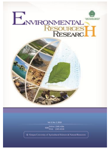

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Effect of land use on physical and chemical parameters of soil and sediment in Qarnave and Yelcheshme watersheds, Golestan Province, Iran

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Abstract
The objective of this investigation was assessment of physical and chemical parameters of soil and sediment in loess lands under different land uses, in the north of Iran. A yearly soil sampling was carried out randomly in three land uses (cultivated, forest and pasture) in Qarnave and Yelcheshme watersheds. Sediment samples were taken monthly in the watersheds at the hydrometrical station of Tamer located in downstream of the watersheds. The results showed that soil texture was silty clay loam and silty loam in forests and cultivated lands, respectively. In both watersheds, the highest amount of pH, carbonate calcium, available phosphorus (P) and bulk density (BD) was observed in cultivated lands, whereas the highest amount of total nitrogen (TN), mean weight diameter (MWD) and organic carbon (OC) was observed in forest. The highest amount of TN was observed in autumn, whereas the maximum amount of K was observed in summer, in both soil and sediment samples. The highest amount of P in soil and sediment was observed in summer and winter respectively. Also, the highest percentage of OC in soil and sediment was observed in autumn and summer respectively. The results showed that tillage and soil cultivation in cultivated lands may lead to reduction of OC and BD, therefore, decreasing the MWD.

Keywords: Land use, Loess, Soil Quality, Sediment

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Introduction

The negative effects of erosion occur not only inside basin and agricultural lands, but also in surrounding areas. Eroded material creates many problems in cultivated lands, pastures, waterbodies and irrigation sections. The movement of nutrients from agricultural lands to water resources has been studied for many years (Ng Kee Kwong *et al.*, 2002). Follet and Delgado (2002) stated that the deposition of soil particles with nutrients is considered as the largest source of pollution to the marine environment. Many studies mention nitrogen and phosphorus because of their important roles in water quality (Hutchinson, 1995). The loss of nutrients by runoff is a dynamic phenomenon that varies during the different seasons of a year. This process causes a decline in soil fertility (Blaschke *et al.*, 2000), due to time-varying dynamics in the original source of nutrients or soil. Saratchandra *et al.*, (1984) found that higher and lower levels of nutrients in sediment occurred in spring and summer seasons respectively, while Arunachalam (2000) stated that the maximum amount of nutrients in soil existed in winter. Studies of soil quality to identify the effects of different management in the areas of cultivated and natural resources are very important. Soil quality cannot be measured directly, but it can be estimated by measuring several soil parameters. The type of indicators depends on the research purposes. Selecting appropriate indicators plays a vital role in measuring soil quality. Land use changes in eastern part of the Golestan Province with loess parent material and high sensitivity to erosion and runoff cause severe soil degradation. The purpose of this study was to investigate the seasonal variation of physical and chemical parameters of soil and sediment in loess lands (with different land uses) in northeast of Iran.

Materials and Method

The study area is Qarnave Watershed, located between "56°04'35"- 55°30'57"E and 37°39'29"-37°25'01"N, with an area of 9600 hectares. The average slope of the watershed is 25.6% and the average height is 513 meters above mean sea level. Yelcheshme watershed is located between "56°04'35"- 55°30'57"E and 37°39'29"-37°25'01"N, with an area of 67,000 hectares. The average slope and height are 18.3% and 972.2 meters above mean sea level, respectively. The Tamer hydrometrical station is located at the outlet of the two watersheds including Qarnave and Yelcheshme (the east of the Golestan Province, northeast of Iran). The sediment data of catchment has been recorded since 1956. The location of this station is 132 meters above sea level and the average annual precipitation in hydrometrical station is 516.3 mm. Soil samples were taken monthly from three land uses: pasture, forest and cultivated, in the Qarnave and Yelcheshme watersheds in different seasons. Ten soil samples were collected from a depth of 0-30 cm in each land use. Consequently, a total of 60 samples were taken in two watersheds. Samples were air dried for one week and passed through a 2 mm sieve in order to analyze them chemically and physically. Sediment samples were taken monthly in two replications throughout the year at the Tamer station, which is monitored by the Golestan Regional Water Company. The samples were oven-dried at 105 °C for 24 h and weighed. For mean weight diameter (MWD) of particles a wet-sieve analysis was used with sieve diameters of 2.0 mm, 1.0 mm, 0.5 mm, 0.25 mm and 0.1 mm. Bulk density was measured using paraffin. Organic carbon (OC) was determined using a wet combustion method (Nelson and Sommers 1982). Soil EC was measured after extracting soil water using a conductivity meter olsen. Carbonate calcium was measured by titration. (Page *et al.*, 1982). OM was determined using a wet combustion method (Nelson and Sommers, 1982) and total nitrogen was determined using Kjeldahl method (Krik 1950). Soil available K was determined using the method outlined by Knudsen *et al.*, (1996) and available phosphorus (P) was measured through the Olsen method (Olsen *et al.*, 1954). Descriptive statistical analyses and comparison of means were conducted using SAS software based on Duncan's test with the completely randomized design (SAS institute, 2000). The parent material for all samples was loess.

