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EFFECT OF ECOTOURISM ON PLANT DIVERSITY, SOIL AGGREGATE STABILITY AND PARTICULATE ORGANIC MATTER IN NATIONAL KHOJIR PARK IN TEHRAN

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Abstract - This work assesses the effects of ecotourism on biodiversity, soil POM and ASI in a semi-arid region in Iran. Three zones as High-pressure (0 to 50 m from the road, visitors density: > 20 persons ha^{-1} day^{-1}), Mid-pressure (50 to 100 m from the road, visitors density: 5-20 persons ha^{-1} day^{-1}), and Low-pressure (100 to 150 m from the road, visitors density: < 5 persons ha^{-1} day^{-1}) ecotourism were selected. Indicators of biodiversity, richness, and evenness (0.77, 5.55, and 0.79, respectively) were significantly higher in the High-pressure zone. Soil bulk density (1.95 g m^3), pH (7.98), and EC (0.82 ds m^{-1}) were significantly higher in the High zone whereas a higher content of total C (0.39%), total N (0.13%), available P (4.83 mg kg^{-1}), available K (3.21 mg kg^{-1}), available Ca (34.91 mg kg^{-1}), and available Mg (5.66 mg kg^{-1}) were found in the Low-pressure zone. POM-C and POM-N were significantly followed by Low (0.21 and 0.03 g kg^{-1}) > Mid (0.14 and 0.02 g kg^{-1}) > High (0.08 and 0.01 g kg^{-1}) zones, respectively. The Low-pressure zone with a population density of only 5 people per ha is associated with enhanced soil biodiversity and nutrient cycles.

Keywords: Ecotourism, biodiversity, soil fertility, national park, conservation.

Introduction

Parks, protected areas, and other natural areas across the world are considered as special places that have been regarded as natural and cultural assets attracting many local, national, and international tourists (Kolahi et al., 2014; Moore et al., 2009). The vegetation types found in arid regions as national parks (shrublands and grasslands) have important roles in determining the soil properties through changes in the inputs from below and above ground (Thoms & Gleixner, 2013). In fact, plants provide different C and nutrient sources for soil which improve the quality and quantity of soil. In different regions, especially in arid and semiarid regions, the presence of woody species has an undeniable role in creating efficient microclimates with multiple facilitating processes such as surface runoff reduction and seed trapping increase (Aerts et al., 2006).
The discussion on tourism and biodiversity tends to focus on the (negative) impacts of tourism on plant biodiversity and soil quality. As a consequence, negative impacts have been quickly observed for wildlife species and habitats due to air and water pollution, vegetation removal for tourist facilities and infrastructures (refuges, camping sites, roads, etc.), reductions in plant and animal fitness, habitat loss and degradation (Rossi et al., 2006; Griffin et al., 2007). Different types of activities including camping and trampling often result in changes in species richness, with taxa more susceptible to the damage

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being lost from a community, but others able to colonize disturbed sites. Trampling of the fragile field mark vegetation along the highest mountain ridges in Australia resulted in a decline in native species richness on the track compared to adjacent vegetation, as well as a decline in the abundance of species (McDougall & Wright, 2004).

Vegetation affects soil properties, which in turn define interspecific competition and therefore plant growth, setting up a plant–soil feedback system. Several properties of the soil such as carbon (C), nitrogen (N), C/N ratio and pH are deeply driven by plant type and coverage, which in turn could be altered by changes in these mentioned variables (Lucas-Borja et al., 2019). In addition to the type of plant cover, the activities of soil biota are highly influenced by changes in biotic and abiotic factors due to seasonal changes (Cui et al., 2019). The changes in environmental conditions, i.e., temperature and moisture regimes, can strongly affect the dynamics of soil biological activities directly and, following that, nutrient cycling and site productivity (Ren et al., 2018). Investigations into the relationship between above (i.e., vegetation type) and below (i.e., soil organisms) ground systems are an ambitious and inspiring area of research adding to the study of functional implications of vegetation diversity (Bardgett et al., 2005).

Iran has a long history of nature protection (Yakhkashi, 2002). Currently, protected areas are divided into four categories under the management of Iran's Department of the Environment (DoE). However, since the 1950s, following new definitions of protected areas, the number of protected areas in Iran has increased dramatically, especially during the last 10 years. In total, 253 protected areas have been declared, covering about 10% of the country's area (Kolahi et al., 2013). Strategic management of national parks can enhance C and N cycles (Kooch et al., 2020) via changes in plant community composition, plant productivity and ecophysiological functions (Barger et al., 2004; Pan et al., 2018). Understanding the relationships between ecotourism and the status of soil C and N is thus not only of academic interest but also crucial for the sustainable use and management of national parks in order to support ecosystem services (Qiu et al., 2013).

