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Comparison of Soil Macro Fauna Biodiversity in Broad Leaf and Needle Leaf Afforested Stands

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Abstract This study evaluated the macro fauna diversity in 20 years Cypress, Poplar, Maple and Alder plantation and also adjacent Natural forest likewise relation with some soil characteristics in shast kela forest that is located in golestan province, northern Iran. Soil sampling performed using core soil sampler 81 cm^2 areas in bottom from 0~10 and 10~20 cm soil depth in May 2012. 5 samples randomly selected in each plantation and totally 50 samples were taken then soil macro fauna segregated with hand and were collected in bags. Then number and fresh weight were measured with 0.01 g accuracy in laboratory. Shannon diversity, Simpson evenness and margalef richness indices were used for comparing diversity. Data showed that afforested stands significantly affected macrofauna biodiversity and soil characteristics. The average of soil macrofauna abundance and biomass were consistently higher in Alder stand than in the other tree plantations, while they were lowest in Cypress plantation. In general, soil macrofauna biodiversity (for both of abundance and biomass) were decreased in Alder, Maple, Natural forest, Poplar and Cypress, respectively. Most of biodiversity indices were significantly higher in 0~10 cm than in 10~20 cm depth for abundance and biomass of soil macrofauna. The Principal Component Analysis (PCA) results suggest that the macrofauna distribution is regulated by total nitrogen and bulk density. In general, it can be pointed out that soil habitants play a significant role in reviving and rebuilding destructed forests and accelerating and reinforcing growth in natural forests. This interacts with the genus type and, hence, species must be planted and reinforced in forest habitats which positively affect biomass and activity of soil habitants and improve habitat conditions and productivity.

Keywords Plantation; Natural forest; Macrofauna; Diversity; Richness

Introduction

Although up to the present time, different kinds of soils have physically and chemically been studied and classified, but they were not biologically taken as important. It was for ignoring the roles of living things to assign soil features and function. Soil creatures can directly or indirectly affect earth production and yield (Barrios, 2007). Soil creatures can be regarded as important and essential elements in any ecological systems (Tondoh et al., 2007). They also have main roles to improve soil fertility, earth products and ecosystem stability (through biological processes) (Barrios, 2007; Szlavecz et al., 2011). In several researches (Kelsey et al., 2011; Holdsworth et al., 2012; Guei et al., 2012; Blouina, 2013) soil fauna is one of the important features to evaluate its quality and health which their abundant and biology can be affected by habitat ecological conditions. Among these, Macro faunas can be said very salient as soil creatures in food and energy cycles, which they could affect mainly organic dynamic and their analysis in soil (Binkley and Giardina, 1998; Barrios, 2007). Earthworms are the most essential ones among macro-faunas family which have the greatest amount of invertebrate biomass (Sinha et al., 2003; Tondoh et al., 2007).

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They are affected through vegetation type (Mboukou-Kimbatsa et al., 2007), soil features (Yong-Chun et al., 2006), weather conditions, humidity (Davis et al., 2006), and sea level height (Kurcheva, 1972). On the other hand, because of land destruction, soil grinding and compressing which all cause reduction in production as well the second succession limitations (Warren and Zou, 2002). Expanding and transforming soil alongside its vegetation can be complex processes which bring change and variation in soil features so that they can affect both forest vegetation and its growth. Often dividing soil function to different physical, chemical and biological steps seems very difficult for their reciprocal effects as well complex natures (Vesterdal et al., 2013). Tree species affect in different ways the biological, physical and chemical characteristics of the soil (Antunes et al., 2008; Wang et al., 2009). There is a non-significant relation between worms numbers, biomass and soil C/N as well between earthworms biomass and soil carbon, moreover a significant positive link between worms numbers and their biomass (Kooch et al., 2008, 2013).

The greatest variety and identity indexes relates to smashed organic layer. Deeper in depth would cause less in indices (Rahmani and Zare Maivan, 2004). Natural jungle areas had more variety in contrast to planed area for afforestation or the applied ones, claimed by Pashani et al., (1991), and Muturi et al., (2009). In some other cases, soil invertebrates' biomass and their varieties in different artificial planted forest areas were more than the natural ones. When soil pH increases, the conditions will improve for soil invertebrates, likewise when soil macro-fauna number and biomass increases, soil fertility improve which it can bring better conditions for trees grow (Bradford et al., 2002). Alder forestation shows the more variety of diversity (Shannon-Wiener) and evenness (simpson) and richness (margalef); however cypress had the smallest amount in number (Agusto et al., 2002, Chitii et al., 2007). Nitrogen raise causes soil invertebrate increase. In some plots with more nitrogen, not only there were seen greater amount of macro-fauna biomass, but also they were bigger in size (Cole and Bardgett, 2002).