Results

The Effect of Land Use on Soil Parameters

The result of the soil particle size assessment is shown in Table 1. Analysis of soil texture in Qarnave and Yelcheshme watersheds showed that the soil surface texture is silty clay loam in forest lands and silty loam in cultivated lands. The reason could be due to, soil erosion and transport of fine particles in cultivated lands. The result showed a significant difference in clay in land uses. The highest and lowest amount of clay was in pasture and cultivated lands respectively, and the highest and lowest amount of silt was in cultivated and pasture lands respectively. No significant difference was found regarding the amount of sand in different land uses. For Yelcheshme watershed, the lowest amount of clay was in cultivated lands; however, regarding the amount of silt, there was no significant differences in lands uses. The highest percentage of sand was obtained in cultivated lands and there was significant trend among forest, cultivated and pasture lands. The results showed that silt is the dominant size particle in the study area, related to the loess parent material. Hebert (1991) reported that silt is dominant in loess soils and the soil texture is usually silty. These results were also mentioned by Tissen *et al.* (1982). They stated that cultivated lands had a lighter texture than forest lands and the percentage of clay decreased in cultivated lands. The investigation of Islam and Weil (2000) in Bangladesh showed that cultivated lands had less clay than forest lands.

The results of the stability of soil aggregates are shown in Table 1. The results showed that the highest and lowest MWD were in forest and pasture lands respectively in the Qarnave watershed and differences were significant statistically ($P<0.05$). In the Yelcheshme watershed, the situation was different. The highest and lowest MWD were in forest and cultivated lands respectively with statistically significant difference ($P<0.05$). Organic carbon decreases land degradation with increasing soil adhesion between particles and reducing ability of separation (Chenu *et al.*, 2000). High amounts of organic matter in forests have increased MWD and a low content of organic matter in pasture lands decreased its quantity. HajAbbasi *et al.*, (1997), Islam and Weil (2000), Kiani *et al.*, (2004), Boiks-Fayos *et al.*, (2012) and Khaledian *et al.*, (2012) stated the highest amount of MWD occurred in forests and the lowest reported in cultivated areas. In the Yelcheshme watershed, the highest amount of MWD were reported in forest lands because of the high amount of organic matter which improved the soil structure, whereas the lowest amount of MWD occurred in cultivated lands due to the plowing that breaks down and destroys soil structure (Lal, 1998). It also seems that quality of organic carbon would have an effect on soil structure. Boix-Fayos *et al.*, (2001) in Mediterranean soils showed that aggregate stability has a positive correlation with clay, while the large aggregates has a high correlation with the amount of soil organic carbon.

The results of the bulk density are presented in Table 1. The results showed the highest and lowest BD in cultivated and forest lands respectively, in both watersheds. These differences were statistically significant ($P<0.05$). Increasing the organic carbon and aggregate stability decreased the bulk density. Bulk density was higher in pastures than in forests (Martinez and Zink, 2004). Aggregate destruction (due to agricultural operations), compacted soil and light soil texture increased soil density more significantly than the other land uses (Yousefifard *et al.* 2006). According to Dang *et al.*, (2005), due to soil tillage and intensive tillage, bulk density and soil quality decreased. Lemenih *et al.*, (2005) stated that an increase in bulk density in cultivated lands is linked to decrease in soil porosity and organic carbon. Celik (2005) concluded that conversion from forest to cultivated areas lead to decomposition of organic carbon, therefore, BD increases.

Table 1. The results of soil physical properties in soils

Land Use	Watershed	Soil texture	Clay %	Silt %	Sand %	BD gr/cm3	MWD mm
Forest	Qarnave	Silty clay loam	32	57	11	1.53	1.05
	Yelcheshme	Silty clay loam	35	56	9	1.35	1.12
Cultivated	Qarnave	Silty loam	24	63	13	1.45	0.3
	Yelcheshme	Silty clay loam	32	54	14	1.5	1.35
Pasture	Qarnave	Silty clay loam	36	53	11	1.45	0.24
	Yelcheshme	Silty clay loam	36	54	10	1.73	0.453

Table 2 presents the results of soil pH. The results show the highest and lowest pH occur in cultivated and forest lands respectively, in both watersheds. The differences were significant in all three land uses in the Qarnave watershed ($P<0.05$), whereas pH showed statistically significant differences between cultivated and forest lands ($P<0.05$), in the Yelcheshme watershed. Kiani *et al.*, (2004) stated that soil basic cations leached, therefore, the soil acidity in forest lands is higher than the other lands. Soil pH is controlled by natural processes, such as root release of carbon dioxide, and soil microbial respiration (NRCS, 1999). Also, soil tillage caused the displacement of cations from the lower soil layers to upper layers. Hence, the pH in cultivated lands is higher than forest soils. The amount of CCE in cultivated lands is higher. In these soils, therefore, the pH value is higher compared to other land uses. Rainfall in no-tillage caused transfer of an amount of cations to the lower layers. Consequently, soil pH in pasture lands is less than cultivated lands (Kiani *et al.*, 2004).

