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Ecological estimation of forest soils in Azerbaijan

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While afforestation is relevant in the study of the ecological state of forest soil, analyses of the soil samples and valuation of the soil types to obtain final yield class is important. Within the National State Afforestation Program, as the research object, the south-east slope of the big Caucasus has been chosen for checking up soils under woodland and woodless areas. After having taken soil samples in this zone, these samples were analyzed and the amount of humus, nitrogen, phosphorus and absorbed matters sum (AMS) have been determined for a hectare (t/ha). Formula (1) was applied to determine the soil fertility factor and mechanical composition quantity (t/ha). By the traditional soil valuation method, proposed by an academician, G. Sh. Mammadov, in comparison with the selected etalon soil type, other soil valuations were given by points. Formula (2) was used to obtain the final points of the soil type and subtypes: 1) The total amounts (t/ha) of the soil types and subtypes which were determined based on formula (1). As summary of the ecological estimation, the final main yield class points of soils was established due to calculation by formula (2) for all soil type and subtypes under woodland and woodless areas in Shamakhi region, situated in the very natural zone. The results obtained from the experiments and calculations, showed the present ecological state of the woodland and woodless soils, their fertility factor and mechanical composition.

Key words: Ecological estimation, main yield class, soil ecology, valuation of soil, valuation point, ecological safety, forest protection.

INTRODUCTION

The protection of woodland begins from the soil safety; this natural complex (Williams et al., 2005) is the keeper of the soil. In the woodless areas, ecological estimation of soil is carried out from time to time. The soils under the forest lines and prairie zones have been studied by soil scientist for a long time in Azerbaijan. But changes in the woodlands' square cause several hazardous factors in soils. That is why the quality of the soils is to be periodically determined for preparing safety measures. While realizing soil cadastre, besides official registration of soil usage, information collection on the financial estimation, implementation of quality, quantity registration and valuation of soils have great importance (Mitchel, 2001). The principal scope in implementation of soil valuation is the comparative assessment of soil types, quality or preparation of their genetic-productive classification. State of the soils in Azerbaijan was studied in laboratory condition during researches at the Institute of Soil Science and Agrochemistry. After the open air (field) work, the soil samples were processed for analyses. Based on the results, soil valuation was evaluated by calculation of indexes and the valuation pound of each soil type was defined. The square of the pilot research area (Pirgulu) was not enough to carry out the soil estimation for all the soil types of forest and woodless zones. Pirgulu is situated in Shamakhi region on the southern-east slope of the big Caucasus Mountains. Taking into consideration the little square of the research object, soil estimation was carried out for wood and woodless soils of the whole Shamakhi. In this research, eleven soil profiles including different soil types and subtypes were studied. Corresponding to the method of the investigation, main yield-class of the soils was established on the basis of internal diagnostic indices of

soil subtypes of wood and woodless areas. Within the region of the etalon soil type, typical mountain-forest brown soil was chosen by comparing indexes of all other soil types with the etalon soil type, the yield class shown was determined for each soil type, for both the wood and woodless areas of Shamakhi.

MATERIALS AND METHODS

To carry out the research, the object was selected from the southern-east part of the big Caucasus; woodland and woodless soils of Shamakhi region were studied. This region was included in the Shirvan economical region being 1611 km^2. As a result of the utilization purposes, soil foundation of the region was rich and multiple. Basically, Shamakhi is a mountainous region which leads to the verity of the landscape and complex relief. The region begins from the north end of Kur-Araz plateau, stretches to the south slopes of the big Caucasus. The height changes between 300 to 2100 m intervals (Gulumdostu pick). Such alternation causes the most colorful natural condition. Going up above the sea level, warm-arid climate appears, winter with mild climate, equal precipitations and summer is short and cool but winter is long with plenty of snow which causes the climate changes in the mountain-forest of the region. The mount of annual atmospheric precipitation alters between 400 to 1000 mm, sometimes 1200 mm. Although in some years, snow was not observed in the southern part of the region (Hajiqadirli village); yearly snow cover was about 219 mm. At times, the snow cover appeared in late October and exists to the middle of May; especially in the south direction, average January temperature never falls below 0°C but in the medium mountainous zone of the region, average January temperature was observed at -3 to 8°C. In some cases, temperature falls to -2 to 3°C in the mountainous zone of Shamakhi. Such climatic condition together with the relief of the region strongly influences the richest topsoils. Besides seismicity characterized to Shamakhi, there are a lot of muddy volcanoes acting there. The biggest of them is located on the way of Shamakhi – Demirchi; about 30 to 31 km away. Also, in the Agsu River bed at the end of the Agsu-Chagan road, the thermal Chagan Bedo spring with 38 to 39°C temperature had medicinal properties.

