International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:13, No:4, 2019

Reduction of Plants Biodiversity in Hyrcanian Forest by Coal Mining Activities

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Abstract**—**Considering that coal mining is one of the important industrial activities, it may cause damages to environment. According to the author's best knowledge, the effect of traditional coal mining activities on plant biodiversity has not been investigated in the Hyrcanian forests. Therefore, in this study, the effect of coal mining activities on vegetation and tree diversity was investigated in Hyrcanian forest, North Iran. After filed visiting and determining the mine, 16 plots (20×20 m^2) were established by systematic-randomly (60×60 m^2) in an area of 4 ha (200×200 m^2-mine entrance placed at center). An area adjacent to the mine was not affected by the mining activity, and it is considered as the control area. In each plot, the data about trees such as number and type of species were recorded. The biodiversity of vegetation cover was considered 5 square sub-plots (1 m^2) in each plot. PAST software and Ecological Methodology were used to calculate Biodiversity indices. The value of Shannon Wiener and Simpson diversity indices for tree cover in control area (1.04±0.34 and 0.62±0.20) was significantly higher than mining area (0.78±0.27 and 0.45±0.14). The value of evenness indices for tree cover in the mining area was significantly lower than that of the control area. The value of Shannon Wiener and Simpson diversity indices for vegetation cover in the control area (1.37±0.06 and 0.69±0.02) was significantly higher than the mining area (1.02±0.13 and 0.50±0.07). The value of evenness index in the control area was significantly higher than the mining area. Plant communities are a good indicator of the changes in the site. Study about changes in vegetation biodiversity and plant dynamics in the degraded land can provide necessary information for forest management and reforestation of these areas.

Keywords**—**Vegetation biodiversity, species composition, traditional coal mining, caspian forest.

I. Introduction

DESPITE the fact that mining is one of the most important industrial activities in the world, it has many environmental impacts [1]. One of the most important environmental effects of coal mining is the production of residues; because these residues contain heavy metals such as cadmium (Cd) and lead (Pb) [2]. This pollution source represents the risk for both the human populations and for vegetation cover in an ecosystem [3], [4].

Mining activities can change the plant structure and biodiversity and removal of vegetation [5]. Mining activities usually affect relatively small areas of vegetation, but loss of species diversity due to erosion may be significant [6]. Loss of plant diversity can affect the ecosystem functions [7]. Negative effects of coal mining on plants have been reported in recent studies [8].

Hyrcanian forest located in the north of Iran (covers the southern coasts of the Caspian Sea and is expanding over the northern slopes of the Alborz Mountains), and this forest is a suitable habitat for many hardwood (e.g. beech, oak, maple, alder) [9], [10]. The Hyrcanian forests are an essential source of genetic variation, biodiversity as well as various environmental services and benefits such as wildlife habitat. However, some of human activities (e.g. traditional coal mining) have led degradation of Hyrcanian forest [11].

To our knowledge, there has not yet been a study about the effect of traditional coal mining on forest ecosystem especially on plant biodiversity in the Hyrcanian forests. The purpose of this study was to reveal the effects of coal mining on vegetation and tree diversity in Hyrcanian forest of north Iran for the first time. Study about plant diversity in degraded areas could be a good solution for rehabilitation and management of these areas.

II. Materials And Method

A. Site Description

The study was conducted in Lavij Forest, western Hyrcanian forests, Noor City, Mazandaran Province, Iran (Fig. 1). The natural forest vegetation is temperate deciduous forests containing broad-leaved species such as beech (*Fagus orientalis* Lipsky), oak (*Quercus castaneifolia* C. A. M), hornbeam (*Carpinus betulus* L.), maple (*Acer velutinum* Boiss., *Acer cappadocium* Gled.). The elevation range is about between 950-1270 m. The average slope is 30%, and the main aspects are West and South-west. The climate is temperate humid and meteorological data provided by synoptic meteorological station indicated that annual average rainfall is 866 mm. Mean annual temperature is 9.8 ˚C. The soil type is brown forest soil, and the permeability and stability of bedrock are very weak and has drift conditions [12].