The soil aggregate stability index (ASI) and particulate organic matter (POM) are two important properties that are strongly influenced by different ecotourism density zones. ASI is related to its ability to maintain particle and pore arrangement when faced with different environmental stresses (Angers & Carter, 1995), and assessment of soil structure is usually expressed based on aggregate stability (Bronick & Lal, 2005). ASI plays a significant role in the development of root systems, carbon and water cycles as well as resistance against erosion (Barthès et al., 2008). ASI can also be improved by proper management practices (Oades, 1993). Protected areas impact soil structure by distributing soil organic matter through litter and recycling of roots and root exudates. Thus, vegetation and soil organic carbon are some of the most important factors determining ASI (Carpenter & Chong, 2010; Fattet et al., 2011; Soleimany et al., 2021). However, any decrease in soil organic matter can lead to reduced fertility, soil structure instability, and declined soil productivity (Obalum et al., 2017).

In this study, we show the effect of ecotourism on plant diversity, soil aggregate stability, and particulate organic matter in three areas characterized by different densities of visitors in the National Khojir Park (Iran). We have studied plant biodiversity indices, soil quality changes and the relationships between the plant diversity and soil quality in Low, Mid and High ecotourism density zones for five years to test: 1) how plant diversity changes in different visitors' density zones of ecotourism, 2) changes in ASI and POM characteristics, and 3) which soil characteristics are correlated to plant diversity in different visitors' density zones of ecotourism. The main hypothesis is that the higher visitor density area of ecotourism has a maximum effect on plant biodiversity and soil quality.

Materials and Methods

Study area

This study was carried out in the Khojir national park, 20 km from Tehran, Tehran province, Iran. It is located at 32°69′ 69″ to 34°68′68″N and 51°30′29″ to 51°56′44″E, with an area of 10,013 ha (Fig. 1). The elevation varies from 1200 m to 2138 m a.s.l. Climate is classified as semi-arid according to de Marton climatic classification. Mean annual precipitation and temperature are 280 mm and 14.7 °C, respectively. Khojir national park includes high mountains and Tappemahoor (hilly and semi-hilly areas). Parent materials are mostly conglomerate, sandstone and limestone, calcareous marl, and partially. Khojir national park is a part of Jajrood protected area and used to be Royal Hunting Resort (200 years ago); ever since the park has been the oldest forbidden hunting resort in Iran. Khojir national park has an environment with more virgin and healthier for the animals and is regarded as the best habitat of the central Alborz. This area is full natural, without any invasive plants and no history of disturbance. The plant species covered the district include *Pistacia atlanticas*, *Prunus scoparia*, *Juniper*, *celtis australises*, *Populus*, *Populus euphraticas*, *willows*, *Tabriz hawthorns*, *maples*, *European ashes*, *Ailanthus*, *Locusts*, *Prunus lycioides*, *raspberries*, *Tamarisks*, *Rubia tinctorum*, *Berberis*, *Sophora japonica*, *Cotoneaster*, *Paliurus spinachristi*, *Colutea arborescens*, and *Ephedra*. This study site was selected because it has a comparatively extensive Protected Area system and a strong management body. Also, Khojir national park is the nearest park to Tehran, the most populated city of Iran that is experiencing increasing pressures from human activities