Although it cannot be claimed just for nitrogen, since they relate to some other factors such as bulk density also soil moisture (Jones and Darrah, 1994). Jalilvand and Kooch (2012) investigated earthworm abundant and biomass considering some soil features, the results showed that there is a positive and significant relation between soil abundant, Macro-fauna biomass and some other soil features such as its moisture and nitrogen. Earthworms can be considered as a suitable agent to evaluate how land control can affect outgrowth dynamic and production, besides it is the best factor in recognizing soil quality (Bird et al., 2004; Richard, 2004, Muturi et al., 2009). Therefore knowing more about its features in different environments is very important. Whereas their reduction in population and variety can bring negative effects on soil structure, analysis flow, gas penetration and exchange processes, then they can disturb plants growth. Consequently we must identify these creatures' variety indexes in ecology, preservation programs, habitat management and ecosystem evaluation (Mohammad Nejad Kiasari et al., 2011; Jalilvand and Kooch, 2012). These indices are very useful to consider soil creatures' varieties in accordance with pattern quality (Gongalsky et al., 2008).

Considering the importance of soil macro-fauna to analyze humus and food cycle, the present research has been done to assess forestation successfulness in accordance with soil invertebrate varieties, the effects of some species such as Cypress, Poplar, Maple, Alder and Natural forest on macro-fauna abundance and biomass as well their links to some other soil qualities.

1 Results

1.1 Soil macrofauna biodiversity

Investigating macro-faunas abundance (Table 1, Figure 1) and biomass (Table 1, Figure 1) showed that alder forestation was greatest in variety while cypress showed the smallest one. Totally soil macro-fauna abundance and biomass will decrease in alder, maple, natural forest, poplar and cypress, respectively (Figure 1 and Figure 2). All the variety indices (except Margalef abundance) showed a significant difference in two different depths, 0~10 cm and 10~20 cm in accordance with excess and biomass however the former one owned the greatest amount (Figure 3 and Figure 4).

Table 1 Two-way analysis of soil macrofauna biodiversity in different types and soil depths

Variable factor		Biodiversity index	SS	DF	MS	F-value	Sig.
Type	Abundance	Shannon - Wiener	6.831	4	1.708	18.648	0.000
		Simpson	0.998	4	0.249	10.762	0.000
		Margalef	6.642	4	1.661	8.599	0.000
	Biomass	Shannon - Wiener	4.114	4	1.029	9.161	0.000
		Simpson	1.288	4	0.322	7.431	0.000
Depth	Abundance	Shannon - Wiener	1.315	1	1.315	14.354	0.000
		Simpson	0.115	1	0.115	4.948	0.032
		Margalef	0.472	1	0.472	2.431	0.127
	Biomass	Shannon - Wiener	1.677	1	1.677	14.938	0.000
		Simpson	0.386	1	0.386	8.896	0.005
Type × Depth	Abundance	Shannon - Wiener	0.456	4	0.114	1.244	0.308
		Simpson	0.013	4	0.003	0.146	0.964
		Margalef	0.456	4	0.114	0.588	0.673
	Biomass	Shannon - Wiener	0.933	4	0.248	2.211	0.085
		Simpson	0.307	4	0.077	1.771	0.154