As for the fauna of the research region, there are 31 diversity of mammal (mammalian) animals, (33% of 92 variety is in the Republic), 65 types of birds, 9 creeping types, 6 types of animals and birds living in water and land. The animals input to the red book are spotted Hyena, Caucasus peregrine, Caucasus colubrid, Newt with Comber. Among the animals, the chief hunting types are forest pig, roe, bear, Caucasian goat, pheasant, partridge, rabbit and the others. At present, the forests huge deeds were realized to broaden the square of Pirgulu State Preserve and the organization of Shahdag National park. Taking into consideration the national potential and anthropogenic influences to all, the evaluation of region woodland and woodless soils has significance in ecological estimation of quality (Thompson and McCarthy, 2008) and the quantity of the soils being utilized by several farms and enterprises in Shamakhi. Due to the organizing of afforestation, forest plantation and also for exact determination of the forest foundation soils, mathematical and statistical analyses are necessary. Due to the value criterion of the main soil indexes, humus, nitrogen, phosphorus, absorbed matters sum (AMS), woodland and woodless soils; mathematical and statistical analyses of the internal diagnostic values of the region soil was carried out. The ecological estimation of soils was carried out in different ways in various countries. The method which was applied in the soil ecology study in Azerbaijan was distinguished from the methods of other countries. At the same time, this method also has several advantages which give the opportunity to the researcher to estimate the ecological state of the soil effectively and easily (Mammadov et al., 1997).

Method advantage

Within the National State Afforestation Program, the south-east slope of the big Caucasus has been chosen for checking up the soils under the woodland and woodless areas. Some differentiating features of the method proposed by the head of the Azerbaijan Soil Scientists Society, an academician, Garib Mammadov during the 90's (Mammadov, 2004). While afforestation was relevant in studying the ecological state of the forest soil (Bolund and Hunhammar, 1999), analyses of the soil samples and valuation of the soil types to obtain the final yield class is important. Since 90 years, the ecological estimation of the soil had been realized based on the genetic factors of the soil that was not effective and profitable for the soil scientists.

First step of the method's first stage

The mechanism of the method is very simple and by this method, the process was done in three stages. The first stage is divided into two steps. After the field, cameral and laboratory preparation, the analysis of the soil samples internal diagnostic indexes of humus, nitrogen, phosphorus, AMS was determined in the range of 0 to 20; 0 to 50 and 0 to 100 sm depth. Due to the experimental results at the first step of the first stage, the amount (t/ha) of the fertility factor (humus) and mechanical composition (nitrogen, phosphorus and AMS) was calculated for a hectare using the formula as follows:

$$L = (d \times \rho \times V) \div 100 \qquad (1)$$

Where, L is the reserves (t/ha) of humus, nitrogen, phosphorus and AMS depends on the depth of the soil layers (0 to 20; 0 to 50 and 0 to 100 sm); d is the amount (%) of humus, nitrogen, phosphorus and AMS; ρ is the density (g/sm^2) of the appropriate layer; V is the capacity (m^3) of the soil in the proper layer (0 to 20; 0 to 50 and 0 to 100 sm). 100 sm showed a hectare in this formula. Using the values criterion of each soil type and subtypes, the amount (t/ha) of the fertility factor and mechanical compositions for a hectare were revealed in the woodland and woodless soils in Shamakhi region fitting into the first step of the method's first stage.

The second step of the method's first stage

At the second step of the first operation, the evaluation points of the soil types and subtypes in diverse depths were defined for discovering final estimation points (Mammadov, 1998). Thus, in this case Formula 2 was applied:

$$B = (Kf \div Kf) \times 100 \qquad (2)$$

Where, B is the soil yield class point; the first Kf is the actual metric of the soil properties and criterion; the second Kf is the compliant index of the etalon soil. Accordingly, the second calculation was realized by this formula taking into consideration all above mentioned factors.

RESULTS

Total amount of humus, nitrogen, phosphorus, AMS

In this research area, the majority of the investigations realized in this natural zone including Shamakhi region were looked through. It was revealed that the forest land of the region was connected to the I Group being the mountainous. In the forest lines, there are 62 types of trees and bushes. Generally, all the forests of the region may be divided into three groups:

a. Below mountain-forest zone with 900 m height above the sea level,
b. Middle mountain-forest zone with 900 to 1500 m height above the sea level,
c. High mountain-forest zone with 1500 to 1900 m height above the sea level (maximum of 2100 m).