Table 2 also presents the result of organic carbon assessment. The highest and lowest percentage of organic carbon was in forests (due to the high proportion of fresh litter and low decomposition) and pasture respectively. This difference was statistically significant in both watersheds ($P<0.01$). Tillage in farm lands improved respiration and increased the rate of decomposition. This practice led to decrease in organic carbon in pasture lands compared to forest soils. However, Khaledian *et al.*, (2011), Ajami *et al.*, (2004), Kiani *et al.*, (2007) and Yousefifard *et al.*, (2006) reported higher organic carbon in forest than cultivated lands. It seems that using fertilizers in cultivated lands and plant residues in the soil increases the amount of organic carbon in these lands. The grazing livestock has reduced the amount of organic matter in pasture lands (Kiani *et al.*, 2004).

The results of CCE are reported in Table 2 showing that the CCE in cultivated and forest lands had the highest and lowest rates respectively. This difference was significant in the Qarnave watershed ($P<0.05$), whereas it was not significant in the Yelcheshme. Khormali *et al.*, (2006) stated in wet conditions with relatively high CO_2, CCE dissolves and transfers to the layers below. It should be noted that the amount of soil nutrient and calcium in loess sediments is abundant. Khormali *et al.* (2009) reported that tillage caused the transition of calcium carbonate from below layers to the surface; therefore, calcium carbonate in soil surface is higher in cultivated lands than the other land uses.

Table 2. The results of some soil chemical properties in soils

Land use	Watershed	pH	CCE (%)	OM (%)	P m/Kg	Total N (%)	K m/Kg
Forest	Qarnave	7.19	14.38	3.9	4.8	0.17	57.8
	Yelcheshme	7.17	20.0	3.93	4.8	0.15	106.9
Cultivated	Qarnave	7.52	19.37	3.54	4.9	0.16	53.83
	Yelcheshme	7.2	22.6	3.35	4.86	0.104	27.9
Pasture	Qarnave	7.35	24.35	2.3	4.83	0.08	59.41
	Yelcheshme	7.19	18.43	2.46	4.07	0.079	49.5

Table 2 shows the results of available phosphorus which is the highest proportion in cultivated lands in both watersheds. There was a significant difference between all land uses in the Qarnaveh and Yelcheshme watershed in terms of phosphorus ($P<0.05$). The amount of phosphorus in cultivated lands was higher than forest and pasture lands. The main reason is that phosphorus fertilizers are applied to a great deal in this land use. Most of the soil phosphorus is in organic form, thus leading to increased phosphorus. Chidumayo and Kwibisa (2003) witnessed no significant difference between forest and cultivated lands regarding the amount of phosphorus. In contrast, Dang *et al.*, (2002) concluded that phosphorus in surface layers of cultivated lands are higher than forest lands. Rasmussen and Douglas (1992) stated that continuous application of phosphorus fertilizer leads to increased concentration of available P in soils.

Table 2 also shows that in both watersheds, the total nitrogen in forest and pasture lands were the highest and lowest respectively, and the differences were statistically significant ($P<0.01$). There was a positive relationship between the amount of organic carbon and total nitrogen. Mainly, total nitrogen is in the form of organic carbon compounds in the soil. While the same amount of nitrogen fertilizers is used in both watersheds, TN in forests was higher than cultivated lands due to the higher content of organic carbon. It seems that soil erosion and leaching of nitrogen prevents accumulation of nitrogen in cultivated land; therefore, nitrogen content is remarkably higher in forest lands. HajAbbasi *et al.*, (1997), Houghton et al (1990) Islam and Weil (2000), Solomon *et al* (2002), and Chidumayo and Kwibisa (2003), Wang *et al.*, (2003), Khaledian *et al.*, (2011). Bijayalaxami Devi and Yadava (2006) found that the largest amount of total nitrogen, available phosphorus and organic matter was in the summer, and the least amount was in winter. Another part of the dynamics of nutrient loss is related to the runoff and sediment properties. Alexander *et al.* (2008) reported that 70 percent of phosphorus pollution is caused by agricultural activities in the western part of the Gulf of Mexico. Topography and type of crops are also important affecting the amount of nutrients in soil and sediment. Ramos and Martinez (2006) reported a reduction of 6% in nitrate levels, in Pend Aniva in the North East of Spain. Xiaowen (2010) stated that plowed and sloped lands had the highest percentage of non-point pollution and among all types of crops, for example wheat had the highest levels of non-point contamination. Researchers have postulated that soil nutrients are the most important source of sediment. Yousefifard (2004) showed that the majority of soil P is in organic form, therefore, with increase in organic matter losses, phosphorus losses also increase.