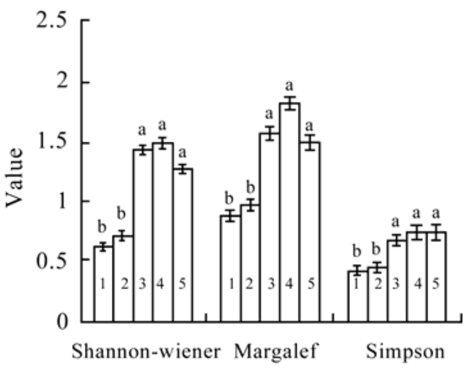

Figure 1 Mean abundance biodiversity indices of macrofauna in different types

Note: 1: Cyrpess; 2: Poplar; 3: Maple; 4: Alder; 5: Natural forest

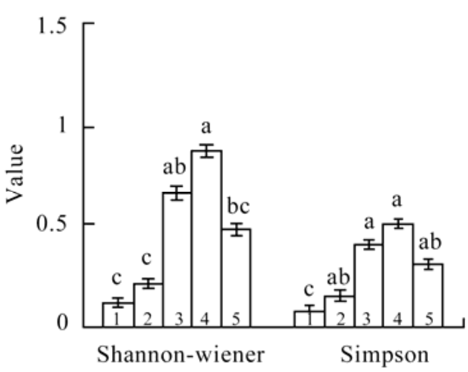

Figure 2 Mean biomass biodiversity indices of mcrofauna in different types

Note: 1: Cyrpess; 2: Poplar; 3: Maple; 4: Alder; 5: Natural forest

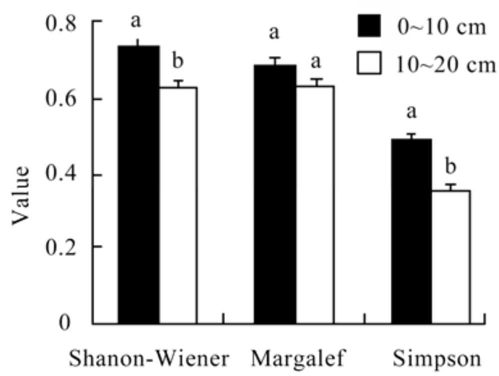

Figure 3 Mean abundance biodiversity indices of mcrofauna in soil depths

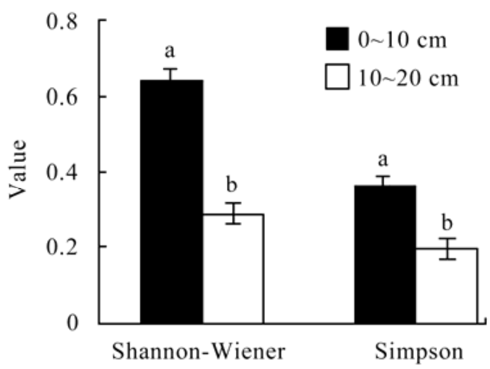

Figure 4 Mean biomass biodiversity indices of macrofauna in soil depths

1.2 Soil features

Considering some soil physical and chemical features showed that there are significant differences statistically between the amounts of pH, organic carbon, total nitrogen, C/N, moisture and bulk density in different types (Table 2). The greatest amount of pH recorded for alder in contrast to natural or the other sorts of forestations. Also the most amount of pH was seen in the second depth (10~20 cm). Organic carbon in Cypress forestation was the most to the other planted stacks besides there was a significant difference between two aforementioned depths (Table 3). Alder and maple had the greatest nitrogen in contrast to Cypress, poplar and natural forest, so that deeper goes down, less in number. C/N in Cypress mass showed a significant difference to the other planted types, although not any differences in both depths. The greatest amount of humidity was seen in broad-leaved species (alder, maple and poplar) to Cypress and natural types. Moreover in depth of 0~10 cm the humidity was significantly different from 10~20 cm. The greatest amount of bulk density was seen in Cypress, as well in the second depth.

Table 2 Comparison mean of soil physico-chemical properties in different types

Types	Moisture (%)	C/N	Total nitrogen (%)	Organic Carbon (%)	pH	Bulk density (g/cm^3)
Cupressus	29.72 (±0.52)^{b}	20.44 (±0.43)^{a}	0.18 (±0.00)^{c}	3.73 (±0.07)^{a}	6.52 (±0.00)^{c}	1.30 (±0.01)^{a}
Populus	31.67 (±0.50)^{a}	7.75 (±0.73)^{d}	0.20 (±0.01)^{b}	1.63 (±0.19)^{d}	7.16 (±0.07)^{a}	1.14 (±0.00)^{a}
Maple	31.53 (±0.45)^{a}	10.96 (±0.25)^{c}	0.28 (±0.00)^{a}	3.09 (±0.03)^{bc}	6.47 (±0.01)^{c}	0.99 (±0.00)^{c}
Cypress	31.69 (±0.59)^{a}	10.20 (±0.33)^{c}	0.27 (±0.00)^{a}	2.84 (±0.11)^{c}	6.33 (±0.00)^{c}	1.03 (±0.01)^{b}
natural forest	26.86 (±1.02)^{c}	15.28 (±0.66)^{b}	0.21 (±0.00)^{b}	3.29 (±0.10)^{b}	6.68 (±0.07)^{b}	1.05 (±0.01)^{b}