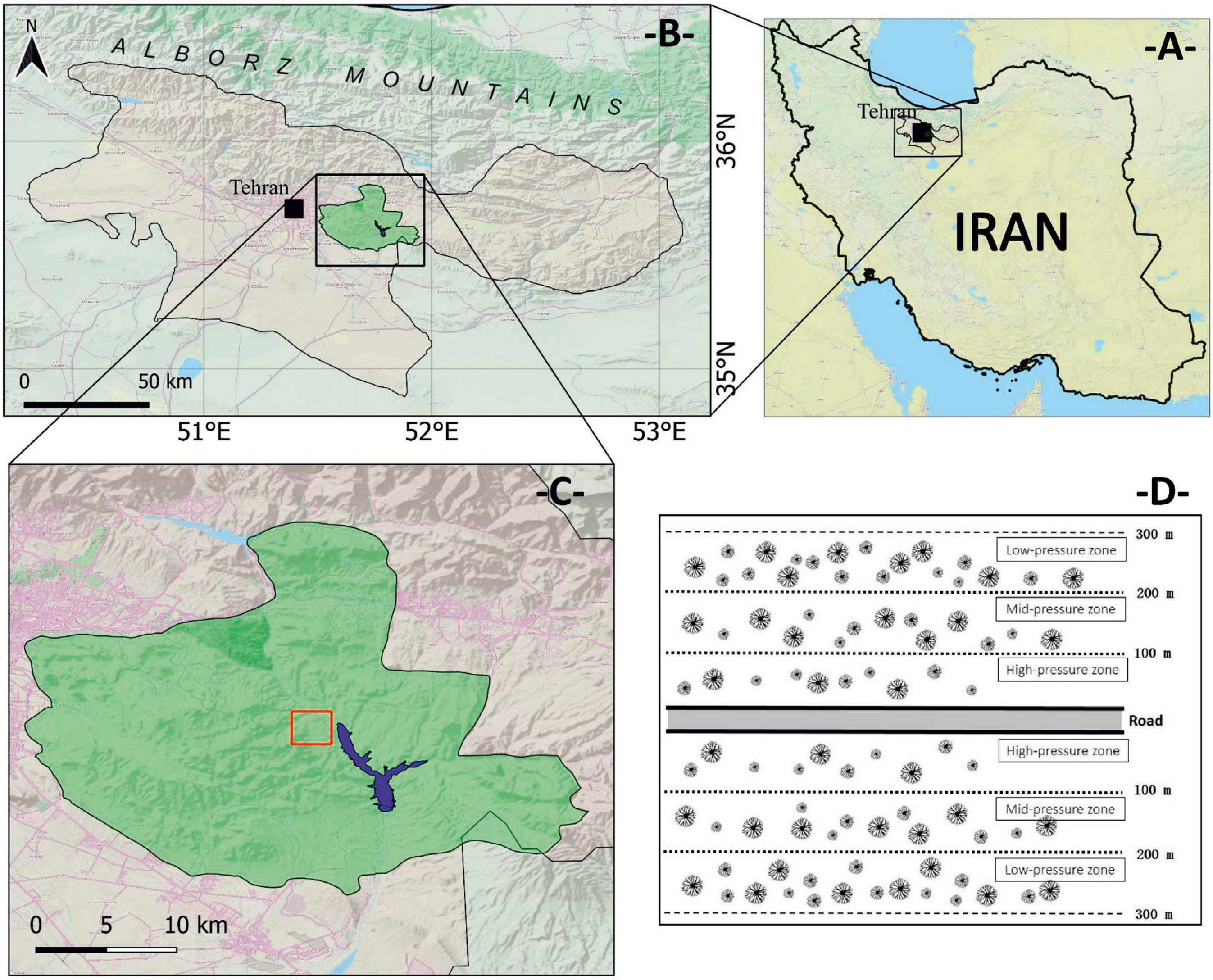

Figure 1. Location of the study site (Iran (A), Tehran province (B), Khojir national park (C) and Schematic showing of distance zones (D).

and climate changes, and management strategies have been carried out to address these changing stressors. This active management allowed us to assess the effectiveness of these strategies after ten years. The selected experiment site has a slope of 0-18% and soil texture mostly is loam and loam sandy. This area is mostly covered by moderate ranges and sparse forests. There is no severe erosion in the study site but signs of severe erosion were observed only in areas close to the road.

Sampling and laboratory analysis

Three zones as High-pressure (0 to 50 m from the road, visitors' density: > 20 persons ha^{-1} day^{-1}), Mid-pressure (50 to 100 m from the road, visitors density: 5-20 persons ha^{-1} day^{-1}), and Low-pressure (100 to 150 m from the road, visitors density: < 5 persons ha^{-1} day^{-1}) ecotourism were selected in an area of 4.5 ha (Fig. 1d). The visitor density in the experimental site was evaluated by counting the number of visitors per ha in 10 random days. The phytosociological survey was conducted by using the Braun-Blanquet approach with emphasis on the representative stand concept in mid-June 2018, when it is expected that most plant species are presented and fully developed in the study area. For evaluation of the plant biodiversity 54 quadrats of 1 m^2 area (18 quadrats with a minimum distance of 15 m in each zone) were taken randomly and then the list of flora and the cover percentage of vegetation were recorded (Dengler et al., 2008). Also, tree species were recorded in three random plots (30 m × 30 m) in each zone.

Soil samples (25 cm × 25 cm × 15 cm) were taken after removing the litter layer within 18 quadrats of each zone during the summer (April 2020). The soil samples were stored at 4 °C for two weeks. Soils were air-dried and passed through a 2-mm sieve (aggregates were broken to pass through a 2 mm sieve) to laboratory analysis. Bulk density was either by the Plaster (1985) method (clod method). Soil pH was determined using an Orion Ionalyzer Model 901 pH meter in a 1:2.5 soil-water suspension. Electrical conductivity (EC) was determined using an Orion Ionalyzer Model 901 EC meter in a 1:2.5 soil-water suspension. Soil organic C was determined using the Walkley-Black technique (Allison, 1975). The total N was measured using a semi-micro-Kjeldahl technique (Bremner & Mulvaney, 1982). Available P was determined with a spectrophotometer and the Olsen method (Homer and Pratt 1961), and available K, Ca, and Mg (by ammonium acetate extraction at pH 9) were determined with an atomic absorption spectrophotometer (Bower et al., 1952). The particulate organic matter C and N (POM-C and POM-N) were determined by physical fractionation (Cambardella & Elliott, 1992). Twenty-five grams of air-dried soil samples were dispersed with 100 ml of 5 g/l of sodium hexametaphosphate. The soil solution mixture was shaken for 1h at high speed (= 500 rpm) on an end-to-end shaker and poured over a 0.053 mm sieve with several deionized water rinses. The soil remaining on the sieve was back washed into a pre-weighed aluminum dish and dried at 60 °C for 24 h, then ground and analyzed for C and N (Kooch et al., 2019).