The results of available potassium are presented in Table 2 showing that the amount of available potassium in cultivated lands is significantly less than forest lands ($P<0.05$). Unwillingness of local farmers to use potassium fertilizers on cultivated lands (according to a survey of the area), could also be another reason for this problem. These results are in accordance with the previous investigation carried out by Dong *et al.*, (2002), McDonald (2002), Kiani *et* *al*., (2004) and Vegan *et al*., (2006). Burger and Kelting., (1999) who stated that intensive farming practices and the use of chemical fertilizers would be effective on the distribution of potassium in soil, increasing the potassium depletion.

The results of soil nutrient analysis in different seasons are presented in Table 3. The highest amount of TN, P and organic matter were observed in autumn and the lowest rates in winter. The table shows a significant difference between summer and autumn ($P<0.05$). The difference of P levels was also significant between summer and autumn with winter and spring seasons ($P<0.05$). The highest and the lowest amounts of potassium levels were in summer and winter respectively, and a statistical significance was observed between different seasons ($P<0.05$). There was also a significant difference between spring, summer and autumn with winter in K ($P<0.05$). Bijayalaxami Devi and Yadava (2006) stated that the highest concentration of total nitrogen, available phosphorus and organic matter was in summer, and the lowest was in winter. They mentioned that the reason for low concentration in winter is the low activity of microorganisms and low speed of plant decomposition and the high concentration in summer was due to activity and speed of microorganism and fungi in decomposing plants. The nutrients were high in the autumn because of addition of nitrogen and phosphorus fertilizers. Saratchandra *et al.* (1984) reported the maximum amount of nutrients in spring and the lowest in summer which were attributed to the relationship between soil moisture and microbial biomass. The maximum amount of nutrients was in the wet season, and the minimum was in the dry season. Arunachalam (2000) observed that the maximum amount of nutrients in winter was due to the high plant decomposition and rainfall patterns. The low amounts of organic matter, phosphorus and nitrogen in winter were due to slow decomposition of organic matter during the cold and dry seasons. Santruckova (1992) observed that the maximum amount of soil microbial biomass was in the wet season and the lowest in the dry season. Bhuyan *et al*., (2010) reported that the greatest and the lowest amount of organic carbon was in winter and summer respectively, and there was no significant difference in phosphorus levels between different seasons. Lal (1998) reported that nitrogen is made in dry seasons and the highest level of nitrate is observed in the beginning of the rainy season. Saratchandra *et al*., (1984) found that the highest and lowest levels of nutrients were in the spring and summer in pasture lands in New Zealand. Arunachalam (2000) observed that the highest level of nutrients in India was in winter. Bijayalaxami Devi and Yadava (2006) reported that nitrogen and carbon fixation and phosphorus fixation during rainy and winter seasons is higher in winter in India. Adeymo *et al.* (2008) stated that water quality was affected negatively by discharge of animal waste, agriculture, and industry in Nigeria.

Table 3. The mean values of chemical indicators of soil quality in different seasons

Watershed	season	N (%)	P (mg/kg)	K (mg/kg)	OM (%)
Qarnave	Spring	0.159^b	3.84^b	42^d	3.38^a
	Summer	0.166^a	4.8^a	84.7^a	3.43^a
	Fall	0.169^a	4.84^a	55.11^b	3.56^a
	Winter	0.063^c	4.82^b	46.22^c	2.6^b
Yelcheshme	Spring	0.12^b	4.85^b	51.2^b	3.2^b
	Summer	0.1^c	5.05^a	108.6^a	3.23^b
	Fall	0.126^a	4.84^b	51.11^b	3.6^a
	Winter	0.08^d	4.83^c	34.7^c	2.9^c

A, b, c classified according to Duncan’s test at 5% level, respectively.

