviors (case study: Ghezel Sofla watershed, Tarem Olya, Zanjan Prov.). the 4th conference of geology and environment. Iran. 2-3 Esfand, 1384. Tarbyat-e-Modares Univ. Iran.

Elliot WJ, Laflen JM, Kohl KD. 1989 a. Effect of soil properties on soil erodibility. Paper No. 892150, ASAE. St. Joseph, Michigan.

Ghadimi Arous Mahale F, Pourmatin A, Ghodoosi J. 2000. The feasibility of moraine classification based on physicochemical properties in Tafresh. Pajouhesh-va-Sazandegi Journal. Vol **12,** No 1, pp 30-35.

Ghadiri H, Hussein J, Rose CW. 2004. The effect of salinity and sodicity on soil erodibility, sediment transport and downstream water quality. 13th International Soil Conservation Organization (ISCO) conference. Brisbane. Paper No.631.

Mazaheri H. 1397. Identification and zoning of susceptible areas to erosion in Abshine watershed, Hamedan Prov. The 2nd conference on erosion and sedimentation.

Valmis S, Dimoyiannis D, Danalatos NG. 2005. Assessing interrill erosion rate from soil aggregate instability index, rainfall intensity and slope angle on cultivated soils in central Greece. Soil Tillage Res., Vol. **80,** pp. 139-147.

Zhang GH, Liu BY, Liu GB, Wuhe X, Nearing MA. 2003. Detachment of undisturbed soil by shallow flow. Soil Sci. Soc. Am. J., Vol. **67,** pp. 713-719.

Zhang GH, Liu BY, Nearing MA, Huang CH, Zhang KL. 2002. Soil detachment by shallow flow. Trans. ASAE., Vol. **45,** pp. 351-357.

Zhang Qiang, Chong-yuXu, Stefan Becker, Tong Jiang. 2006, Sediment and runoff changes in the Yangtze River basin during past 50 years, Journal of Hydrology **331,** 511- 523.