Table 1. Floristic list and individual numbers of the recorded plant biodiversity in the study area.

Scientific name	**Form**	**Family**	**Ecotourism zones**		
			Low	**Mid**	**High**
Artemisia annua L.	Forb	Asteraceae	77	102	113
Alhagi camelorum Medik.	Forb	Fabaceae		5	9
Astragalus spp.	Forb	Fabaceae	46	51	5
Onobrychis gaubae Bornm.	Forb	Fabaceae	46	33	5
Ajuja chamaecistus Ging. ex Benth.	Forb	Lamiaceae	23	6	
Amaranthus blitoides S.Wats.	Forb	Amaranthaceae	22	3	
Paganum spp.	Forb	Zygophyllaceae	2	3	8
Sophora alopecuroides L.	Forb	Fabaceae		1	2
Nardurus subulatus (Banks & Sol.)	Forb	Poaceae	10	13	7
Buffonia hebecalyx Boiss.	Forb	Caryophyllaceae	36	23	
Camphorosma monspeliacum L.	Forb	Amaranthaceae	25	9	6
Matthiola alyssifolia (DC.) Bornm.	Forb	Brassicaceae	10	5	
Cirsium lappaceum (M. Bieb.) Fisch.	Forb	Asteraceae		10	6
Centaurea cyanus L.	Forb	Asteraceae	7		
Pterocephalus canus Coult.	Forb	Caprifoliaceae	16		
Silene commelinifolia Boiss.	Forb	Caryophyllaceae	4		
Stroganowia persica N. Busch	Forb	Brassicaceae	28		
Allium rubellum M.Bieb.	Forb	Amaryllidaceae	2		
Prangus uloptera L.	Forb	Apiaceae	30		
Cotoneaster spp.	Shrub	Rosaceae	3		
Amygdalus communis Linn.	Tree	Rosaceae	11	7	4
Atrophaxis spinosa L.	Tree	Polygonaceae	6	3	3
Pistacia atlantica Desf.	Tree	Anacardiaceae	7	3	2
Zygophollium eurypterum Boiss. & Buhse	Tree	Zygophyllaceae	3	1	1
Ephedra spp.	Shrub	Ephedraceae	2	1	
Amygdalus scoparia Spach.	Tree	Rosaceae	5	2	1

Statistical analysis

All statistical analyses were conducted using the SPSS 19.0 statistical software package. The normality of the variables was checked by the Kolmogorov- Smirnov test and Levene's test was used to examine the equality of the variances. One-way analysis of variance (ANOVA) was used to compare soil properties data among the ecotourism zones. Duncan test was employed to test for differences at the $P = 0.05$ level. The biodiversity (Shannon, Simpson), richness (Menhinick, Margalef) and evenness (Camargo, Smith-Wilson) indices were calculated by using PAST software. To estimate gamma diversity for each of the three zones, we used a sample-size-based rarefaction-extrapolation approach, which estimated the rate of increase in diversity with the increasing number of samples and extrapolated the number of species to twice the actual sample size. Calculations were performed with the iNEXT package (Hsieh et al., 2016) in R (R Core Team, 2017). Multivariate correlations were analyzed using factor analysis based on principal components analyses (PCA) performed by PC-Ord version 5.0 (Mc Cune & Mefford, 1999).

Results

The relatively dominant species of trees in total were *Amygdalus communis* (32.4%), *Atrophaxis spinose* (22.1%), and *Pistacia atlantica* (17.6%). In shrubs, *Artemisia annua* (36.1%), *Asteragalus spp*. (12.6%), *Onobrychis gaubae* (10.4%), *Buffonia hebecalyx* (7.3%) were the most dominant species (Table 1). The total numbers of species in Low, Mid and High zones were 16, 13, and 9, respectively (Table 1). However, the results show significant differences of numbers of species and individuals in Low, Mid and High zones (Fig. 2a and 2b). The canopy covers in Low, Mid and High zones were significantly different; 59.4%, 33.6%, and 23.1%, respectively (Fig. 2c). Sample-base plant diversity showed at Low, followed by Mid and High (Fig. 3). The Margalef richness index shows a significant difference of Low, Mid and High zones with 5.55, 4.01, and 2.45, respectively (Fig. 4). The Menhinick richness index shows a significant difference between Low and High zones (Fig. 4). The result of the Camargo and Smith-Wilson evenness indexes shows the highest and lowest evenness in low and High zones (Fig. 4). Shannon–Wiener and Simpson index had the same results;