Results of chemical analysis of suspended sediments

The results of chemical analysis of sediments are shown in Table 4. The highest and the lowest amount of total nitrogen were in autumn and in spring. Statistical analysis showed significant differences between the spring and autumn ($P<0.05$). There were no statistical differences between winter, autumn and summer ($P<0.05$). The highest concentration of total nitrogen was in autumn. The sediments resulting from eroded soils in autumn had the highest TN. The highest and lowest amounts of phosphorus were observed in winter and spring respectively. There was no significant difference between winter and other seasons ($P<0.05$); and also, no significant differences between spring, autumn and summer ($P<0.05$). Arunachalam (2000) studied humid tropical forests and reported that the highest amount of phosphorus was in winter. Phosphorus losses by erosion can be remarkable, because the erosion of soil particles from the environment reduces the amount of phosphorous in fine particles more than coarse particles. The higher phosphorus level in soil resulted in higher phosphorus losses as a result of erosion (Salardini, 1995). The greatest loss of phosphorus occurred in winter due to higher precipitation. Yousefifard (2004) stated most phosphorous is organic; therefore, the loss of organic matter results in increase of phosphorus losses. It also causes more leaching of soil's phosphorus than nitrogen in winter affected by the levels of lime in loess soil. The highest and lowest amount of organic matter was observed in summer and in spring respectively, and there was a significant difference between the summer and spring ($P<0.05$). The highest and lowest potassium contents were in spring and autumn respectively, and there was a significant difference between all seasons ($P<0.05$). Adeymo *et al.* (2008) observed the highest and lowest amounts of phosphorus in rainy and dry seasons, respectively, and the highest amount of nitrogen and organic carbon in dry and rainy seasons. Eida *et al.* (2012) carried out a study regarding water and sediment characteristics in different seasons and reported that the highest amount of phosphorus was in summer and the highest amount of nitrogen in winter. The changes in soil nutrient and sediment from output of both watersheds showed that although there is a relationship between potassium and nitrogen in different seasons, there is no significant difference among different nutrients in all seasons in both watersheds. In other words, in the process of particle transport by runoff, there were large variations in the type, quantity and quality of nutrients and organic carbon. Therefore, biochemical changes are affected by runoff and soil quality. Clark *et al.* (2006) believed that the spatial variability of soil and sediment in transport, is the main reason for these differences. They also stated that diversity of land uses in different hydrological characteristics made this association uncertain. Van Der Perk *et al.* (2006) and Packman *et al.* (2006) stated that without knowing about the bedding materials and properties of transition, there is no possibility of predicting sediment characteristics. These researchers believed that the type of sediments and sediment transport pathways changed sediment characteristics. Haagi *et al.* (2006) and Hanafi *et al.* (2006) found that the microorganisms' activities determine the chemical properties of soil and sediment. The microorganisms caused nitrification and decomposition of organic matter, which changed soil properties. The key to find the relationship between soil and sediment is to find biological quality or assess activities of microorganisms. Adeymo *et al.*, (2008) showed that the highest rate of phosphorus losses in sediments occurred in rainy seasons and the highest amounts of nitrogen and organic matter losses were in dry seasons. Contrarily, Clark *et al.* (2006); Van Der Perk *et al.* (2006); Packman *et al.*, (2006) and Haggi *et al.* (2006) stated a weak relationship between soil properties and sediments. Correlation of nutrients in soil and sediment from the outlet of the watershed was not significant. Biochemical cycles of runoff and soil and changes in their quality shows no significant correlation between the indicators. Comparison of nutrients and organic carbon in soil and sediment is presented in Figures 1 to 4.

Table 4. The mean values of chemical indicators of sediment quality in different seasons

Elements	Spring	Summer	Autumn	Winter
N(%)	0.14^{c}	0.17^{b}	0.18^{a}	0.176^{ab}
P(mg/kg)	4.8^{b}	4.81^{b}	4.8^{b}	4.9^{a}
K(mg/kg)	80.4^{c}	122.7^{a}	111.8^{b}	60.41^{d}
OM(%)	0.91^{c}	3.05^{a}	2.08^{b}	2.96^{b}

A, b, c classified according to Duncan's test at 5% level, respectively.