The major forest forming trees are hornbeam (*Carpinus*), oak (*Quercus*), beech (*Fagus*), ash tree (*Fraxinus*), birch (*Betula*), ulmus (*Ulmus gen*) for all woodland of the region. For saving forest lines, the Pirgulu State Nature Preserve was established by an academician, Hasan Aliyev's initiative in 1968. Before, the square of the Preserve consisted of 1521 ha, which was widened up to 4274 ha in 2003 (Mammadov et al., 2009). None of the natural lakes exists in the region but 10 artificial lakes (water-storage basins) exist. Within the region, some rivers were supplied by rain, snow and ground waters including the Pirsaatchay, Agsuchay, and Gozluchay run. Consequently, the long-term researches discovered that, 520 types of the florid plants grew in the Shamakhi region, of which; 130 of them are trees, bushes and the rest are annual or perennial herbs. Inherently, researches and investigations compiled at the Scientific Department of Pirgulu State Nature Preserve revealed that, 441 types of the florid plants of which, 130 of them are trees and bushes generally spread within the flora of the zone. In this region, only elementary mushrooms were not studied.

Beside the extension of 410 types of mushroom were discovered, 16 of them were newer kinds for the Republic. Almost 50 nadir, endemic and relict types exist in Shamakhi. At the same time, 46 types are being saved and protected in Pirgulu Preserve. The juniper (*Juniperus*), yew (*Taxus*), Shamakhi larches (*Larix*), Radde's bush warbler (*Phylloscopus schwarzi*) was frequent. Generally, 42 of 50 medicinal plants nourishes in the Pirgulu Preserve. These are 27 trees and 15 herbs being divided into 18 families and 26 kinds. The widely propagated herbs are sage (*Salvia*), yarrow (*Yarrow*), violet (Viola), orchis (Orchis), mallow (*Malva*), shorebird (*Chardriidae*), thyme (*Thymus*), primrose (*Primula officinalis*), asparagus (*Asparagus*), aril, sumac (*Rhus*), tutsan (*Hypericum*) and medicinal trees are juniper (*Juniperus*), linden (*Tilia*) and others. All plants mentioned in the region have beneficial soil cover, climate and relief for afforestation and safety deeds. The study of the ecological status and estimated soils, under the forests, allows right measurements of the forests to be carried out, while forest managements (Pickett and Cadenasso, 2008), forest measuration, forest recreation, implementation of forest organizations in woodlands and protection of forest park and forest litter, eventually lead to an increase in forest productivity and environmental safety. Therefore, the quantities (t/ha) of humus and mechanical composition were determined for woodland and woodless zone in Shamakhi. These are presented in Table 1.

Final main yield class points of soils

With ecological estimation of soil as the value criteria, indices of the chemical and agrochemical soil analyses are taken into account. During evaluation of soils, some soil properties and features considered as the value criterion are classified in details (Mammadov et al., 2009). Initially, thickness of humus horizon and its reserve must be checked up in the zone. Both criterions may be the general and main leading indices in evaluation. Thus, soil fertility is assessed according to the quantity of humus in it firstly. Humus is the integral index (Ayvazov, 1989) of the soil concentrates. In the formation of soil fertility, plant growth and development, humus composition in soil has great role. Humus is not only chemical and biological factor but also an ecological factor (Cole and Ewel, 2006). Humus matter possesses high absorption and adsorption capabilities, it generate the most important property, soil buffer capacity, together with its colloid particles. So different fertility indices have close connection with humus matter that shows its integral feature. That is why by estimating humus status in soil, majority of the properties of soil might have been appraised. For soil evaluation, a second necessary value criterion is phosphorus reserve in the soil. This is non random, phosphorus is a more significant factor for plant nutrition, and provision of physiological action (Hiremath et al., 1997). The whole exchange processes in plant's organism relates with phosphorus. Due to this, all indexes were considered, on account of the calculations carried out, the main evaluation scale of the woodland and woodless soil types and subtypes in Shamakhi region was stabled and the yield class points were shown in Table 2.

From the table, it was revealed that, in order to establish main yield class scale, value criterion of the typical mountain- forest brown soil type characteristic of the region was considered. On the very etalon, comparative evaluation points of other soil types and subtypes were found. While evaluating soil, reserves (t\ha) of phosphorus, humus, nitrogen, AMS in 0 to 20; 0 to 50 and 0 to 100 cm depths were taken as the value factor. Soil evolution points were determined by taking into consideration, the general amount (%) of phosphorus

Table 1. Total amount (t\ha) of humus, nitrogen, phosphorus, AMS in woodland soil of Shamakhi region.