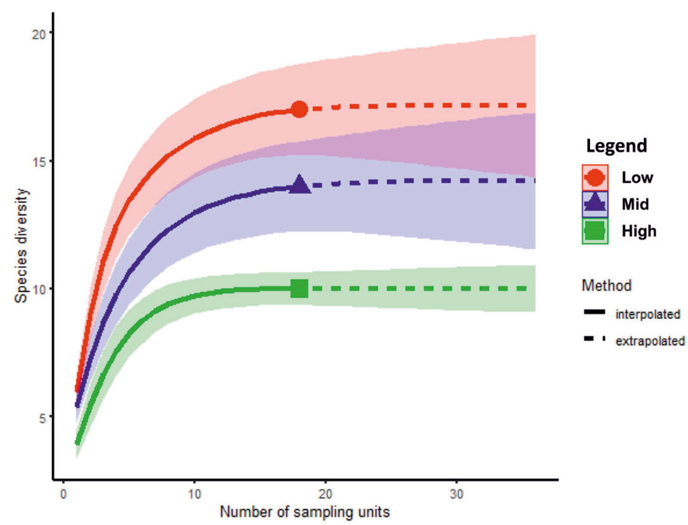

Figure 3. Sample-based rarefaction (solid lines) and extrapolation (dotted lines, up to twice the actual sample size) of plant diversity, along with 95% unconditional confidence intervals (transparent shading).

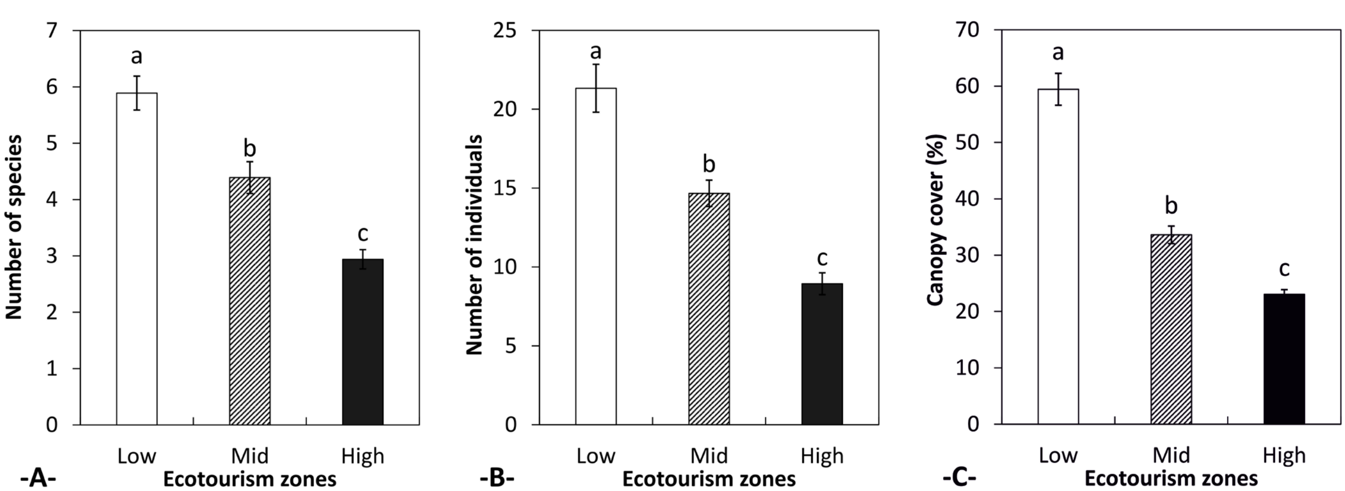

Figure 2. Mean values (±SE; n = 18) of the number of species (A), the number of individuals (B), and canopy cover (C) in Low, Mid and High ecotourism zones.