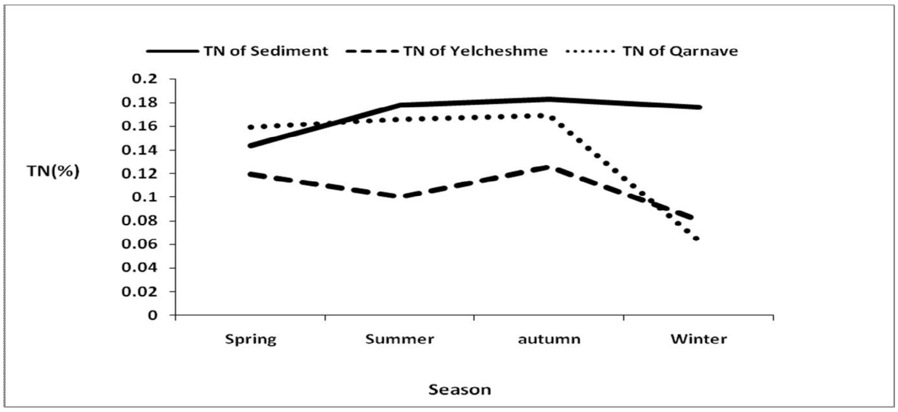

Figure 1. Total nitrogen in soils and sediments of the study area

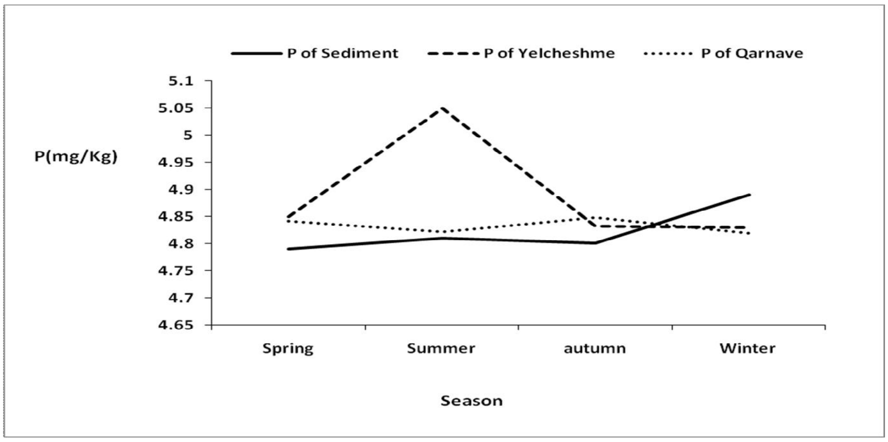

Figure 2. Available phosphorus in soils and sediments of the study area

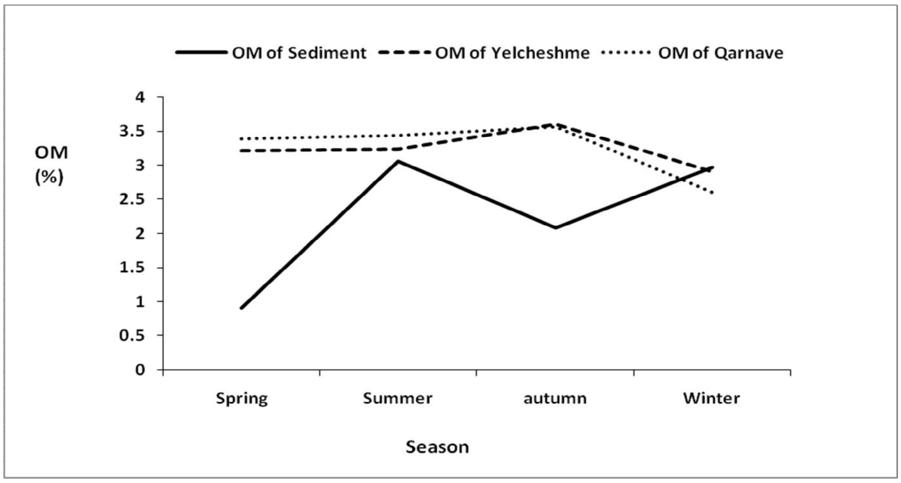

Figure 3. Organic matter in soils and sediments of the study area

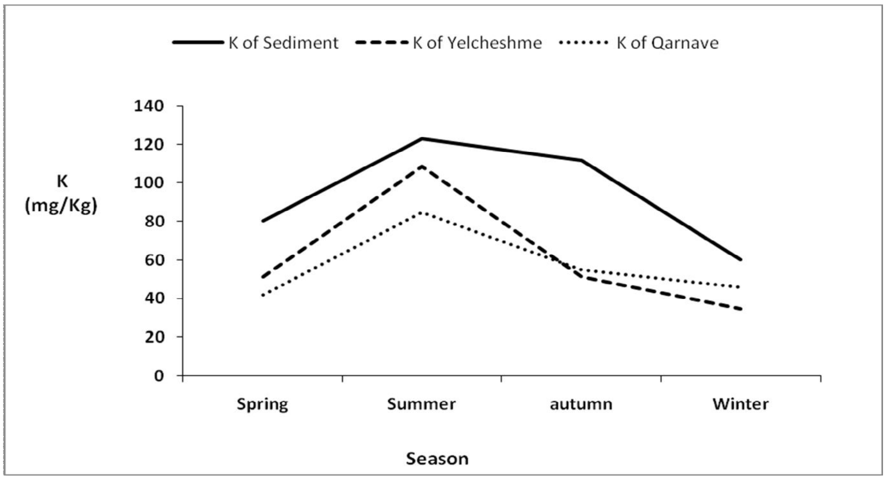

Figure 4. Available potassium in soils and sediments of the study area

The results of sediment assessment from the Tamer station during five years are shown in Figure 5. The largest amount of sediment occurred in late winter and early spring. Yousefifard (2004) stated that the lack of adequate coverage and high intensity rains increased soil erosion; consequently, increasing sediment discharges in winter. From discharged sediment of the watershed and amount of nutrient in sediment, the amount of total removed nutrient in different times were evaluated. Nitrogen removal rate ranged from 6.9 kg in August to 21.5 tons in March in the whole watershed (Figure 6). Phosphorus removal rate ranged from 20.0kg to 2.67 kg in August and March, respectively (Figure 7). Potassium loss changed from 7.0 kg in August to 8.0 tons in February (Figure 8). Organic carbon loss varied from 2.0 tons to 376 tons in August and March, respectively (Figure 9). The difference in the amount of nutrient loss and organic carbon depended on runoff and geochemical characteristics of the areas. Nitrogen, phosphorus, potassium and organic carbon losses in sediment during the year was 40.42, 135.0, 10.08, and 585 tons per year, respectively. If the SDR (sediment delivery ratio) equals 5.0, the erosion rate will double.