B. Experimental Design

In this study, after visiting and determining the location of the mine, 16 plots (20 × 20 m^2) were established systematic-randomly (a 60 × 60 m grid) in an area of 4 ha (200×200 m^2), in the way that mine entrance placed at center [13], [14] (Fig. 1). Then, an area adjacent to the mine, which was not affected by the mining activity (approximately 2 Km distances), was selected and considered as the control area and plots were established with the mentioned method. In each plot, the

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number and type of tree species were recorded. In order to study the biodiversity of vegetation cover, 5 square sub-plots (1 m^2) were considered in each plot [15].

C. Statistical Analysis

Values of diversity indices (Simpson and Shanon-Wiener indices), richness indices (Margalef and Menhinic indices) and evenness indices (Camargo and Smith-Wilson indices) were calculated by using PAST and Ecological Methodology software (Table I). Differences in biodiversity indices (diversity, richness and evenness) between mine and control sites were tested with independent sample T-test. Significant differences among treatment averages for different parameters were tested at $P \leq 0.05$. For all statistical analyses, SPSS v.20 software was used.

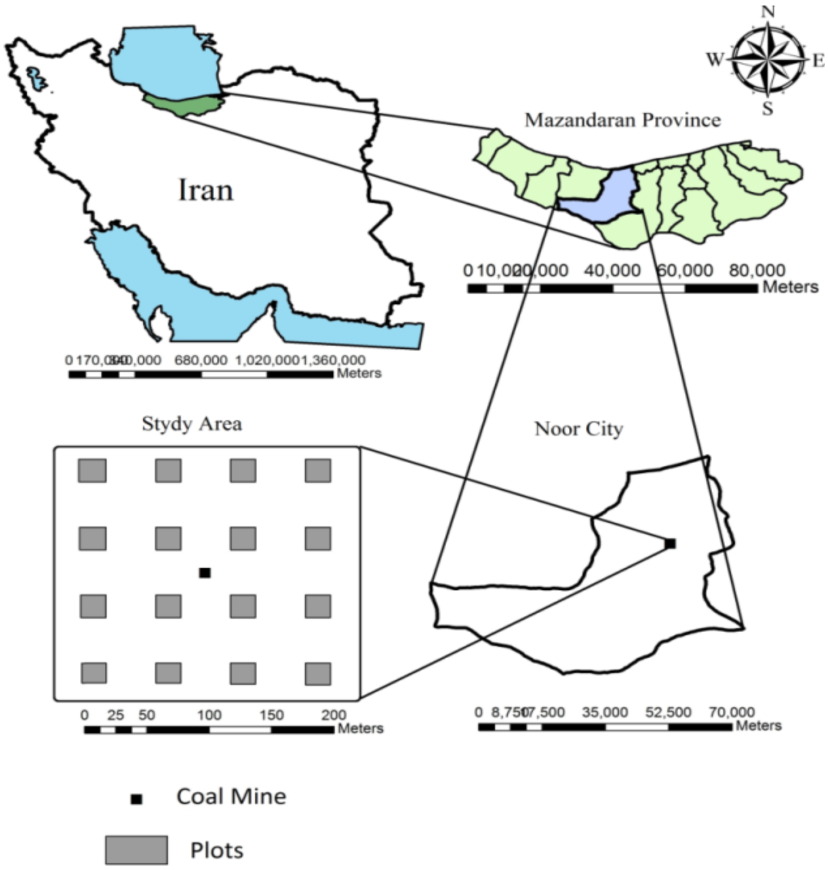

Fig. 1 Location of the study area, western Hyrcanian forests

TABLE I
BIODIVERSITY INDICES

	Indices	Formula
Diversity	Simpson	$D = 1 - \sum n_i(n_i - 1) / (N(N-1)$
	Shannon-Winner	$H = -\sum_{i=1}^{S}(Pi)(\ln Pi)$
Richness	Margalef	$R = S - 1/LnN$
	Menhinick	$R = S/\sqrt{n}$
Evenness	Pit	$E = H/ln(S)$
	Camargo	$E = 1 - (\sum_{i=1}^{s}\sum_{j=1+1}^{s}(\frac{P_i - P_j}{s}))$