Note: In each column there is not seen any significant difference between averages amounts with at least one common letter between

Table 3 Comparison mean of soil physico-chemical properties in 2 different depths

Depth(cm)	Moisture (%)	C/N	Total nitrogen (%)	Organic carbon (%)	pH	Bulk density (g/cm^3)
0~10	^{a}(0.46±)31.59	^{a}(0.88±)12.91	^{a}(0.00±)0.25	^{a}(0.130±)3.12	^{b}(0.02±)6.39	^{b}(0.02±)1.08
10~20	^{b}(0.50±)29.00	^{a}(1.04±)12.95	^{b}(0.00±)0.21	^{b}(0.170±)2.72	^{a}(0.03±)6.68	^{a}(0.02±)1.12

Note: In each column there is not seen any significant difference between averages amounts with at least one common letter between

1.3 Macrofauna biodiversity and soil features

The first and second principal components (PC1) and (PC2) maximized a total of 85.75% of the variance in the data set (Figure 5 and Figure 6). The eigenvectors for total nitrogen in both of depths are greatest in relation to Alder and Maple types whereas the character of bulk density is lowest compared to the eigenvectors of other variables (Figure 5 and Figure 6). Whole of macrofauna biodiversity indices (for both of abundance and biomass) are tended to Alder and Maple types (Figure 5 and Figure 6).

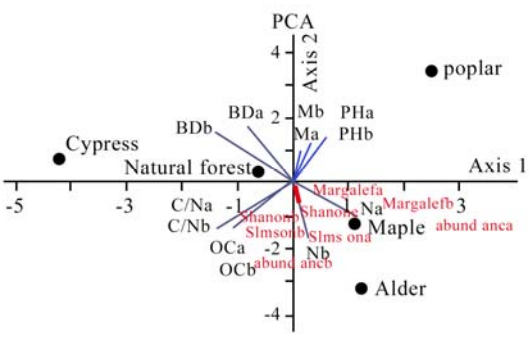

Figure 5 PCA biplots of forest types, abundance biodiversity and soil features

Note: PC1: Eigen value = 5.41, percent of variance = 45.09, cumulative variance percent = 45.09 and PC2: Eigen value = 4.87, percent of variance = 40.65, cumulative variance percent = 85.75

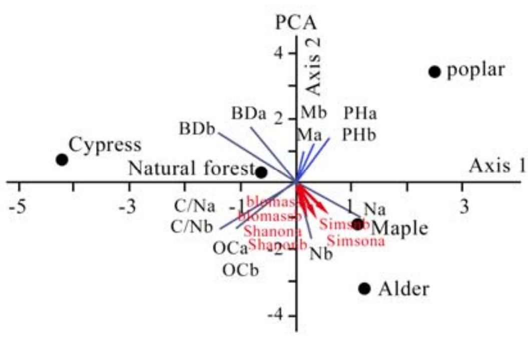

Figure 6 PCA biplots of forest types, biomass biodiversity and soil features

Note: PC1: Eigen value = 5.41, percent of variance = 45.09, cumulative variance percent = 45.09 and PC2: Eigen value = 4.87, percent of variance = 40.65, cumulative variance percent = 85.75

2 Discussions

According to forest destruction raise, using native species in forestation is a suitable procedure to revive destructed and ruined forest. To choose a type, not only some growth qualities and quantities should be realized, but also the effect of the picked type is so important in ecosystem revival procedure. The environment conditions, humus and soil qualities affect soil invertebrate constructions and numbers (Kling et al., 2007). If humus is not qualified, then tiny microphages and analyzers show fewer activities which cause organic accumulation in soil surface. When humus analysis reduces, food elements will return to soil which brings less growth and fertility. Consequently the organic layer is very substantial in soil invertebrate bio-variety (Dindal, 1990). If during harvesting the layer damages, the forest invertebrate variety will decrease a lot. Comparing the studied cases showed that there are some significant transformation in soil macro-fauna abundance which the least amount was seen in Cypress and most ones in alder and maple (Dechaine et al., 2005). Humus accumulation on the surface shows fewer breaks down activities. Humus analysis relates a lot to adequate activities of tiny microphages and analyzers (Dindal, 1990; Tondoh et al., 2007; Vesterdal et al., 2013). On the other hand in deeper soil they would decrease in variety which is for food resource decrease or organic mines. Gongalsky et.al (2008) revealed that soil depth and humidity were the most effective factors on soil invertebrate abundance in contrast to the other tree conformations. In some other studies thee were shown that more variety of invertebrate affects vegetation coating (Hooper et al., 2005). Soil temperature and moisture are the main factors in earthworms' activities (Kooch et al., 2013).