The results show that changes in land uses in both watersheds affected soil's physical and chemical properties. The study showed that soil particles in both watersheds altered from silty clay loam in forests to silty loam in cultivated lands. In contrast, the highest amount of MWD was measured in forest lands in both watersheds, and the lowest MWD was seen in pasture lands in the Qarnave watershed and in cultivated lands in the Yelcheshme watershed. The highest and lowest BD were observed in cultivated and forest lands respectively, in both watersheds. The highest amount of TN and OC was in forest lands and the lowest happened in pasture. The highest and lowest amount of CCE was seen in cultivated and forest lands. The highest amount of phosphorus and available potassium in both watersheds occurred in farm lands. Correlation analysis of nutrients in soil and sediment samples in the outlet of the watersheds showed statistically significant differences. The results showed that soil erosion in the study areas has resulted in soil degradation and decreased soil fertility. In this study we tried to determine the relationship between the losses of nutrients in the sediment with their sources. The results showed that although there was a relationship between the amount of potassium and nitrogen in soil and sediment, there was no clear relationship between nutrient trends in sediment and soil resources in all seasons. The reason could be attributed to different land uses and soil spatial variability in sediment transport, bedding materials and changes in properties of hydrothermal and hydrologic flow.

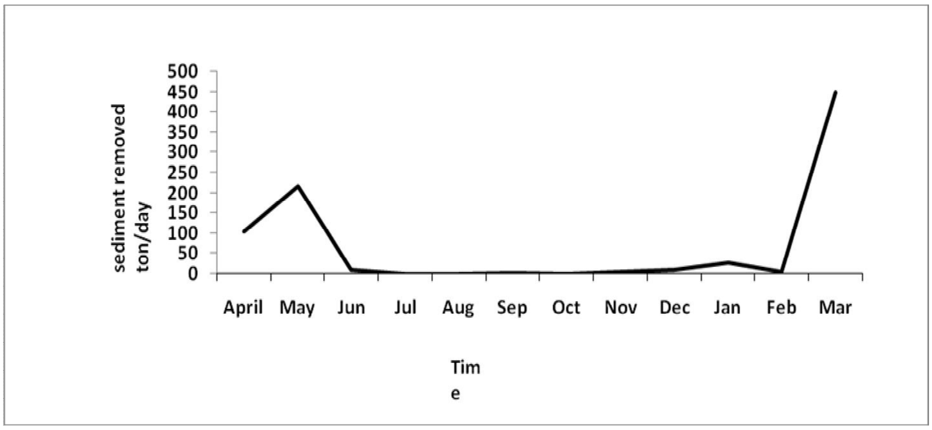

Figure 5. The removed sediment before reaching the outlet of the watershed

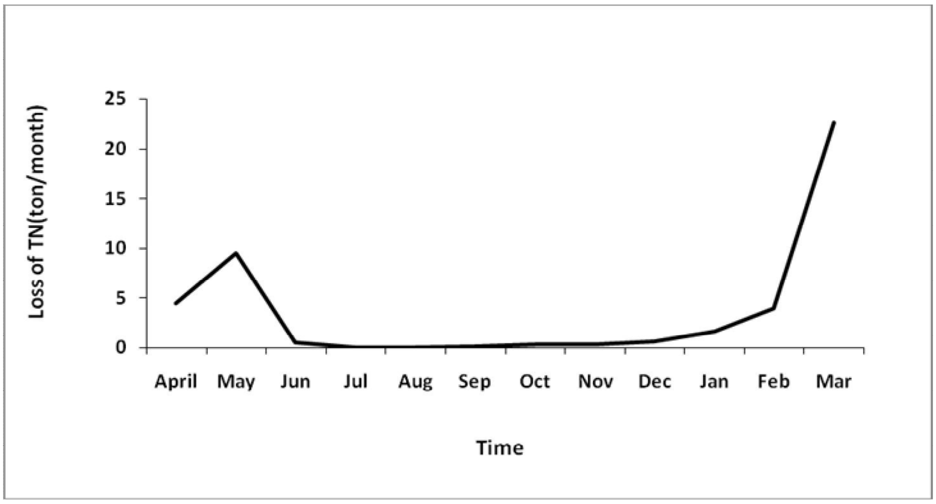

Figure 6. The amount of nitrogen lost by deposition (tons per month)