III. RESULTS

A. Species Composition in the Mining and Control Areas

The results showed that the mining activity caused a change in the composition of the tree and vegetation species. Ironwood and walnut trees were not found in the mining area; however, the abundance of hornbeam, caucasian wing nut (*Pterocarya fraxinifolia*), alder, Cappadocian maple (*Acer cappadocicum)* and beech in the mining area was greater than that of the control area (Fig. 2 (a)). In both areas, *Alnus glotinosa* had highest SIV index (Fig. 2 (b)). A total of eight grass species were identified in the control area and 15 grass species in the mining area. *Rubus hispidus; Euphoribia helioscopia; Ruscus hyrcanus; Pteridium aquilinum* and *Urtica dioica* were found in both areas; whereas *Carex; Polygonum hyrcanicum; Phyllitis Scolopendrium; Danae racemosa; Asperula; Sambucus Ebulus; Polygonum aviculare; Solanum Dulcamara; Bromus pubescens and Vitex Negundo* only were found in mining area (Table II).

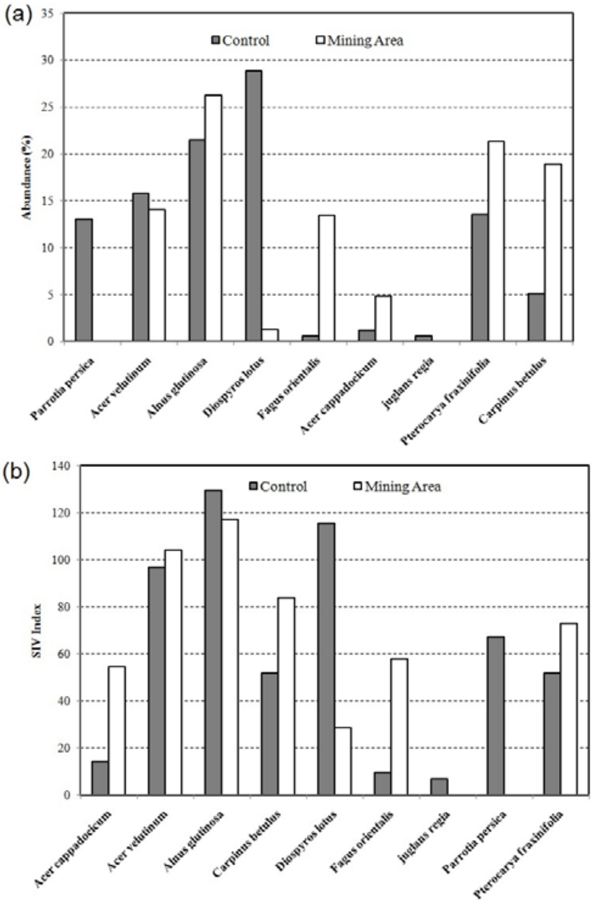

Fig. 2 Identified tree species abundance (a) and SIV index (b) in the control and mining areas

TABLE II
IDENTIFIED VEGETATION SPECIES AND SIV INDEX IN THE CONTROL AND MINING AREAS

vegetation species	Control area	mining area
Rubus hispidus L.	101.40	133.83
Euphoribia helioscopia L.	133.54	62.08
Ruscus hyrcanus Woron	94.15	82.49
Pteridium aquilinum (L.)	52.31	82.58
Urtica dioica L.	35.28	7.62
Dactyloctenium Willd	8.26	0
Mentha Iongifolia (L.)	14.26	0
Lamium album L.	23.28	0
Carex L.	0	6.72
Polygonum hyrcanicum L.	0	11.47
Phyllitis Scolopendrium (L.)	0	14.05
Danae racemosa (L.) Moench	0	6.71
Asperula L.	0	8.59
Sambucus Ebulus L.	0	22.16
Polygonum aviculare L.	0	8.59
Solanum Dulcamara L.	0	15.01
Bromus pubescens	0	8.10
Vitex Negundo L.	0	29.88

B. Diversity Analyses

The results of this study showed that mining activity has a significant effect on the tree cover biodiversity indices. The value of Shannon Wiener and Simpson diversity indices in control area was significantly higher than mining area. The value of evenness indices in the mining area was significantly lower than that of the control area (Table III).

The results of this study showed that the mining activity had significant effects on biodiversity indices of vegetation. The value of diversity indices in the mining area was significantly lower than the control area. The value of evenness indices in the mining area was significantly lower than the control area and value of Menhinick index in the mining area was significantly higher than that of the control (Table IV).