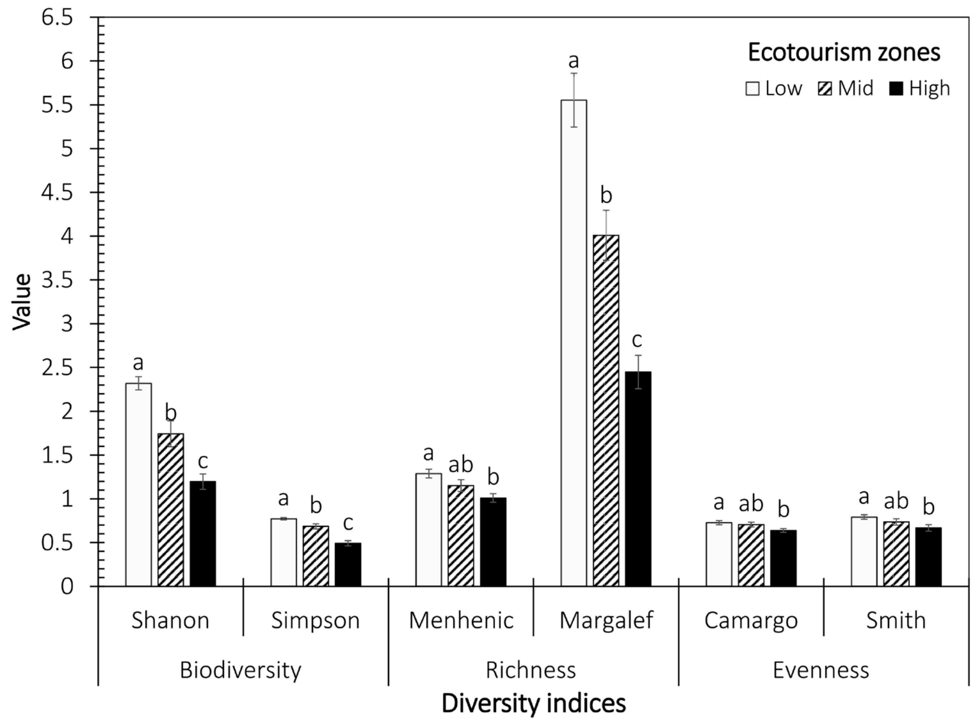

Figure 4. Mean values (±SE; n = 18) of biodiversity, richness, and evenness indices of herb biodiversity in Low, Mid and High ecotourism zones.

they represented that Low zone had the highest diversity than Mid and High zones (Fig. 4).

Soil bulk density was highest in the High zone (1.95 g cm^{-3}). Soil pH was significantly higher at the High zone (7.98) in comparison with the Mid and Low zones (6.7.61 and 7.25), respectively (Table 2). EC was close than twofold in the High zone (0.82 ds m^{-1}) compared to Low zone (0.43 ds m^{-1}). The decrease of visitors density resulted in an increase in soil organic C, so the Low zone (0.39%) had higher values than the other zones. Total N was found in ranked order of Low >Mid > High zones with more than four-fold in the Low zone (0.13%) compared to High zone (0.03%). Soil available P was significantly higher in the Low ≈ Mid zones (4.82 and 4.13 mg kg^{-1}) in comparison with the High zone (2.31 mg kg^{-1}).

Table 2. Mean values and standard error (SE, n = 18) of the analyzed soil features.

Soil features	**Ecotourism zones**						***F* test**	***P* value**
	Low		**Mid**		**High**			
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**		
Bulk density (g cm^{-3})	1.55 b	0.062	1.68 b	0.096	1.95 a	0.093	1.896	0.009
pH (1:2.5 H_2O)	7.25 c	0.109	7.61 b	0.133	7.98 a	0.086	7.985	0.000
EC (ds m^{-1})	0.43 b	0.038	0.54 b	0.085	0.82 a	0.061	0.761	0.003
Organic C (%)	0.39 a	0.034	0.14 b	0.044	0.03 c	0.011	1.034	0.000
Total N (%)	0.13 a	0.039	0.10 a	0.009	0.03 b	0.007	0.592	0.002
P (mg kg^{-1})	4.82 a	0.795	4.13 a	0.995	2.31 b	0.549	8.347	0.013
K (mg kg^{-1})	3.21 a	0.494	2.28 b	0.339	1.37 c	0.346	2.248	0.000
Ca (mg kg^{-1})	34.91 a	3.185	21.34 b	2.961	18.72 c	1.728	31.499	0.000
Mg (mg kg^{-1})	5.66 a	0.832	3.28 b	0.734	1.28 c	0.143	3.643	0.001

Results from the ANOVAs are included (*F* test and *p* value). Different letters in each line indicate significant differences ($p < 0.05$ by Duncan test) among Ecotourism zones.