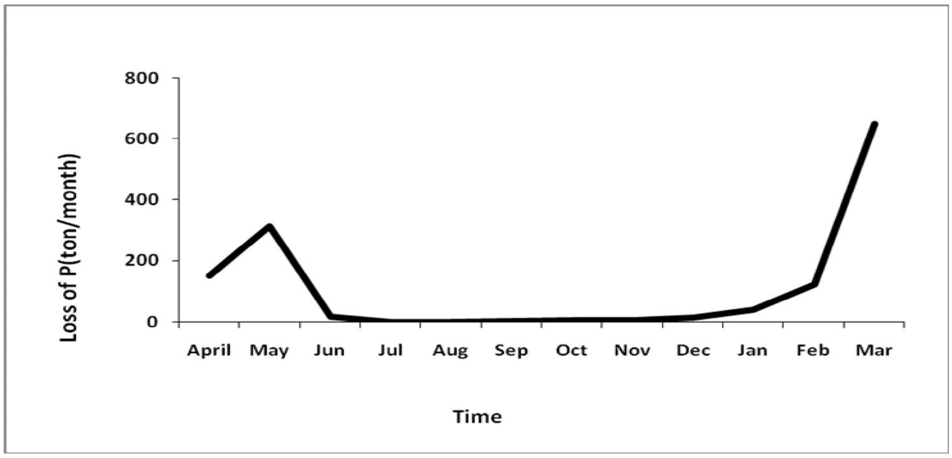

Figure 7. The amount of available phosphorus lost by deposition (tons per month)

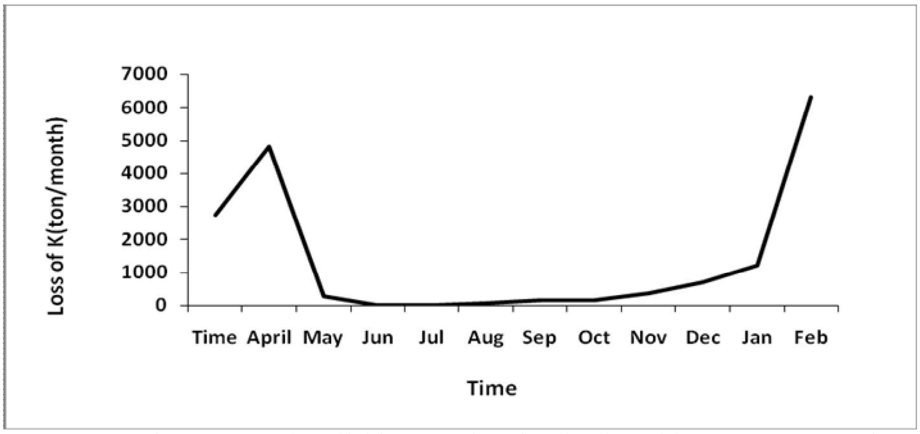

Figure 8. The amount of available potassium lost by deposition (tons per month)

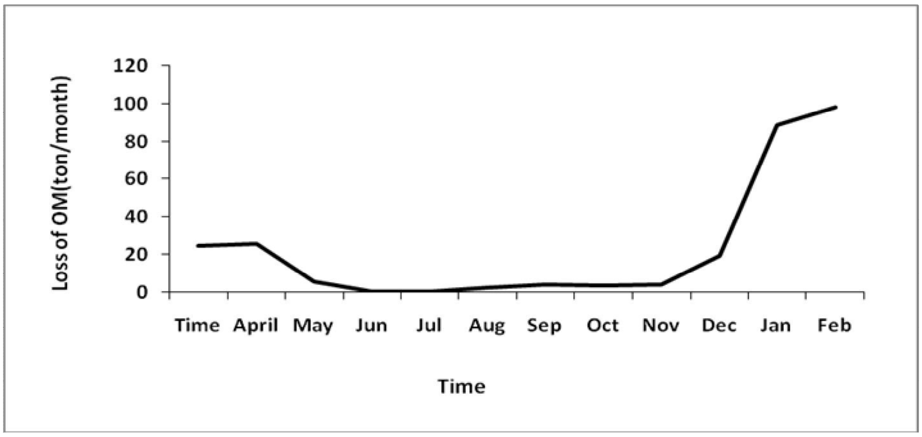

Figure 9. The amount of organic matter lost by deposition (tons per month)

Conclusion

Correlation analysis of nutrients in soil and sediment samples in the outlet of the watersheds was not significant. The results showed that soil erosion in the study areas has resulted in soil degradation and a decrease in soil fertility. This study tried to determine the relationship between the loss of nutrients in the sediments with their sources. The results showed that although there was a relationship between the amount of potassium and nitrogen in soil and sediment, there was no clear relationship between nutrient trends in sediment and soil resources in the following season. The reason could be attributed to different land uses and soil spatial variability in sediment transport channels, parent materials and changes in properties of hydrothermal and hydrologic flow.

Conflict of Interest

The authors declare that they have no conflict of interest.

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