The present research has shown that Cypress plantation in Shast Kalate research-educational forest (Gorgan, Iran) resulted in litter accumulation which is, first, influenced by the composition type of nutrients available in litter and the weak ability of soil inhabitants in consuming it. This is consistent with Rahmani and Mohammad Nejad Kiasari (2003), Cole et al. (2006), Jalilvand and Kooch (2012) findings. Low abundance of soil mcrofauna in Cypress type can originate from phenolic compounds available in the leaf and nitrogen limitation in soil. Habitats with humid soil and nutrition pool are appropriate for detritivore and macrofauna and also play an important role in regression of nutrients to the soil.

Table 4 Two-way analysis of soil properties in different types and soil depths

Variable factor		SS	DF	MS	F-value	Sig.
Type	pH	4.098	4	1.025	46.613	0.000
	Organic Carbon	24.934	4	6.2335	68.797	0.000
	Total nitrogen	0.080	4	0.02	90.400	0.000
	C/N	1001.442	4	250.3605	90.427	0.000
	Moisture	174.859	4	43.71475	16.502	0.000
	Bulk density	0.604	4	0.151	115.524	0.000
Depth	pH	0.074	1	0.074	3.354	0.047
	Organic Carbon	1.988	1	1.988	21.941	0.000
	Total nitrogen	0.016	1	0.016	73.636	0.000
	C/N	0.021	1	0.021	0.008	0.931
	Moisture	83.774	1	83.774	31.625	0.000
	Bulk density	0.014	1	0.014	10.542	0.002
Type × Depth	pH	0.048	4	0.012	0.541	0.706
	Organic Carbon	0.731	4	0.183	2.018	0.110
	Total nitrogen	0.006	4	0.001	6.364	0.000
	C/N	8.960	4	0.240	0.800	0.532
	Moisture	2.022	4	0.506	0.191	0.942
	Bulk density	0.005	4	0.001	0.963	0.439

Some habitats allocated to alder with wet soil are suitable food sources for analyzers. They also revealed a significant role in food elements return to soil (Rahmani and Saleh Rastin, 2000). Organic carbon is a practical element and a fertility factor which can broadly be used in forest soil management and habitat fertility (Doweling et al., 1986). Doran and Parkin (1994) claimed that organic carbon in soil is one of chemical parameters, which facilitates food access as well it is an effective environment element in soil quality. There is a converse relation between earthworm abundance and carbon (Kooch et al., 2008; Jalilvand, and Kooch, 2012). In the paper the greatest amount of soil carbon was seen in Cypress with a significant difference which is correspondent with Chiti et.al 2007 (Table 4). Regonald and Palmer (1995) used nitrogen as a chemical feature in soil to evaluate its quality disturbances in different under control systems. Soil carbon and nitrogen is much related to its biological and physic-chemical features and generally they can be considered as quality indices (Pashani et al., 1991; Warren and Zou, 2002; Yan et al., 2012).

Moreover there is a significant link between earthworm number, sub-mass and C/N (Table 4). It means more this ratio is, less their abundances. In several studies soil carbon and nitrogen contents considered as important variables in forest soil fertility (Loffler, 2007). C/N is a great index to assign humus breakdown which through it we can calculate weight and volume drop-offs in humus (Sinha et al., 2003). Antunes et al. (2008) confirmed that C/N is a non-biological factor affects on macro-fauna plenty, their existence or lack of them. Neiryck et al. (2000) found that the small soil C/N ratio in Maple sub-canopy cover resulted in an increase in the number of soil habitant invertebrates. Soil macro-fauna abundance and biomass relates to this ratio conversely (Rahmani and Saleh Rastin, 2000). However, Mboukou-Kimbatsa (2007) noticed how nitrogen affects positively earthworm abundance and biomass. Leaves of broad-leave trees are better than needle- leave ones.