TABLE III
BIODIVERSITY INDICES OF TREE (MEAN ± STANDARD ERROR) IN THE CONTROL AND MINING AREAS

Biodiversity index	area	mean	T Value
Shannon Wiener	control	1.04±0.34	2.16^{*}
	mining	0.78±0.27	
Simpson	control	0.62±0.20	2.78^{**}
	mining	0.45±0.14	
Menhinick	control	1.05±0.39	0.13^{ns}
	mining	1.04±0.30	
Margalef	control	1.04±0.51	0.28^{ns}
	mining	0.95±0.39	
Peet	control	0.82±0.22	2.64^{*}
	mining	0.64±0.14	
Camargo	control	0.75±0.02	2.33^{*}
	mining	0.67±0.01	

TABLE IV
BIODIVERSITY INDICES OF VEGETATION (MEAN ± STANDARD ERROR) IN THE CONTROL AND MINING AREAS

Biodiversity index	area	mean	T Value
Shannon Wiener	control	1.37±0.06	2.33^{*}
	mining	1.02±0.13	
Simpson	control	0.69±0.02	2.61^{*}
	mining	0.50±0.07	
Menhinick	control	0.031±0.01	3.57^{**}
	mining	0.43±0.03	
Margalef	control	0.71±0.05	0.14^{ns}
	mining	0.73±0.01	
Pit	control	0.88±0.01	2.76^{**}
	mining	0.68±0.08	
Camargo	control	0.68±0.01	2.38^{*}
	mining	0.77±0.03	

Ns: No significant difference, *: Significant difference at 5% level, ** Significant difference at 1% level

IV. DISCUSSION

In this study, the effect of mining activity on the plant biodiversity was investigated. The results showed that the species composition was changed by mining activity. Considering that the climatic and habitat characteristics of the two areas were the same, hence it can be said that this difference was due to the mining activity. The main reason for this can be the random tree harvesting in the mining area for mining activities, including the eradication of native trees, the unauthorized harvesting of young trees to provide the foundation for strengthening the tunnel walls, which had changed the main structure of the forest ecosystem. The results were in accordance with the results reported in other studies [16]-[18]. Sarma [19], Sarma et al. [20] and Lyngdoh [21] also reported in their studies that the species composition in the mining area was lower than the control area while Iverson and Wali [22] stated that mining had increased the number of species in the mining area. The high frequency of hornbeam, Persian maple and alder in the mining area indicated the ability of these species to grow in this area, where the main reason for this is their light-demanding nature. The results of this study were consistent with the results of Sarma et al. [20], while Lyngdoh [22] and Das Gupta [18] achieved the opposite results.

The biodiversity indices of trees and vegetation in the control area were significantly higher than in the mining area. The reason for lower biodiversity in the mining area could be due to the destruction of habitats, soil compacting and aggregate loss and ultimately increased bulk density and reduced water penetration and soil aeration. Among other mining activity impacts on forest soil characteristics are soil loss, destruction, contamination with heavy elements; mass movement and erosion, which all of these finally lead to the inability of plant growth and establishment in the affected areas by mining [20], [23]. The results of Frouz et al. [24] also showed that mining had changed the vegetation, which is consistent with the results of this study. The higher evenness index in the mining area indicated an increase in the frequency of the establishment of species per unit area, which in general showed a change in the forest floor vegetation cover.

The high SIV of vegetation species in the mining areas suggests that it can multiply rapidly in the disturbed environments [20]. This perennial grass, due to its stolon and roots in each node, can bind soil particles, and make the soil more stable. Nutrient deficiency habitats are usually covered by species with a relatively low growth rate, and these adaptations cause colonial species to maximize the absorption of nutrients and ensure the high nutrient utilization in low nutrient environments [18], [19], [21].

The results of this study confirm that mining activity can affect tree and vegetation composition. Also, the amount of diversity and richness indices in the mining area was significantly lower than the control area. One of the first visible signs of environmental stress caused by pollution is the changes in plants diversity and composition. Therefore, study about changes in vegetation biodiversity could be a proper approach for management of degraded land.

Acknowledgment

This study was financially supported by *Sari Agricultural Sciences and Natural Resources University*. The authors would like to thank Miss Rasta Rajaei and Dr. Mahya Tafazoli for their kind cooperation.

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