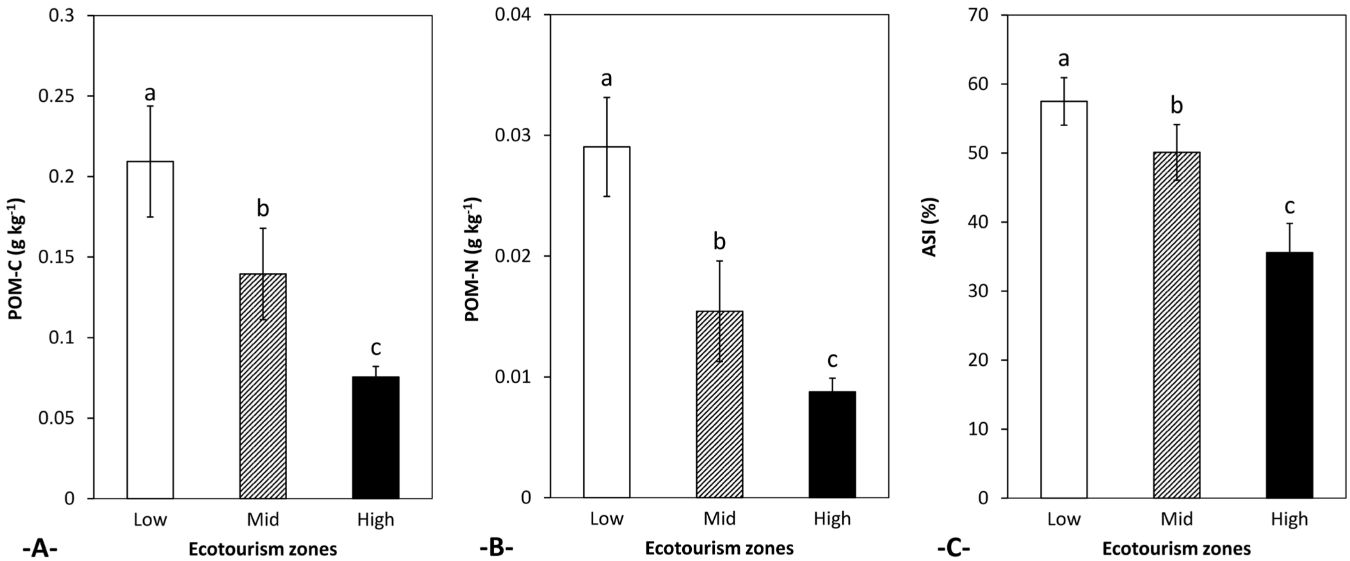

Figure 5. Mean values (±SE; n = 18) of soil POM-C (A), POM-N (B) and ASI (C) in Low, Mid and High ecotourism zones.

Soil available K was significantly in order of Low > Mid > High zones (3.21, 2.28 and 1.37 mg kg^{-1}), respectively. A significantly higher content, about two-fold, of soil available Ca was found in Low zone (34.91 mg kg^{-1}) in comparison with Mid and High (21.34 and 18.72 mg kg^{-1}). Soil available Mg was significantly different among the zones, and the Low zone (56.66 mg kg^{-1}) had the highest values compared to Mid and High (3.28 and 1.28 mg kg^{-1}) zones, respectively. There were significant differences in POM-C and POM-N between Low (0.21 and 0.03 g kg^{-1}), Mid (0.14 and 0.02 g kg^{-1}), and High (0.08 and 0.01 g kg^{-1}) zones, respectively (Fig. 5a and 5b). A significantly higher ASI was found in Low zone (57.49) in comparison with Mid (50.10), and High zones (35.57) (Fig. 5c). The studied Zones and soil properties presented different locations in the PCA output. The first and second axes respectively accounted for 31.14 and 18.27% of the explained variance (Fig. 6). The low zone presented a good condition of soil fertility and improved the soil POM-C and POM-N.

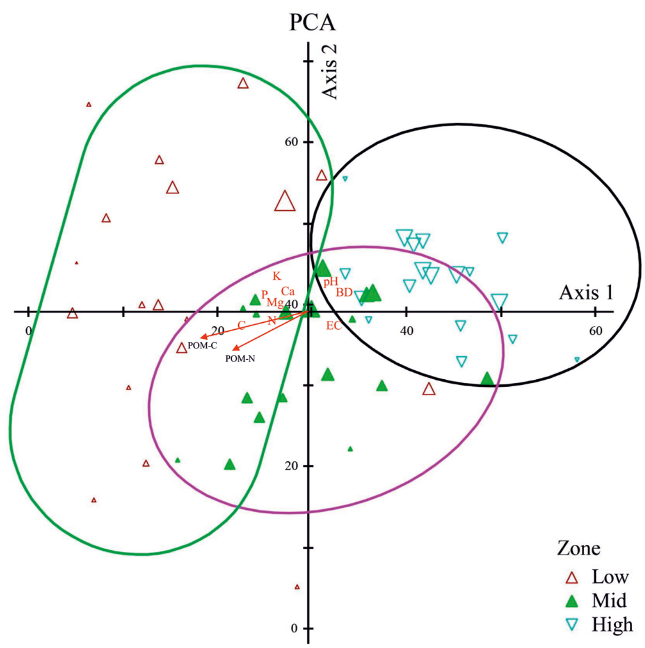

Figure 6. PCA based on the correlation matrix of the ecotourism zones (Axis 1: eigenvalue = 2.25 with 33.14% of the variation and Axis 2: eigenvalue = 1.96 with 18.27% of the variation).

Discussion

Environmental awareness of the relationships between humans and nature is crucial to applicate the appropriate management and result in maximum conservation (Zhao and Hou, 2019). The results show a significant effect of ecotourism on biodiversity indices of diversity, richness, and evenness. However, in a study by Sanjay & Paul (2007), the condition of vegetation deteriorated on a highly traveled trail, and the deterioration has significantly increased with the use of the trail. But in this study, the results were considerably different and indicate that the effect of ecotourism is more severe in the High zone. Our results are in line with Naidoo and Adamowicz (2005), Baral et al. (2008) and Zarghi & Hosseini (2014) which indicate that Tourism negatively affects the ecosystem by disturbances from visitors. Numerous studies have been conducted on this topic and researchers have discovered negative effects in national parks