Therefore, they decompose faster and form sweet humus (alkaline) which, in turn, in decomposed by microorganisms' activity. But needle- leave trees produce sour humus (acidic) and this reduces the number of soil habitant invertebrates. However needle-leaved produce acidic (sour) humus which it decreases soil invertebrate population. Soil acidity is an effective factor that affects directly or indirectly macro-fauna as well food access (Armour et al., 2004). But it can be different in accordance with the age of a tree and area conditions (Agusto et al., 2002). The earthworms are sensitive to acidity in such a way their population and biomass will reduce in acid soils. The soil under cypress is more acidic in contrast to the other types; it means its reaction rate is slower, since most of soil creatures are sensitive to acid environment which it causes fewer in number and biomass (Rahmani and Saleh Rastin, 2000; Klimenk et al., 2011). Noticing the studies presented, most of tiny microphages prefer almost neutral reaction (Bird et al., 2004).

Based on available figures it is specified that most macrofauna are present in 0~10 cm depth and their number and biomass declines in deeper sites. Proper ventilation, enough space and abundant nutrients are main factors increasing the number and biomass of earthworm in 0~10 cm depth. The 10~20 cm layers are not proper in terms of mentioned factors and, hence, the number and biomass of macrofauna is smaller in them. On the other hand, deeper layers downward would be more compressed, that is the bulk density increases (Jafari haghighi, 2003), it is obvious in deeper layers (10~20 cm). in upper layers while soil is furrowed also the plants roots as well worm activities are more than the deeper ones then soil privileges more pores which it reduces bulk density. All these results are correspondent with ones gained by Kooch (2008). Going down in depth, the bulk density increases which brings consequently heavier texture. Some of soil features such as moisture and food elements relate to soil texture. This characteristic for sure affects detritivores population (Rahmani and Saleh Rastin, 2000; Groffman et al., 2004). In the research whereas the bulk density in 0~10 was less than 10~20 layers then macro-fauna abundance and biomass in the former layer is greater. In addition to aforementioned factors, the picked species for forestation can affect these creatures population.

3 Materials and Methods

3.1 Research site

The research was conducted in four plantations and an adjacent broadleaved natural forest located in compartment 1 of Shast Kalate (Bahram Nia) training forest, at the Gorgan University of Agricultural Sciences and Natural Resources (Figure 7). It is located in northern Iran (36° 41’ to 36° 45’ northern latitudes and 54° 20’ to 54° 24’ eastern longitudes) with an average annual precipitation of about 650 mm and an altitude ranging from 700 to 730 m a.s.l. The area is on flat and uniform terrain with low slope (3%~5%). The forest is established on brown forest soil with mostly sandstone as bedrock Clay-loam-silty texture and worn stones are spread around the region. Thickness of A horizon is 5 cm to 10 cm dark brown full of organic matter and grain with high permeability capacity, B horizon is reached to 50 cm depth and its color is brick with dense texture (Moghimian et al., 2013). The investigated treatments in this research consisted of 20-year-old plantations with species of Alder (*Alnus subcordata* C. A. Mey.), Poplar (*Populus deltoids* Marsh.), Maple (*Acer velutinum* Bioss.), Cypress (*Cupressus sempervirens* L. var. horizontalis) and the adjacent mixed natural forest. Tree spacing within the plantations was 5 m × 5 m and the stands were never fertilized. The tree species in the natural forest consisted of Beech, Hornbeam, Maple, Alder and other broad -leaved species.