Soil	Humus			Nitrogen		Phosphorus		AMS		Medium amount (t/ha)			Total amount (t/ha)
Quantity (t/ha)	0-20	0-50	0-100	0-20	0-50	0-20	0-50	0-20	0-50	0-20	0-50	0-100	
Washed mountain-meadow forest brown soil	59.3	167.9	294.4	3.1	9.9	3.1	8.8	37.6	41.7	26	57	294.4	94.35
Typical mountain-forest brown soil	143.5	338.1	495.3	6.8	11.2	4.0	8.1	31.7	35.8	46.5	98.05	495.3	213.18
Carbonated mountain-forest grown soil	90.6	130.6	-	4.5	5.6	5.6	11.9	26.5	25.4	31.8	43.38	-	37.57
Washed mountain-/garden/ brown soil	129	239.4	-	5.6	18.2	-	-	39	27.9	57.86	95.16	-	76.51
Carbonated mountain-/garden/ forest brown soil	32.6	70	-	1.8	44	5	13.8	50	34	22.35	40.45	-	31.4
Woodless washed mountain brown soil	71.9	140	260.4	4.2	6.9	5.6	13.2	31	32	28.18	48.02	260.4	112.2
Woodless Typical brown soil	72.5	165.6	205.7	4.7	9.4	5.2	13.8	30.6	30	28.25	54.7	205.7	96.22
Woodless carbonated mountain brown soil	54	117.5	231.2	3.3	6.9	6.2	107	25.8	27.9	22.32	64.83	231.2	106.12
Steppe mountain brown soil	59.7	117	136.5	3.3	5.4	4.6	10.3	32.3	33.3	24.97	41.5	136.5	67.66
Grown typical mountain brown soil	57.7	140	226.2	2.6	5.5	-	-	35.2	36.2	31.83	60.56	226.2	106.20
Grown carbonated mountain brown soil	39	94.4	197.6	2.4	6.7	5.1	11.5	29.5	30.4	19	35.75	197.6	84.12

Table 2. Main yield class scale of woodland and woodless' soils of Shamakhi region.

Fertility and MC	Humus			Nitrogen		Phosphorus		AMS		Medium point			Total points
Depth	0-20	0-50	0-100	0-20	0-50	0-20	0-50	0-20	0-50	0-20	0-50	0-100	
Soil													
Washed mountain-meadow forest brown soil	41	49	59	45	88	77	108	118	116	70	90	59	73
Typical mountain-forest brown soil	100	100	100	100	100	100	100	100	100	100	100	100	100
Carbonated mountain-forest grown soil	63	38	_	66	50	140	146	83	70	88	76	_	82
Washed mountain-/garden/ brown soil	89	70	_	82	162	_	_	123	77	98	100	_	99
Carbonated mountain-/garden/ forest brown soil	22	20	_	26	392	125	170	157	94	82	100	_	91
Woodless washed mountain brown soil	50	41	52	61	61	140	162	97	89	87	88	52	75
Woodless Typical brown soil	50	48	41	69	83	130	170	96	83	87	96	41	74
Woodless carbonated mountain brown soil	37	34	46	48	61	155	132	81	77	80	76	46	67
Steppe mountain brown soil	41	34	27	48	48	115	127	101	93	76	75	27	59
Grown typical mountain brown soil	40	41	45	38	49	_	_	111	101	63	64	27	51
Grown carbonated mountain brown soil	27	27	39	35	59	127	141	93	84	70	71	39	60

phosphorus, humus, nitrogen, AMS and the density (g\sm^2) of the proper soil type or subtypes. Other main factors of the fertility are the content, quantity and comparison of cations in soil (Mammadov, 2006). They are used as the value factors whilst AMS assessment is characteristic for soil evolution processes. The major important among the AMS are Ca^+ and Mg^+ cations. Both elements are necessary for the plants to be grown and to give harvest.

DISCUSSION

Study of the ecological state on the southern-east slope of the big Caucasus Mountain has been carried since 1960s. Thermal-physical properties of the major soil types of the mentioned slope was revealed and investigated by Mammadov H. M. The research led the scientists and investigators to determine thermal regime depending on the physical characteristics of soil types in the region. Today, the main literature indexes are based on his re-searches realized in the very natural zone. Other investigation carried out in the region concerns erosion process development on the south slope of the big Caucasus Mountain that was accomplished by Mustafayev X. M.; for estimating the ecological condition of the zone. Therefore, epigenetics of erosion process on the slope and the dangerous or hazardous influences to the soil cover under woodless areas were defined and the preventing measurements were proposed. A genetical and forestation characteristic of mountain-forest soils in Shamakhi region has been analyzed by some scientists, one of them was Hasanov X. N. Unlike other researchers, the unique one was implemented on the southern-east slope of the Caucasus Mountain by Piriyeva F. Firstly; the forest soil for ecological estimation in Azerbaijan was evaluated. Lately, such kinds of researches were not carried out in this zone especially in Pirgulu. Due to the present state of the forest, woodland and woodless areas were not sufficient, that was why the study of the soils was important. The research was based on the ecological estimation of forest and woodless areas' soils and their evaluation due to the current method put forward by an Academician; Mammadov G.Sh (Mammadov, 2003). Finally, it can be concluded that, in order to prevent soils from undergoing degradation, afforestation and forest protection measurements are to apply. Also, with the ecological estimation map at present, researches are been done on the usage of alternative energy sources instead of forest wood for woodland soils' protection.

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