(Kelly et al., 2003). Liu & Zhang (1997) also concluded that shrub coverage is an important factor in determining the degree of disturbance caused by tourists. Goleiji (2011) came to the same conclusion that the High pressure of tourism causes significant impacts on the reduction of plant species, diversity, richness as well as the increase of evenness. Tourism activities like Hiking, Camping, etc. has many impacts on vegetation such as plant richness and cover, Root damage, vegetation clearing/damage, reduction in height, reduced cover, change in litter, changes in species, reduced sapling and seedling species, biomass changes, plant density, and plant size and reproductive performance (Jahani et al., 2019). However, it must be considered that different forms of ecotourism participation affected ecological behaviors in different ways (Ren et al., 2021). Andrés-Abellán et al. (2005) asserted that tourist disturbance reduced the diversity and richness of the herbaceous layer. Also, Cheng et al. (2002) found that tourist disturbance decreased the height of the herbaceous layer. One of the important indirect and potential effects of ecotourism is the unintentional introduction of new species through tourists' shoes, clothes and equipment (Whinam et al., 2005), which ultimately leads to changes in biological communities and the physical environment Ecosystems (Monz et al., 2010). According to Wen et al. (2016), shrub coverage increased significantly as the distance of tourists from the trail increased. However, this may be related to invasive species growth against anthropogenic factors (Hosseini et al. 2011). Also, ecotourism affects the plant species in protected areas by increasing their stress and pressure (Buckley, 2004). Indeed, new species pose a major threat to biodiversity in many protected areas.

Our data revealed that the C content increased followed by Low, Mid and High zone. The changes in the C in the different zones also reflect the differences in quantity and quality of herbal litter inputs, litter C decay and root biomass C (Zheng et al., 2008). Contrary to our findings, previous reports (Salamon et al., 2004; Wardle et al., 2006) claimed that the type of aboveground vegetation has no remarkable effect on the soil properties. According to the findings of Kooch et al. (2016), the soil total N content is the main factor that affects the decomposition of litter, and litter decomposition rate is a major source of soil CO_2 emission. In the current study, greater values of total N were found in Low zone. Parallel to this study, Cao et al. (2011) reported that the soil N content promoted the release of CO_2 from the soil. Gnankambary et al. (2008) stated that the increase in soil N and also P enhanced soil organism activities. So, the high soil respiration in Low zone can be explained by an increase in the contents of soil nutrients (i.e., N, P, K, Ca and Mg). The environmental effects of tourism activities can be the result of kicking, changes in soil and groundwater nutrients, changes in the structure of vegetation or indirect effects such as: introduction of new species (weeds), pathogens and Habitat fragmentation occurs (Monz et al., 2010; Ballantyne et al., 2014). Also, with soil erosion due to tourism activities and tourist density, the nutrients required by the plant are reduced.

In ecotourism zones, a steep gradient of POM (POM-C and POM-N), identifying above-ground litter being the major source of POM has been found under different vegetation canopy covers (Poeplau & Don, 2013). This difference was probably majorly due to the physical and chemical nature of the flora litter inputs (Mendham et al., 2004). Soils C and N are the most labile C and N fractions in the biogeochemical cycling of surface soil (Zhou et al., 2015) that are dependent on vegetation type and litter quality (Laik et al., 2009). POM-C and POM-N are very important for in site increase productivity. Based on the research review, different results have been reported in relation to the variability of soil C and N under different canopy covers. Soil chemical features as the major factors affecting surface-soil C and N (Zhou et al., 2015). Based on this, different vegetation covers in the zones produced litters with various litter mass and chemicals that can be effective on the changes of C and N concentrations (Van den Berg et al., 2012), that is confirming our data at different ecotourism zones. Higher ASI in Low zone compared to Mid and High zones was expected because of conditions of undisturbed lands. The results of Nael et al. (2004) are consistent with our findings. Soil texture and clay content (Kemper & Koch, 1966), acidity, SOM content (Kandiah, 1976), and management practices and land use (Emadodin et al., 2009; Oades, 1993) are among the factors influencing the aggregate stability. Studies of Khazaee et al. (2008) and Onweremadu et al. (2010) indicate a positive effect of C on ASI. It is well-known that there is a direct linear relationship between ASI and soil C (Six et al., 2002; Carpenter & Chong, 2010).

Conclusion

Our findings indicate that the Low ecotourism zone has better plant conservation and improves the properties of soil fertility and stability. Highly successful ecotourism can support biodiversity conservation by influencing the national policy. However, tourism on a scale that can generate this degree of political support also carries serious risks of negative environmental and social impacts (Kiss, 2004). Considering the long history of Khojir national park and also the adverse condition of the biodiversity indices at the High-pressure zone, the executive solution is recommended in order to modify the existing conditions: (i) the High-pressure area should be under conservation and tourism management frequently for environmental remediation. (ii) The tourist dispersal should occur temporarily and in short-term periods so that it will be prevented from population dispersal in one area and consequently the subsequent adverse impacts on flora. We propose that through adapted soil management practices, we can optimize and sustain the multi-functionality of soils, including soil functions such as primary productivity, C and nutrient cycling and habitat quality for biodiversity. These processes are essential to sustainable land management, and for protecting the quality of water, air, and habitat. Therefore, by appropriate management manner, we can optimize that presence of plants improves soil quality at high altitudes sites of mountainous regions. It is hoped that the results would improve scientific approaches to further understand the mechanism of plant-soil feedback to ecotourism, and help in optimizing a management strategy to enhance ecosystem services.

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