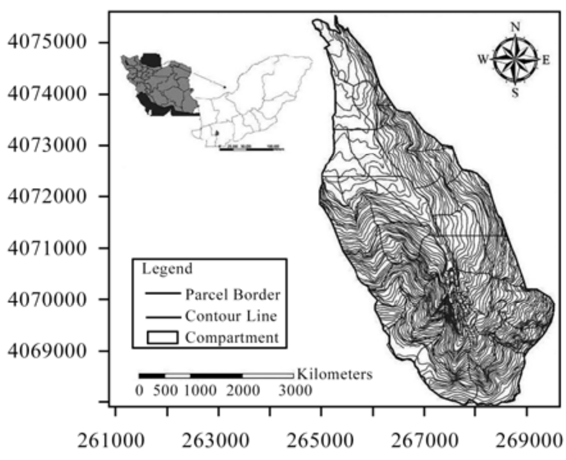

Figure 7 Geographical position of the study site in the north of Iran

3.2 Sampling of soil macrofauna

Five soil samples were randomly collected from each afforested type and also adjacent mixed natural forest. Whole of soil macrofauna were collected using core soil sampler with 81 cm^2 cross section from 0~10 cm and 10~20 cm depths. The samples transferred to lab then the earthworms in them were manually separated (Rahmani and Zare Maivan, 2004; Mohammad Nejad Kiasari et al., 2011). Soil macro-fauna biomass was weighed by a scale with 0.01 g accurateness.

3.3 Soil sampling and analysis

Soil samples were kept simultaneously with macrofauna sampling and then conveyed to laboratory due to physico-chemical analysis. Soils were air-dried and passed through 2-mm sieve (aggregates were broken to pass through a 2 mm sieve). Bulk density is a measure of a soils mass per unit volume of soil. It is used as a measure of soil wetness, volumetric water content, and porosity. Factors that influence the measurement include; organic matter content, the porosity of the soil, and the soil structure these factors will intern control hydraulic conductivity. Bulk density was measured by Plaster method (clod method). Soil moisture was measured by drying soil samples at 105 ℃ for 24 hours. Soil pH was determined using a pH meter in a 1:2.5, soil: water solution. Soil organic carbon was determined using the Walkey-Black technique (Allison, 1975). The total nitrogen was measured using a semi Micro-Kjeldhal technique (Bremner and Mulvaney, 1982).

3.4 Diversity measures

There are various ways of measuring diversity of soil fauna. In current research, the formulas of Shannon - Wiener (diversity), Simpson (evenness) and Margalef (richness) indices were used as follows (Moghiman et al., 2013):

1- Shannon-Wiener diversity

$$H' = -\sum_{i=1}^{s} (P_i \ln P_i)$$

Where H' is Shannon-Wiener index; *S* is invertebrate's group's number; *Pi* is average abundance of per invertebrates groups; *Ln* is natural logarithm.

2- Simpson evenness

$$D = \sum_{i=1}^{s} p_i^2$$

Where, *D* is Simpson evenness index; *S* is invertebrate's group's number; *Pi* is average abundance of per invertebrates groups.

3- Margalef richness

$$R = \frac{S-1}{L_n N}$$

Where *R* is Margalef richness index; *S* is invertebrate's group's number; *Ln* is natural logarithm; *N* is number of populations.

3.5 Statistical analyses

The normality of the variables was checked by the Kolmogorov - Smirnov test, while Levene's test was used to examine the equality of the variances. Differences in macrofauna biodiversity and also soil physico-chemical features among afforested stands and depths were tested with two-way analysis (ANOVA) using the General Linear Model (GLM) procedure, with stands (Alder, Maple, Poplar, Cypress and Natural forest) and depths (0~10 cm and 10~20 cm) as independent factors. Interactions between independent factors were also tested. Duncan's test was used to separate the averages of the dependent variables which were significantly affected by treatment. Significant differences among treatment averages for different parameters were tested at $P \leq 0.05$. SPSS v.16 software was used for all statistical analysis. In addition, for evaluate the factors affecting macrofauna biodiversity indices over the whole range of stand and soil physico-chemical features, the data for all stands were analyzed using Principal Component Analysis (PCA) to find the most effective factors on macrofauna distributed in areas.

4 Conclusions

The study showed that, the strong faunal effects on decomposition argue for greater consideration of the role of decomposer organisms in subtropical ecosystems. If feedback between detritus food-webs and ecosystem processes occur, this may affect subtropical soil fertility. Therefore, it can be pointed out that soil habitants play a significant role in reviving and rebuilding destructed forests and accelerating and reinforcing growth in natural forests. This interacts with the genus type and, hence, species must be planted and reinforced in forest habitats which positively affect biomass and activity of soil habitants and improve habitat conditions and productivity. The present paper emphasizes the point that forestation using native broad-leaf species consistent with region's ecological conditions can act as a proper method to revive and rebuild destructed forests. Moreover, using various species for forestation has different effects on abundance and biomass of earthworm and hence species must be selected carefully in order to improve soil conditions. Considering an increase in productivity and soil macrofauna, Acer and Alnus are among favorable species to be used in forestation in this region.

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